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INDIAN CARTOGRAPHER

Volume 35, 2015

Indian National
Cartographic Association

Jawaharlal Nehru
University

XXXV INCA INTERNATIONAL CONGRESS

on

Spatial Governance for Development,
Planning Smart Cities and Disaster Management

15th to 17th
December, 2015

Convention Centre,
Jawaharlal Nehru University,
New Delhi

Journal of the Indian National Cartographic Association (INCA)

INDIAN CARTOGRAPHER

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Journal of the Indian National Cartographic Association

RK BOOKS

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CONTENTS

ABOUT THE VOLUME

It is a matter of great pride and privilege for me to have been the Editor of 35th issue of the INDIAN CARTOGRAPHER. The volume includes the selected 91 papers which were presented in various technical sessions of the 35th INCA International Congress held from 15-17 December, 2015 at Delhi. The Congress with focal theme 'Spatial Governance for Development, Planning Smart Cities and Disaster Management' was organised by the Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi under the aegis of the Indian National Cartographic Association (INCA). It was inaugurated by Prof. K Kasturirangan, former head, Indian Space Research Organisation and Chancellor, JNU. The Congress was spread over three days and witnessed some great deliberations, exchange of academic views and brainstorming.

Reviewing and editing papers of experts has been an uphill task but a very rewarding personal experience. This volume could not have been published without the help extended by the members of Editorial Support Staff. I am confident that the ideas expressed by the experts in their papers will reinforce the importance of Cartography in problem solving and would be used as good reference material not only by Geographers and Cartographers but also by policy makers.

I extend my heartiest wishes to one and all engaged in the field of map-making to further their endeavours in popularising Cartography, and encourage everyone not only in making maps but to promote this discipline further, by increasing collaboration between academia, professionals and industrialists. Furthermore, maps generated, should be user friendly so as to also benefit the common man. A holistic approach is needed for popularising Cartography and extending its professionalism on one hand and on the other to encourage its usage among people for furthering national life with the ultimate aim of human development.

Centre for the Study of Regional Development
School of Social Sciences
Jawaharlal Nehru University
New Delhi 110067
September, 2016

Prof. Anuradha Banerjee
Past President INCA and Editor,
Indian Cartographer, INCA

MESSAGES

शमीमा सिद्दिकी
SHAMIMA SIDDIQUI
भारत के राष्ट्रपति की उप प्रेस सचिव
Deputy Press Secretary
to the President of India

राष्ट्रपति सचिवालय,
राष्ट्रपति भवन,
नई दिल्ली-110004.
PRESIDENT'S SECRETARIAT,
RASHTRAPATI BHAVAN,
NEW DELHI - 110004.

MESSAGE

The President of India, Shri Pranab Mukherjee, is happy to know that the Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi is organising the XXXV INCA International Congress on "Spatial Governance for Development, Planning Smart Cities and Disaster Management" from December 15-17, 2015.

The President extends his warm greetings and felicitations to the organisers and participants and sends his best wishes for the success of the event.

Deputy Press Secretary to the President

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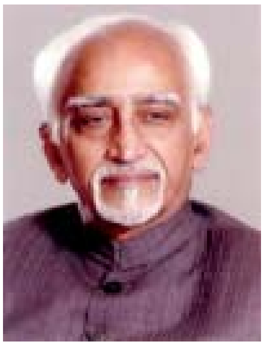


भारत के उप-राष्ट्रपति के विशेष कार्य अधिकारी
OFFICER ON SPECIAL DUTY
TO THE VICE-PRESIDENT OF INDIA
नई दिल्ली/NEW DELHI - 110011
TEL.: 23016422 / 23016344 FAX : 23012645

MESSAGE

The Hon'ble Vice President of India is happy to learn that the Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi is organizing the XXXV INCA International Congress on 'Spatial Governance for Development, Planning Smart Cities and Disaster Management' from December 15 – 17, 2015.

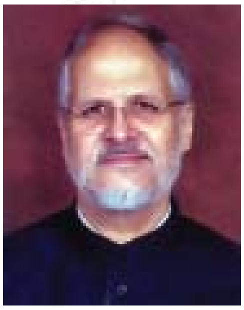
The Vice President extends his greetings and congratulation to the organizers and the participants and wishes the event all success.

(Anshuman Gaur)

New Delhi
28th October, 2015.

उपराज्यपाल
दिल्ली
LIEUTENANT GOVERNOR
DELHI

राज निवास
दिल्ली-११००५४
RAJ NIWAS
DELHI-110054



9th October, 2015

MESSAGE

I am happy to learn that the Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University is organizing the XXXV INCA International Congress on "Spatial Governance for Development, Planning Smart Cities and Disaster Management" from 15th to 17th December 2015.

The organizers have chosen to approach the question of development, planning smart cities and disaster management by employing the tools and methods of geo-spatial studies. I am sure the deliberations at the congress will help sharpen the debate around these areas, which will also be of relevance to planners and policy makers.

I convey my warm greetings to the organizers and participants of the conference and wish their endeavours my very best.

(Najeeb Jung)

डॉ. हर्ष वर्धन
DR. HARSH VARDHAN

सत्यमेव जयते

मंत्री
विज्ञान और प्रौद्योगिकी एवं पृथ्वी विज्ञान
भारत सरकार
नई दिल्ली - 110001

MINISTER
SCIENCE & TECHNOLOGY AND EARTH SCIENCES
GOVERNMENT OF INDIA
NEW DELHI - 110001

MESSAGE

I am very glad to know that Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University is organizing XXXV INCA International Congress on Spatial Governance for Development, Planning Smart Cities and Disaster Management on 15-17 December, 2015 at New Delhi.

Centre for the Study of Regional Development aims to focus on interdisciplinary programme of studies for teaching and research, placed in an overall framework of regional development in India. It would be a good platform to provide an opportunity to highlight the role of Surveying, mapping, remote sensing and GIS techniques to mitigate, effectively organize rescue efforts and undertake post disaster reconstruction and rehabilitation.

I convey my best wishes to Centre for the Study of Regional Development on this occasion and wish for its successful completion.

Harsh

(Dr. Harsh Vardhan)

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M.S. SWAMINATHAN RESEARCH FOUNDATION

M.S. Swaminathan
Founder Chairman
Ex-Member of Parliament (Rajya Sabha)

MESSAGE

I am glad that the INCA International Congress scheduled to be held between 15-17 December 2015 at JNU, New Delhi will have its focus on planning smart cities and disaster management. Both these are exceedingly important topics and I hope the conference will show how our smart city and smart villages programmes can be mutually reinforcing. I wish the conference much success.

M S Swaminathan

M S Swaminathan

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जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
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NEW DELHI-110067

प्रोफेसर सुधीर के. सोपोरी
कुलपति
Professor Sudhir K. Sopory
Vice-Chancellor

September 28, 2015

MESSAGE

I am happy that the Centre for the Study of Regional Development (CSRD), School of Social Sciences, is organsing the 35th XXXV INCA International Congress on "Spatial Governance for Development, Planning Smart Cities and Disaster Management" from 15 to 17the December, 2015. This is a mega event in which about 700 delegates from India and abroad are expected to participate.

Spatial Governance for Development, Planning Smart Cities and Disaster Management is such a vast field that some isolated efforts would not yield desired outcome in the area. Spatial governance is an important element of governance. It is instrumental in shaping of towns, cities and regions through policies, plans and strategies centering on land use planning, public policy and community engagement. Spatial data plays a vital role as it can be utilized by the planners and decision-makers to draw attention to the socio-economic issues of the city and to include the poverty hot spots in the development process. Governance influences many spheres and extends its support to disaster risk reduction as well. Surveying, mapping, remote sensing and GIS techniques are now increasingly being used for disaster management through the production of model for visualization of the effect of disaster, to mitigate, effectively organize rescue efforts and undertake post disaster reconstruction and rehabilitation.

The Centre for the Study of Regional Development was granted the status of 'Centre of Advanced Studies' (CAS) under the Special Assistance Program (SAP) of the UGC in April 2003 which was renewed in April 2009 for a period of five years. This has enabled the Centre to enhance its teaching and research activities in continuing as well as new research areas including building up of infrastructural facilities with emphasis on thrust areas identified as Advanced Remote Sensing and GIS, Climate Change and Disaster Management, Natural Resource Management, Globalization/Urbanization/Population, and Regional Disparities and Social Exclusion, which are so important in dealing with such issues in larger context.

The utility of the subject under deliberation is not limited, but extends to various spheres, including governance. I am sure the participants of the Conference will make the best use of this platform to formulate and evolve innovative framework for governance and development.

I congratulate the Centre for the Study of Regional Development for taking up such an innovative and interdisciplinary topic for deliberation in the Conference and convey my best wishes to the Centre, its faculty, staff and students for the success of this prestigious event. Special compliments to Prof. Anuradha Banjerjee, President, INCA, for playing a leading role in the organization of a Conference of this magnitude.

Sudhir K. Sopory

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जवाहरलाल नेहरू विश्वविद्यालय
नई दिल्ली-११००६७
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067

प्रो. भुपिन्दर जुत्सी
कुलसचिव
Prof. Bupinder Zutshi
Registrar

Dated:27 November 2015

MESSAGE

I am glad to know that the Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi is organizing XXXV INCA International Congress on the theme of Governance for Development, Planning Smart Cities and Disaster Management in collaboration with the Indian National Cartographic Association, from 15-17th December 2015.

There is a strong need to gather and analyse spatial data for making Smarter Cities with Disaster Risk Reduction (DRR) mechanisms, through the use of modern cartographic techniques. Need for building Smarter Cities is to ensure access for all; adequate, safe affordable housing, basic services and sustainable transport services.

Modern Cartography has advanced in collecting spatial data with the use of new technological innovations especially through innovations in developing communication and information systems. New Software technologies of map preparations have made their niche in the digital realm. The Use of modern cartography is no longer restricted to Geography but it has shown significant relevance for building Smarter Cities, Governance, spatial planning and disaster management and mitigation. There is strong need to generate awareness among scientific community about the use of modern cartography to solve the problems of urbanization and disaster management.

The XXXV INCA International Congress is an excellent knowledge sharing platform, where the recent research and field based practices will be exchanged and discussed to bridge the gaps in the implementation of effective models of spatial governance plans for developing smarter cities. The International Congress theme on governance in development, planning smart cities and disaster management though a geo-spatial approach will go a long way to bridge this gap by depicting Scientific and technological innovations, capacity building measures, good governance and community resilience for Greener, Inclusive , healthy, compact and resilient cities.

Prof. Bupinder Zutshi)
Registrar

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नई दिल्ली - 110067

Prof. Sukhadeo Thorat
Chairman

Ref.No.PS/CH/ICSSR/2015

28 September 2015

<u>Message</u>

I am glad to learn that the Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi, is organizing XXXV INCA International Congress on "Spatial Governance for Development, Planning Smart Cities and Disaster Management" during 15-17 December 2015 in New Delhi.

I note that sub-themes of the Congress include recent trends in cartography for development planning, spatial aspects of Governance for urban local bodies, cartography for population, environment and development natural resource monitoring and management, rural planning and decentralization, mapping social exclusion and discrimination, among others.

I understand that about 700 delegates from all over India and abroad are expected to participate in this important Congress.

I also understand that an exhibition of Geospatial products and services; cartographic, surveying, remote sensing, GIS, GPS and related products and latest maps, globes, mobile mapping will be held at the Congress, to encourage interested companies to showcase their products and services, which is expected to be a great boon to the Congress.

I wish the Congress a great success.

Sukhadeo Thorat

Prof. Anuradha Banerjee
President and Convener
XXXV INCA International Congress
Centre for the Study of Regional Development
School of Social Sciences
Jawaharlal Nehru University
New Delhi - 110067

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Dr. V. K. Dadhwal
Director

MESSAGE

I am happy to learn that the Jawaharlal Nehru University, New Delhi is organizing the XXXV INCA International Congress with focus on "Spatial governance for Development, Planning Smart Cities and Disaster Management" during 15 -17, December, 2015 at New Delhi.

Spatial Data offers immense scope for a variety of applications through multiple platforms. Recent government initiatives on Smart cities, AMRUT, Digital India etc require quality base maps, spatial data etc for better decision making. Thus, it is heartening that the Congress has chosen a theme of contemporary significance. Space borne spatial data along with derived information and better visualization tool like BHUVAN provide planners and administrators an edge in rolling out government's initiatives to reach to the public with a quick turnaround time.

With a host of space borne and ground based sensors, the volume of spatial data has exponentially increased posing challenges to the spatial analyst. There is also a need to ensure the reliability and assimilation of data as per agreed standards. ISRO has developed significant services through the BHUVAN platform, encompassing visualization, free data download OGC web services, disaster information, crowd sourcing and GIS applications.

I am sure the XXXV INCA International Congress will provide an excellent platform for the professionals and researchers in exchange of ideas on various topics in furtherance of addressing the research challenges.

On this occasion, I extend my best wishes to the INCA, JNU and the participants for a successful congress.

VKdadhwal
(V.K. Dadhwal)
Director

Nov 02, 2015

भारतीय अन्तरिक्ष अनुसंधान संगठन
अन्तरिक्ष विभाग
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e-mail : chairman@isro.gov.in

आ. सी. किरण कुमार / **A. S. Kiran Kumar**
अध्यक्ष / Chairman

MESSAGE

It is my pleasure to extend best wishes for the successful organisation of XXXV INCA International Congress. I am also happy to note that the focal theme of this Congress is "Spatial Governance for Development, Planning Smart Cities and Disaster Management".

Cartography and maps are essential tools for developmental activities. Map making has undergone tremendous change in the past few years with the availability of high-resolution satellite data. I hope that the advantage of using high-resolution satellite data in obtaining large scale information, scope of governance in development, planning smart cities and disaster management though a geo-spatial approach will be the focus of the Congress.

Future advance in satellite imagery, digital photogrammetry, GAGAN, IRNSS and GPS based precise positioning services will open up totally new vistas for the preparation of topographic maps and cadastral mapping. The biggest impact will be for town planning, urban infrastructure and transportation system planning, monitoring the developmental activities, property management, facilities planning, legal enforcement, damage assessment etc.

I hope that this Congress will focus on specific action plans to be taken up for the betterment of the lives of the people through supporting the smart cities, disaster management and other developmental projects. I also urge INCA to enable the maximization of the use of GAGAN enabled positioning services for satellite data preparation, mobile data collection and support cartographic applications.

I wish all the success for the INCA International Congress.

आ सी किरण कुमार
(आ. सी. किरण कुमार)
(A. S. Kiran Kumar)

Bangalore
December 09, 2015

डॉ० पृथ्वीश नाग
कुलपति

Dr. Prithvish Nag
Vice Chancellor

FORMER PRESIDENT, INCA
FORMER SURVEYOR GENERAL OF INDIA
FORMER DIRECTOR, NATMO
FORMER VC, SSVV, VARANASI & UPRTOU, ALLAHABAD
FORMER UN CONSULTANT IN CARTOGRAPHY, OMAN

महात्मा गांधी काशी विद्यापीठ,
वाराणसी-२२१ ००२

Mahatma Gandhi Kashi Vidyapith,
Varanasi-221 002.

Dated : 15 November, 2015

MESSAGE

I am delighted to know that the Centre for the Study of Regional Development of the Jawaharlal Nehru University, New Delhi is organizing the XXXV International Congress of the Indian National Cartographic Association (INCA) from 15th-17th December, 2015. Considering the priorities in front of the nation, the topic has been rightly chosen as Spatial Governance for Development, Planning Smart Cities and Disaster Management. Several nation-wide projects have been identified recently including Digital India. Hence, this is an occasion for Cartographers to contribute towards the multi-dimensional goals. I am sure that the participating cartographers will make full use of this event in order to work out a strategy in this regard.

As a former President of INCA, I am pleased to see that this expert body has been continuously contributing towards professionalism in Cartography. There are challenges in terms of endlessly finding new roles; and opportunities, in the form of jump in technology. The combination of both has been responsible for refocusing our objectives and goals.

I am sure that this international event would be a great success.

(Prithvish Nag)
Vice-Chancellor

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XXXV INCA INTERNATIONAL CONFERENCE, NEW DELHI

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Prof. Anuradha Banerjee

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THEME AND SUB-THEMES

The **main theme** identified for XXXV INCA International Congress was**"Spatial Governance for Development, Planning Smart Cities and Disaster Management".**

The XXXV INCA International Congress was focused on several sub-themes.

1. Recent Trends in Cartography for Development Planning
2. Spatial Aspects of Governance for Urban Local Bodies
3. Geo-Spatial Technologies for Planning Smart Cities
4. Cartography for Population, Environment and Development
5. Geo-Spatial Approach and Regional Development
6. Cartography for Disaster Management
7. Geo-Spatial Technologies for Sustainable Tourism
8. Natural Resource Monitoring and Management
9. Rural Planning and Decentralisation
10. Mountain Cartography
11. Geo-Spatial Technologies for Defence, Conflict Resolution and Human Development
12. Mapping Social Exclusion and Discrimination
13. Cartography Education and E-Learning Courses
14. Historical Cartography
15. Web Maps and Atlases

PROGRAMME SCHEDULE

Date	Time	Event	Venue
15 Dec 2015	10.00-11.30 hrs	Inaugural Function	JNU Convention Centre (Main Auditorium)
	11.30-12.00 hrs	Inauguration of Exhibition And High Tea	
	12.00-13.15 hrs	Todar Mal Memorial Lecture	
	13.15-14.15 hrs	Lunch	
	14.15-16.00 hrs	Plenary Session I	
	16.00-16.30 hrs	Tea	
	16.30-17.30 hrs	Prof. S.P Chatterjee Memorial Lecture	
	18.30-21.30 hrs	Cultural Programme and Dinner	
16 Dec 2015	10.00-11.15 hrs	Technical Session – 1, 2, 3	Lecture Hall 1, 2,3
	11.15-11.30 hrs	Tea	
	11.30-13.00 hrs	Technical Session – 4,5,6	Lecture Hall 1, 2,3
	13.00-14.00 hrs	Lunch	
	14.00-15.15 hrs	Technical Session – 7, 8, 9	Lecture Hall 1, 2,3
	15.15-15.30 hrs	Tea	
	15.30-17.00 hrs	Technical Session – 10, 11, 12	Lecture Hall 1, 2,3
	18.30-21.30 hrs	Cultural Programme and Dinner	Main Auditorium
17 Dec 2015	10.00-11.15 hrs	Technical Session – 13,14,15	Lecture Hall 1, 2,3
	11.15-11.30 hrs	Tea	
	11.30-13.00 hrs	Technical Session – 16,17,18	Lecture Hall 1, 2,3
	13.00-14.00 hrs	Lunch	
	14.00-15.00 hrs	Plenary Session-2	JNU Convention Centre (Main Auditorium)
	15.00-16.00 hrs	Presentation of Conference Proceedings and CLOSING FUNCTION	
	16.00-16.15 hrs	High Tea	
	16.15-17.15 hrs	ANNUAL GENERAL BODY MEETING	

CONFERENCE PROCEEDINGS

The XXXV INCA International Congress was organised by the Centre for the Study of Regional Development (CSRD), Jawaharlal Nehru University (JNU) under the aegis of Indian National Cartographic Association (INCA) from 15-17 December 2015 at the Convention Centre, JNU. The theme of the Congress was centred on ***"Spatial Governance for Development, Planning Smart Cities and Disaster Management"***. The congress was spread over three days and witnessed some great deliberations, exchange of academic views and brainstorming. Overall, there were 15 technical sessions, 2 plenary sessions and 2 panel discussions. Over 500 participants registered in the Congress representing various organizations such as JNU, DU, IIDS, Survey of India, NRSC, Inland Waterways, NRDMS, Disaster Research Programme, Census of India, National Hydrographic Office, Power Grid, Gas Authority of India (GAIL), Jadavpur University, Ranchi University and many others. There were over 250 papers and poster presenters.

Inaugural Function

The inaugural function was chaired by Prof. K Kasturirangan, former head, Indian Space Research Organisation and Chancellor, JNU. It commenced with the lighting of lamp and inaugural song by CSRD choir. The welcome address was given by Prof. Prasenjit Sen, Rector, JNU and the conference theme was introduced by Prof. Bupinder Zutshi, Registrar JNU. Presidential address was given by Prof. Anuradha Banerjee, President, INCA. This was followed by the presentation of INCA map quiz prizes and release of the souvenir. The keynote address was given by Shri. C.K Mishra, MoHFW; followed by addresses by Shri. R.M Tripathi Surveyor General of India; Prof. Sachidanand Sinha, Chairperson CSRD, JNU; Shri.A.K Singh, Secretary General of INCA and the Chief Guest Prof.Kasturirangan. The function ended with vote of thanks by Dr.Nandita Saikia, CSRD, JNU.

Special Lectures –Todarmal Lecture and Prof.S.P. Chatterjee Lecture

The inaugural function was followed by special lectures namely the Todarmal Memorial Lecture given by Prof. László Zentai, Secretary General, International Cartographic Association which focused on modern cartography according to ICA and Prof.S.P Chatterjee Memorial Lecture, delivered by Dr.Prithvish Nag, Vice Chancellor, MG Kashi Vidyapeeth, Varanasi, which focussed on the development of thematic cartography in India. Prof. Zentai's lecture elucidated the requirement of integrated interdisciplinary approache from domains such as information technology, communication science, human-computer interaction, telecommunication sciences, cognitive sciences, geospatial information management and cartography for the successful development of the subject. He spoke about the need for interdisciplinary approaches which ensure human-centred application in a highly volatile technological framework. A number of important technology-driven trends have a major impact on what and how we create, access and use maps, create previously unimaginable amounts of location-referenced information thereby placing cartographic services in the centre of the focus of research and development. The paper therefore focused on the information technology background of this process and the effect of development on cartography and the International Cartographic Association itself.

Dr.Prithvish Nag's lecture illuminated on the contributions of Prof.S.P Chatterjee in the realm of cartography and evolution of NATMO. He spoke about the journey of the preparation of the National Atlas of India. Prof Chatterjee considered models of several countries in order to develop the National Atlas Organisation in particular and thematic cartography in general in India. Some of these were: (a) French National Atlas model of bringing out a national atlas of the country for the first time with German map calligraphy (Royal German Hand Atlas); and (b) On the lines of the institutes of the then socialist countries to establish an Institute of Geography. In the later case, the Institutes of Geography in Socialist Block were not entrusted with the preparation of National Atlases. Further, the Institutes of Geography were established under the aegis of the Soviet Academy of Sciences and Polish Academy of Sciences. Professor Chatterjee chose to integrate both the approaches, i.e. to have an Institute of Geography entrusted with the preparation of the National Atlas of India. In fact, National Atlas Organisation was tilted towards the East European model of the Institutes of Geography where the cartographic exercise was driven by geographical researches.

Plenary Session I and II

Plenary Session I

Plenary session I was titled **"Emerging Trends in Cartography and Geo-spatial Techniques"** and was attended by eminent scholars and chaired by Shri.P.G Diwakar. Prof.Saumitra Mukherjee, suggested that Neotectonic activities not only influence the landform but it has the potential to change the water resources. In his study, he has used multispectral/multidate satellite data to show the changes in the surface water as well as groundwater in tectonically active terrain. A detailed investigation has been carried out since last two decades in and around parts of Haryana-Delhi-Noida-Ghaziabad area to infer the changes in lineament, length and density and its correlation with ground water quality. Microtremor data from IMD, USGS as well as Jawaharlal Nehru University Broadband Seismic Observatory has been incorporated. Groundwater samples from the active fault of representative areas were collected. High spatial resolution satellite data (CARTOSAT) and medium resolution (LANDSAT) has the potential to infer the structural lineaments and its spatial distribution. He concluded that ground water quality is related with seismically active terrain and national land use be drafted in tandem with rain water harvesting.

Prof.Al. Ramanathan through his study elucidated that Chhota Shigri Glacier (probably the Lahaul and Spiti glaciers also) is losing mass, though less rapidly or quite similarly like mountain glaciers in other parts of the world. He suggested the long term monitoring of the issue to minimize the error.

Dr.Baisakhi Sarkar elaborated on how the technological revolution in cartography has opened up new dimensions and has improved phenomenally its potentialities for effective use in solving complex natural resources and social planning problems. She emphasized that cartography is not a dying subject, rather plays key role in meeting societal needs in real time. Digital cartography, geo-information technology, geo-web services, mobile based application programmes, cloud computing, DEM, Health GIS, web maps and micro level planning were the thrust areas of the presentation.

Dr.Milap Punia talked about Geovisualisation or geographic visualization, approach through which maps and graphics are used to gain insight from geographic information. He pointed out the challenges of visual representation of landscape, paper maps and linkages among geography, GIS and visualization.

Dr.D.K Mandal elaborated on the denudo-structural hills of the Siwaliks and Pre-Tertiary rocks and residual hills of old Doon gravel form. He deliberated on targeting and management of ground water resources by using remotely sensed digital data and GIS tools in Doon valley. The study mainly focused on the delineation of dugwell sites, ground water potential with groundwater prospects map through GIS and cartographic tools.

Dr.Padmini Pani showed that modern technology is very essential to quantify and map the inaccessible terrain like Chambal Badlandsand helped to understand the changing spatial dynamics and its long term implications. She pointed out the issues on land degradation and human interference in nature.

Plenary Session II

Plenary Session II was titled "**Future trends in Cartography and Geo Spatial Techniques for Development**". The first lecture was delivered by Prof. Vibhash Chandra Jha focused on the pure and applied aspect of cartography, conversion of paper maps to digital maps. The historical perspective of cartography was explained along with NATMO's and Prof.S.P Chatterjee's contribution in the field of cartography. He spoke about District Mapping projects; satellite data interpretation, field work and planning maps preparation. Dr. Shefali Aggarwal described the trends in 3D modeling, depth perception. Measuring topography and monitoring its changes has a bearing on understanding physical-biological-chemical processes that shape our planet. She also mentioned that for assessing climate change updated information is required. She mentioned image based, range based techniques and surveying methods. There is emerging opportunity in NASA –ICESAT 2 for ice cloud and hard elevation satellite. Dr. PS Acharya said that the future is based on GIS data. He also mentioned the advantages of cyber cartography where one can have maps which produce sounds. NSDI and NGIS were more focused on processing; there was a need to make these data available to the general public easily. Prof. Atiqur Rahman spoke about the evolution of International Cartographic Association. Production of topographical and thematic maps is an important discipline in today's digital India. Maps are being used in every field, be it the health sector (Health GIS) or any other field. Dr. S. Sreekesh also advocated the use of cyber cartography and said that cartography is moving from the static to the dynamic realm. He mentioned that cyber cartography and GIS allowed the integration of data from various sources, one can change the content easily. The future would be of 4D maps where time based conditions would also be represented on the maps. Dr. Dipendra Nath Das expressed concern that innovation in cartography has seized. There was limitation in software application. For example migration flow is missing. There was also monopoly of data which was hindering easy access and use of data. There is a need to connect the society and technology.

Technical Sessions

Technical Session I

The session on **Recent Trends in Cartography for Development Planning (Technical Session I)** was chaired by Prof. Atiya Habeeb Kidwai and had papers covering diverse topics within the broad ambit of the sub-theme. The first paper attempted an investigation into the application of the integration of remote sensing and geographic information systems (GIS) for detecting urban growth and assessing its impact on surface temperature in the region. The analysis tried to show that higher temperature in the urban heat island is located with a scattered manner due to the change of land use pattern and urban growth. In this study, four Indian cities were taken into consideration and they showed different dimensions of Indian cities. Among them, Kolkata and Delhi were mega cities, Chandigarh was a planned city and Ranchi was an upcoming big urban agglomeration. The next paper attempted to estimate the Land Surface Temperature of Thiruvananthapuram City Region, Kerala, India. The output revealed promising results with higher heat signatures in the core of urban areas and lower heat signatures in the outer portions of the urban areas. Another paper elucidated how new technology for mapping can be made inclusive for small towns where the case study of Ballarpur was cited. A sample survey was done to understand the user aspirations. One study tried to indentify the spatial dynamics of urban green spaces in Delhi National Capital Territory and its surrounding area through Linear Spectral Unmixing (LSU) technique. The study showed that green areas in Delhi NCT region experienced positive growth during 1977 to 2014. The process of urbanization did not affect the ridge forests much and some of the green pockets remained unchanged. In fact, the green areas had become greener due to afforestation, densification and proper maintenance of forests and parks. The session also had a paper assessing the relative position of the Kolkata Urban Agglomeration in the backdrop of the other million plus cities in India since the beginning of the twentieth century till date thereby addressing its loss of vibrancy in the Indian urban cartographic space. One of the papers attempted to study the spatial expansion of Kochi city focusing on the changes in the built-up and other land forms over a period of 3 decades and its relation with the socio – economic changes of the city. A study on preliminary data analysis of IRNSS FORPNT services was also shared. One technical paper brought out the details on the exercise for the evaluation and comparative study on C2 DEM & orthoimage thereby revealing that product accuracy better than 3m can be achieved. Another paper described the in-house developed specialized software tools which are used to ensure high quality of CartoDEM during the process of DEM generation. The broad recommendations emanating out of the session included advocating the use of land surface temperature for delineating urban heat island, use of remote sensing and GIS for studying urban expansion.

Technical Session 2

The session on **Spatial Aspects of Governance for Urban Local Bodies (Technical Session 2)** was chaired by Prof. Milap Punia and had some very interesting papers. One paper questioned the objectivity of maps and showed that maps are also a result of perception. The study used city of Kolkata as a case along with data provided by the Census of India (2001 and 2011) and brought together the flipsides – the city and the urban, a city dweller and a cartographer, choropleth maps and mental maps. A paper on study of patterns in private sector involvement in urban water supply in India discussed the paradigm shift in public piped water supply across cities in India emphasising the need to have a strong institutional and regulatory framework in order to cater to the needs of the poor. It described the underlying factors concurrent with the prevalence of public private participation in urban water supply in different states of India. Two of the presentations covered disparity in basic facilities in urban cities such as Barasat town of Kolkata and Jaipur and social groups of Jharkhand state and were analysed with statistical techniques and GIS mapping techniques. Another paper explored the various techniques by which food can be mapped into urban areas including food sheds, production and processing zones, supply and distribution of essential food items, food deserts and food walks with a case study of Chandernagore Town in West Bengal, India. The paper also looked into the possible applications of food mapping for urban planners, municipal bodies as well as citizens for changing existing towns into flourishing all inclusive, resilient and convivial smart cities through planning aided by maps in a GIS environment. Another paper elucidated the risks of natural calamities and reasons for why natural disasters have increased in urban cities citing the case of Bhubaneshwar city.

GIS based analysis of hazard maps and climate change maps were prepared along with proposed development zones to understand the risk potentials to suggested development zones. It was observed that the master plan emphasizes heavily on economic growth and have largely overlooked disaster risk and climate change impacts while defining future development zones. Another presentation paper related urban growth and inequality over different size class cities in Maharashtra. The main objectives of the study were to trace the status of basic amenities in the Mumbai Urban Agglomeration, to analyse the inter-city variation in the access to basic amenities in the state of Maharashtra, to assess the levels deprivation in terms of basic amenities over different size class cities of Maharashtra, examine the changes in the level of deprivation in the year 2001 and 2011 and to bring about an association of urban growth with that of the change in the level of deprivation. Recommendations of this session included a need to question the objectivity of maps, to use GIS mapping techniques for efficient mapping of social facilities and the role of GIS in building disaster resilient cities.

Technical Session 3

The session on **Geo-Spatial Technologies for Planning Smart cities (Technical Session 3)** was chaired by Dr. Shahnaz Parveen and was very topical. The first paper underlined the scale and pace of changing trends in urbanisation due to ongoing urban revolution with special reference to census towns. It also examined the trends and spatial patterns from the perspective of the notion of 'subaltern urbanisation'. Another paper outlined the conceptual model for the development of urban green space in Bhubaneswar city. In this study, based on the high resolution remote sensing images and other auxiliary data, a suitability analysis for the city of Bhubaneswar was done with the support of GIS technology. The study began with the analysis of Land use and Land cover and its change over time, quantity and availability of urban green spaces, changes in green spaces, and suitability analysis for green space development. A study presented the theoretical perspective on the smart cities and analysed how cloud computing focused on big data management can help in making the city smarter. Another paper studied different forms of exclusion within Indian cities in the competition to become smart cities. With the help of mapping various forms of social exclusion across selected cities, it was an enquiry into whether these competitive reforms in urban development take cognizance of the idea of balanced urban growth for all. A study on the nature of urban spatial growth of Jaipur city showed that using Shannon's entropy, the city had grown in a dispersed form till 2000 and thereafter it had shifted to compact form of urban growth. The results of dasymetric mapping also reflect the two different patterns of population growth in last decade. De-urbanisation or negative growth in the interior, congested and older areas while high urban growth and spatial expansion in the exterior areas. Another paper investigated the development and shortcomings in the newly developed areas of Indore from the sectors of transport, energy, health care, water and waste water and factors using GPS, ground survey and other digital technologies to assess the feasibility and time bound implementation potential. Further the paper assessed the potential and challenges for the city to be developed into the projected smart city. Another paper elucidated the concept of smart city and highlighted the shift in administrative procedures and governance structures to accommodate the modern needs of involving citizens extensively in building these cities, not only literally but also figuratively. Another paper highlighted the importance of Spatial Data Infrastructure (SDI) for instantaneous context aware services for geospatial community and its key role in / smart cities. In another presentation described the importance of participatory models for the successful implementation of smart cities were considered. The last paper described the importance of geo-spatial technologies for planning smart cities. It advocated the preparation of Digital Master Plans to improve efficiency and capacity of city services. What emerged was that though there is no common consensus regarding the definition of smart cities but sustainability is the key word in establishing such cities. Such cities necessarily aim at providing the basic infrastructures to the citizens for improving their lifestyles make citizens aware and involve them in decision-making and future planning. The concept of smart cities initially started with the definition of garden cities. Retrofitting, redevelopment and green field development are the three strategies adopted for the development of smart cities. From this session it could be concluded that present cities needs to get smarter to handle the growing complexities of increasing urbanization with disaster resilient infrastructures, proper water, waste and traffic management and having a system of emergency e-governance. The geo-spatial technologies like cloud computing, digital data and internet are essentially an aide to this.

Technical Session 4

The session on **Cartography for Population, Environment and Development (Technical Session 4)** was chaired by Prof.Sudesh Nangia and had excellent diverse papers within the ambit of Population, Environment and Development. One paper by young research scholar showed that while the playgrounds exist as before, they are devoid of children with Barrackpore as the case study. The study attempted to find the pattern of shrinking of open space; to identify the areas that are served by the existing playgrounds and to identify leisure time activities of the urban children. Another study attempted to understand urban sprawl in Thiruvananthapuram City Region (1980-2015) using satellite images of different periods 1980, 1990, 2000 and 2015 which were processed in Arc GIS 10 and ERDAS IMAGINE 9.1 to analyze change detection during the last thirty five years. It was noticed that Thiruvananthapuram city is developing multiple nuclei of urban growth. A study from Kochi identified the phases of urbanisation and direction of growth. Another study aimed to calculate the pace of urbanisation of Kolkata city and demarcated its suburban areas with the expansion of the city. The study revealed that the pace of urbanisation is more rapid in southern part of Kolkata rather than the northern part and more specifically it was seen that the rate of urbanization is very high in south eastern and south western parts of Kolkata.

A paper on the disability divides demonstrated that the burden of disability falls disproportionately across geographic regions and socio-economic groups; therefore, the design of public health policy should be specific to regions and groups. Another paper on TB prevalence showed that living standards, place of residence, absences of windows and electricity in the households are the factors associated with the TB Prevalence. A study on Maternal Mortality demonstrated that rural women in Manipur have underutilized maternity care despite government initiatives to reach out to pregnant women in all parts of the country to provide all components of maternal health care free or with nominal charges. Apart from women's literacy, economy plays a significant role for institutional delivery and delivery assistance by health professionals in far-flung remote villages.

Technical Session 5

The session on **Geo spatial Approach and Regional Development (Technical Session 5)** was chaired by Prof.Sachidanand Sinha and was very interesting. The first paper was a study on the preparation of a Land use capability map for the midlands of Kannur district using various thematic maps namely slope map, land irrigability map, soil depth map, soil drainage map, soil type map, surface soil map, soil texture map, erosion map. A study on determinism showed how geomorphic terrain, relief variation, average gentle slope formation, river bank erosion, geomorphic flood and water logging, Geomorphic drainage alignment determine change of agricultural practice and pattern. Mainly food crops field has been highly converted and changed to commercial crops field. Another paper discussed the spatial distributions of social facilities and analysed the magnitude of regional disparities at inter block level of Barddhaman district. The paper revealed that the social disparity is more prominent with respect to health facilities than educational facilities. One interesting paper demonstrated that (Under) development process is extremely fractured and complex and it can be due to various factors. The case study of Mewat was taken. The findings revealed that socio-demographic structure was characterized by unbalanced age-sex composition, high dependency ratio. The percentages of illiterates far outnumbered the percentage of literates. Employment status of the population was heavily biased in favour of the out of labour force population while casual labour and unproductive workforce abound greatly. One study showed the inter district and intra district variation in development across different districts in the state of Telangana. The study relates to disparities in various indicators of agriculture, irrigation, industrial, infrastructure and human resource development. The analysis was done by comparing averages for various development indicators from 1981-1982 and 2011-12 to compare the inter-district and intra-district inequalities in Telangana. On the basis of these indices, the paper classified the different districts and sub districts of Telangana into very backward, backward, developing and developed categories using GIS and other cartographic Techniques. Another paper attempted to provide a scheme of regionalisation of social exclusion and deprivation on the basis of multidimensional deprivation of households across the districts by considering household dwelling characteristics, access to basic services and available assets within the households by mining 2011 Census data. The frame work suggested that the households deprived of good housing conditions and basic amenities are also mostly asset poor as the previous facilities are essential for healthy and productive man power to create asset. In all the study indices, the districts in the *Empowered Action Groups* states (EAG) were found to be worst performing. The western and southern states and their districts are best performing in all the indices. Intra-state disparity is the highest in Maharashtra with both the best and the worst category of districts. It is the lowest in Kerala where all the districts are in lowest deprivation category and in Bihar where all the districts are in the highest and high deprivation category. Another interesting study showed that land use change is accelerating throughout southern India and is the cause of many environmental problems. The case study was of Kallada river basin. A study on land use projection model showed the future direction of urban growth in sonarpur block giving an estimation of the total amount of cropland lost so that proper land reclamation measures and suitable land management policies can be taken at a prior stage. This paper mainly tried to project the future land use pattern of the concerned study area using the Land Transformation Model (LTM), which analyses the driving factors of land use changes and its impact on the economic and ecological integrity of a region.

Technical Session 6

Session on **Cartography for Disaster Management (Technical Session 6)** was chaired by Dr.Narayan Chandra Jha and provided interesting insight in the myriad ways in which the use of remote sensing and geoinformatics can be used for predicting as well as mitigating disasters. A paper focussed on the relationship between hydromorphological environment and inundation in the Moyna basin. His findings revealed the maximum susceptibility of the central Moyna basin to inundation and that a 2- meter rise in sea level would lead to the entire basin being submerged under water. Another study mapped the susceptibility of Hamren sub-division in Karbi Anglong district to landslides and found that the distribution is scattered though the eastern part of the area is relatively less susceptible due to its relatively flat terrain and dominance of paddy cultivation in the area. Spatial distribution of different landslide susceptibility zones showed a normal distribution as predicted. One study traced the role of a flood in ancient times to the emergence of the present city of Vadodara and has shown that the present city is still susceptible to flood events which are largely due to unplanned urbanisation which has had an impact on the hydromorphology of the area. There is a need of considering the topology of an area while town planning. Another study showed that the river course of Subarnarekha has shifted and the study identified zones which are more susceptible to major bank shifting which can be helpful in preventing disasters. One study modelled the flood relief camp sites in Dhemaji in Assam based on four important factors viz. elevation, slope, river networks and road networks. Another paper has mapped the flood-prone and agricultural drought-prone areas in Kannur district using four parameters and found that the percentages of flood-prone towns in the district has increased in the last four decades. Simultaneously, agricultural drought –proneness of certain areas such as Kankole-Alapadamba has increased. Another interesting paper on theoretical cartography, pointed out the role of hue value and chroma in better communicating the meaning of maps depicting disaster-proneness of an area and has rightly emphasized on the need to focus as much on the "art" of map-making as the science behind map-making.

Technical Session 7 (Panel discussion)

The **technical Session 7** was dedicated to a **panel discussion on Gender Atlas**. The session was chaired by Prof.Saraswati Raju. The panelists were Prof. Sucharita Sen, Dr. Bhaswati Das, Dr. Neetha N and Dr. Mallarika Sinha Roy. It came to the fore from this panel discussion that the Gender Atlas launched on 23rd November 2015, is essentially an effort to bring out various socio-economic and demographic components of population segregated by men and women, boys and girls through the visual media of maps. It is primarily based on the Census data though data from other governmental sources are also taken into account. The atlas contains six broad sections under the heads of population and demography, literacy and education, livelihood and employment, marriage, health and well-being and social and political environment. A separate section highlights on the gender vulnerability index. The maps in this Atlas are accompanied by interpretative texts and the language used is mostly non-technical to ensure its usage by a wide range of users from different fields. In this discussion, the overlap of the quantitative and qualitative approach in feminist research was brought to the fore. At the same time, the problems associated with gender statistics were also discussed.

Technical Session 8

The session on **Geo-spatial Technologies for Sustainable Tourism (Technical Session 8)** was chaired by Dr.S.Sreekesh , the session was comprised of very interesting papers. The first study showed the effect of change in land use and land cover on bird sanctuary. The study was focussed on Kulik bird sanctuary, West Bengal. This paper attempted to monitor the habitat of seasonal migratory birds using remote sensing and GIS techniques. NDVI, NDWI, Tasseled Cap Transformation upon Landsat Data and MODIS NDVI temporal analysis were adopted to detect land use change. The primary focus of the paper was on mapping and monitoring of nesting zone, the detection of land use & land-cover changes, mapping of wetland zone for birds food collection, mapping eco-park zone and determination of ban period to tourists.Land use & land-cover changes,especially of the built-up zone,are gradually increasing around the surroundings of the sanctuary causing habitat threats. The next study particularly focused on tourist maps for Rajasthan. Travel companies and customers are equally interested in reliable and detailed maps, whether on water, land or air. Detailed maps for travel guides, city maps or wall maps must be drawn manually in precision work. Tourist maps are essential resources for tourists in an unfamiliar city because they visually highlight landmarks and other points of interest such as museums, restaurants, parks, and shopping districts. The most effective tourist maps are carefully designed to present this information so that they can easily navigate to the places they are most interested. The study suggested that tourist maps can be divided into three groups: general tourist maps, specialised tourist maps and thematic tourist maps. Another study showed that the potentiality of ecotourism depends on a number of natural as well as cultural factors such as, relief, altitude, slope, aspect, drainage, forests, accessibility and population. A case study of Nainital district was taken. One paper attempted to investigate the scope of geospatial technology for ensuring sustainability of tourism industry in the Indian Sundarbans. The recent dispute over the closure of a number of resorts in Indian Sundarbans by the order of

West Bengal Pollution Control Board generates the immediate necessity for application of geospatial technology in search of suitable project sites. A web based GIS environment is required to be created in the public domain for satisfying the queries of stakeholders. The present closure incidents not only affect the entrepreneurs but also the local people and the rural economy because tourism provided them alternative livelihood to fight against poverty. The study attempted to utilise GIS for delineating suitable sites for tourism activities. The next paper explored the relationship between trajectories of forest-cover change and fragmentation with the physical and social characteristics of the landscape in Sariska Tiger Reserve. To assess the spatial- temporal variation of forest cover, Landsat TM data across three dates (1989-1994-2014) were used. Extent and pattern of forest degradation has been examined with the help of fragmentation model. The fragmentation statistics revealed a significant degradation of forest health. There has been a significant increase in perforated, edge and patch classes of forest while core area has decreased at the expense of other fragmentation classes. Fragmentation around 1 km buffer area of villages, roads, and pilgrimage centre has shown human interference in degrading and fragmenting the forest. In another study, GPS compatible maps were shown how they can be effective in the Sinhastmela in 2016 in Ujjain.

Technical Session 9

The session on **Natural Resource Monitoring and Management (Technical Session 9)** was dedicated to NRDMS, DST, GoI and was chaired by Bhoop Singh. It was enlightened with papers on natural resource monitoring, land use change in ecologically fragile areas, groundwater level assessments, soil analysis, forest health analysis, a study on wetlands and water shed. One paper highlighted the importance of natural resource monitoring using remote sensing techniques. Another study analysed the temporal land use and land cover change using geo-spatial technology tools in order to understand the trend of land use/land cover changes of this ecologically sensitive village in Kannan Devi hills. The data base used for the analysis were Survey of India Toposheets 1920-21 (1:63360), SOI-Open Series Maps published in 2010 (updated 2005-2006) and latest Geo-Eye Satellite data with a spatial resolution of 0.5m. Common Ground Control Points (GCPs) with WGS 84 Datum have been established using Dual frequency Global Positioning System (DGPs) for image registration. The digital database was integrated in a GIS platform. The land use / land cover vector data generated using ArcGIS software for the study area is categorized into 15 classes. The results show that during the last nine decades settlement area has considerably increased and there is a decline in natural forest area. Rocky surface / Rocky cliff area have also been exposed due to erosion in highly undulated fragile terrain and which reduced the growth of natural grass. There was no Eucalyptus plantation in 1920s but at present there is 16 percent of total Geographical area of KDH under Eucalyptus planation. The paper on groundwater utilisation attempted to analyze the correlations between the physiography, geomorphology, geology, hydrogeology, soils, climate and land use - land cover of the region with the groundwater zones. The present level of groundwater utilization in the district was mapped. Amount and quality of groundwater extracted, the levels of groundwater abstraction development block-wise are examined along with different types of mechanical structures related to this. The nature of groundwater level fluctuation throughout the district at the Block level, in the Pre-Monsoon and Post-Monsoon season is also depicted and the long term of the peizometric surface behaviour analysed from these maps. The study demonstrated that northern and southern reaches of the district are seemingly poorer off than the central and western parts in the Puruliya district. The study on soil analysis examined soil, geomorphology and land use characteristics of landscape constituting Sarkara watershed of Vamanapuram river basin in order to understand the existing land use and its degree of correspondence with its inherent potentiality. The paper showed that the influence of anthropogenic factors is more prominent than that of either geomorphology/soil characteristics of the landscape constituting the watershed. In another study, the forest canopy density model was used for examining spatial-temporal variation in canopy closure and validated forest health through fragmentation model. The forest canopy density model was used for examining spatial-temporal variation in canopy closure and validated forest health through fragmentation model. Forest canopy density and fragmentation maps were generated using Landsat TM satellite data during 1990-2011.The study demonstrated usefulness of remote sensing derived forest canopy density and GIS based fragmentation. Another paper was a study about the degradation of wetland ecology of *Anjana*, an abandoned river channel which is a floodplain wetland situated in *Krishnanagar town*, of Krishnanagar1 block of Nadia district in West Bengal. The primary objectives of the study were to analyze the impact of loss of this wetland on the surrounding environment and to suggest measures for conservation of this fragile ecosystem. The research work was based on modern methodology including GIS and Digital image processing techniques as well as intensive field work, sample survey and collection of primary data. The last paper was a study on the water resources monitoring and management using advanced geospatial technology of Arakhasa Watershed In Bankura and Puruliya

Districts,West Bengal. The villages of the study area were found to be fast heading towards a water crisis. Most parts of the area have traditionally relied on local rainfall for meeting the water requirements for drinking, washing and other purposes and for agriculture. Water shortage is likely to be so acute that in the future, conflicts may arise regarding sharing of water resources among various villages.

Technical Session 10

This session on **Rural Planning and Decentralisation (Technical Session 10)** was chaired by Rabi N Sahoo and revolved around the importance of rural planning and decentralisation. A number of papers were directed towards the study of changing agricultural sector and its implications. One Paper explored the agricultural situation and socio-economic condition of peasants in Rajputana under the feudal state. There were no tenancy rights and farmers were over burdened with many taxes, cess and *'begars'*. The study was an attempt to assess the agricultural situation and socio-economic conditions of peasants in Rajputana. Princely state wise historical data on land system, agriculture, and population for the years 1900-01, 1930-31 and 1950-51 were analyzed. To show status and trend various parameters viz. land tenure and land revenue, land use, irrigation, cropping pattern and demographic aspects were worked out. Historical maps were interpreted and with the help of recent maps, various thematic maps showing above aspects were prepared. Cropping pattern, land tenure system and agricultural situation were traced over a time span. Another study demonstrated the utility of Natural Resource management for rural development of Gaighata block in North 24 Parganas. A case study of Bijnor district analysed the crop system efficiency using Landsat images of Kharif and Rabi seasons. To formulate the optimum cropping pattern within an agro-ecological region, up-to date information regarding present cropping pattern and changes in cropping pattern in a region is a pre requisite. Multi-date satellite data from the Indian Remote Sensing Satellite (IRS)-P6 LISS III was used for the generation of the cropping pattern and crop rotation during Rabi and Kharif seasons in Bijnor District. Multiple cropping index (MCI) and cultivated land utilization index (CLUI) were used to assess the efficiency of the systems. A total of 17 cropping patterns were identified and mapped in the study area. The study revealed that nearly 79 percent of the total geographical area was devoted to net cropped area. Among the various cropping patterns, sugarcane as a single crop, rice-wheat, and sugarcane-wheat were the major crops occupying about 33 percent, 11 percent and 8 percent of the total geographical area of the district respectively. In the next paper, it was shown that Geospatial technology can be good source of fulfilling the need of farmers as it can assist in building resilience to hazards, in identifying geographical hotspots like land degradation, crop damage, change of land use, condition of ground water and can aid in sustainable land management and risk assessment. A study on caste hierarchies and access to agricultural land in a village in Murshidabad district showed that there is a hierarchical pattern which is established across the castes groups in an unfavourable geographical condition. In ownership holding, upper castes own maximum proportion of the land in the selected village.

Technical Session 11

The session on **Mountain Cartography, Cartography Education and e-learning Courses (Technical Session 11)** was chaired by Prof.Milap Chand Sharma and had diverse papers. The study on NATMO's contribution in mountain cartography demonstrated that NATMO as a pioneer mapping organization contributing in the field of Mountain Cartography through the following publications: a) DPMS to emphasis the planning aspects, b) GMS signifies the mapping of the urban nodes, c) adventure Tourism & Tourist maps emphasize the special tourist attractions and connectivity and d) Geomorphological, Geological, soils, Natural hazard zonation. NATMO has prepared District Planning Maps for all the four districts of Sikkim – North, South, East, and West. NATMO has published a map of 'adventure tourism-Sikkim & Darjeeling' to promote tourism in this hilly stretch. In another study, a comparative study of satellite based estimated rainfall data with rain gauge data over Himalayan river basin of India was done. Another paper focussed on the volley of technological advances bearing on the whole range of spatial sciences in the late 20th century. The session also had a paper to study the changing nature of the uses of various mode of electronic mode communication in Jammu and Kashmir. An important technical recommendation comprised seamless integration of Glacier 3-D mapping with the Climate data and Land Surface Temperature (LST) which would help in accessing the present glacier sensitivity to climate, as well as help model future scenario more accurately for robust management of this finite resource.

Technical Session 12 (Panel Discussion)

The **technical session 12** focussed on the **Disaster Research Programme, JNU** was chaired by Dr.P.K Joshi and highlighted on the study of disaster in space and time. Significance of technological developments which are used as an important tool to address issues pertaining to the warning systems was put on the table. The study on coastal vulnerability from a global perspective was covered. It was also emphasized that importance was laid on natural disaster and that less significance is laid on the consequences. Perception and adaptation to the challenges of climate change in the case of coastal community of Jamnagar city regions was also discussed. Bhuwan site was demonstrated and how it can be harnessed for disaster mitigation.

Technical Session 13

Technical Session 13 dedicated to **Cartography for Population, Environment and Development** (II) and chaired by Prof. Aslam Mahmood and co-chaired by Dr. Nandita Saikia had paper presentations addressing a wide range of topics covering pertinent issues of use of cartography in studying climate change, in crime mapping on one hand and understanding the population dynamics on the other. The first paper came up with valuable suggestions on how availability of medical facilities could be mapped and how access to health facilities could be determined. Another presenter through his study tried to bring out the ecologically fragile landscape of Sunderban and vehemently questioned the ongoing debate of the economy vis-à-vis environment. One study tried to address the population dynamics and the livelihood issues of the tribal areas adjoining the Sardar Sarovar Dam. Another study tried to focus on the fact that cartography could be used as a tool to address the issue of demographic ageing. A paper on Crime Mapping also strengthened the fact that geo-spatial techniques has evolved as a useful tool in recent days in solving a wide range of problems.

Technical Session 14

Technical Session 14 dedicated to **Mapping Social Exclusion and Discrimination** was chaired by Prof. Sanghamitra S. Acharya and co-chaired by Dr. Vinod K. Mishra. The session had paper presentations dealing with various issues of social exclusion and discrimination. The session had an interesting blend of papers touching India from all the cardinal directions. Paper on Kerala's shifted spaces highlighted on the Christian Dalits who still remain under shades of dispossession. From the North, presentation on the sex workers in Delhi red light area highlighted on the plight of these women and the bondage of stigma which they experience every day even in old age. Presentations from Assam and Odisha revealed the aspects of social exclusion of the lower echelons of social groups and their continuing inequalities and how exclusion is taking place in the region promoting uneven development. The presentation was on the importance of GIS as a tool to bring out the public participation in building social infrastructure in Mumbai. How houseless population succumb to lifestyle risks and morbidity by consuming addictive substances resulting in exclusion from the mainstream society was also addresses in the session. The session ended with the presentation on the importance of the affirmative action in the form of reservations is needed to bring down the continuing disparities especially in employment.

Technical Session 15

Technical Session 15 dedicated to **Natural Resource Monitoring and Management** (II) was chaired by Prof. Sucharita Sen and co-chaired by Dr. Lubna Siddiqui. The session had paper presentations addressing issues of a wide variety of geographical landscapes like desert, mangroves, river basins, mountain slopes and forest areas. The papers in the session focused on wide ranging aspects of using geo spatial techniques in identifying land use pattern in desert areas of the Thar and a detailed appraisal of mangrove ecosystem in the Sindhudurg Coast of Maharashtra. One paper highlighted on the Assessment of ground water recharge in the Barddhaman district of West Bengal. Another study tried to emphasize on the integrated Geo spatial approach for Monitoring and Managing Forest resources and concluded that slope played a direct role in soil erosion and the subsequent deforestation and further suggested that human interference is not always detrimental to forest resources. One of the interesting presentations in the session was made by V.G. Kutty who tried to highlight on the Geographical Approach in revitalizing the cultural landscape of Naubad Karez.

Technical Session 16

The Session was titled **Historical Cartography, Web Maps and Atlases** and chaired by Dr.Jyoti Atwal. The first paper on the ancient story of map making virtually introduced the session. The earliest maps using rudimentary survey techniques portraying land features were discerned from ancient Babylonia that again can be considered as symbolic representations on tablets. The paper also described the earliest maps made by the Egyptians, Arabs and the Chinese. Unfortunately, now there are very few evidences of these ancient maps. The next paper on Geographies of violence, described how the British started map making in India in order to govern areas. The aim was to discuss the ways in which the colonial state introduced a geographic idea of space, shaping ultimately the geographic violence in the colonial and post-colonial India. The case studies of the states of Kashmir and the North-East, were explored to question spatial politics of violence and the geographies that were both created and implicated in the politics of violence- to reflect that these states are cases of inhabitation of violent geographies. Another study attempted to explore aspects of Historical Cartography which was used as a tool for creation and appropriation of spaces in India by the Colonial power. The different strategies of colonial domination and control would be analyzed with the help of Foucauldian concepts of 'governmentality'; 'power over subjects' (techniques of power and their effects upon subjects) and as reorganization of spaces as panopticons for surveillance over native population. One paper tried to analyze the technological advancement in 21st century, the decentralization of cartographic knowledge and its impacts on insurgency. The paper also examined the' power of mapping' in counter insurgency strategies. It mainly emphasised on the easy access of spatial information to insurgents through maps and the danger it poses. In another research paper, an attempt to give a detailed account of the various developments in the field of nautical cartography which have helped nautical maps to evolve into essential tools of maritime navigation was made. Starting with the rudimentary paper nautical charts of the 2nd century BC, followed by the portalan charts in the mid thirteenth century to the most recent developments of the Electronic Nautical Charts with the integration of maps with GPS, GIS and Remote sensing in the Electronic Chart Display and Information System (ECDIS). Most of the current nautical maps are provided by the National or International Hydrographic Organization. An account of the various international bodies, which are involved in the publication of nautical maps together with the development of new navigation techniques, was undertaken along with methods to standardize and unify the various chart systems. Another study elucidated on the PostgreSQL high-performance object-relational database management system with PostGIS spatial extension which has the capability to deal with huge amount of raster as well as vector database. The study used the Geoserver capabilities for Web GIS based GIS application which emphases on creation of geodatabase of spatial information. This helps in extending the benefit of GIS and Web technology for minerals and other resources available in the area to locate mineral exploration targets for augmentation of strategic minerals resources based on parameters chosen by the end-user of the system. With all the components of the GIS integrated into the system, an individual not specialised in the use of a GIS can view, update, customized retrieval, query and analyse spatial information for locating mineral exploration targets. The next study was on the monuments of Delhi. The objective of the study was to establish the link between different historical phases and events. The historical timescale of Delhi, ranging from the Pandavas to the British was grouped into five broad time periods namely Pre Classical, Early classical, Late Classical, Medieval and Modern, further subdivided into smaller periodical segments highlighting the influence of different powers in the Delhi 'Masnad'. Consequently the evolution of architectural forms and styles were replicated through maps which helped to trace the changes from Ashokan Pillar age to Sultaniyat architecture extending upto the British architecture. The entire historical setup was mapped and analyzed from various angles, such as areal extent of different kingdom, royal patronage, cultural diffusion and others. The monuments were represented through a 3D impression to signify the structural beauty. Another paper was an attempt to trace the development of cartography in colonial India involving a series of innovations in mapping technologies including the early mapping efforts, introduction of surveying and production of maps as investigative tools for fostering imperialist ideologies. Strong interests in certain regions dominated mapping exercises; while other areas and pockets were left as blanks.

Technical Session 17

The session on **Cartography for Disaster Management (II)** chaired by Masood Ahsan Siddiqui threw light on the use of cartography for disaster management. The first paper took the case study of Darakeswar-Mundeswari Interfluve in Hugli District of West Bengal and attempted to study the nature of flood, find out the causes responsible for flood and its occurrences, and suggested possible measures towards reducing the devastating nature of flood. The methodologies used included different cartographic techniques like Bar graph, Line graph, Hydrograph, Unit Hydrograph.GIS technique was used for demarcation of flood-affected areas and preparation of flood intensity mapping. Structural and non-structural measures were suggested. In the next paper on assessing flood inundation and landscape vulnerability to flood in Malda district, Landsat 8 Operational Land Imager (OLI) and ASTER DEM data were used to assess landscape vulnerability to flood inundation and flood risk in Malda district of West Bengal state, India. Flood inundation map was prepared on the basis of water and non-water pixels on images (before and during the flood event). Flood risk map was prepared using equal interval of separation based on elevation and inundated flooded area. Flood inundation map was overlaid on the pre-monsoon land use/ land cover map to produce landscape vulnerability to flood. The study suggested that efforts should be made to remove the sediments for increasing the depth of river. Spurs and bed bars should be constructed to avoid great loss of prime agricultural land, property and lives of people. The next paper on coastal geo-environmental hazards and its management was an attempt to recommend viable plan for reduced hazard vulnerability in Digha-Shankarpore area due to coastal action. It also tried to assess the short change of sea level. Another paper studied the application of remote sensing and GIS for flood hazard mapping. An additive model was utilized to create a composite flood hazard index of the study area. A composite flood hazard index was developed incorporating variables like elevation, population density, proximity to the rivers, number of household and cropland. The study demonstrated the potentials of GIS applications in flood hazard mapping. The identification of different hazard zones will also be helpful in studying the problems of agricultural land use, cropping characteristics in the area. The last paper focussed on the use of geo-spatial means for disaster mitigation, response, relief and recovery.

Industry Session- ESRI and GAIL

ESRI

The session for industry-delegate interaction was dedicated to presentation by ESRI India representative, Ms. Seema Joshi- Division Head - Strategic Presales & Technology Solutions. She gave an excellent presentation on the need to have a common platform for data assimilation and how ESRI can contribute in this domain. She also discussed the various features of 3D modelling. She mentioned the links for free data access within the ESRI website for the benefit of students. A wonderful part about the session was the engaging of the audience in the pre and post presentation discussion which was very fruitful as it answered the queries of the audience members.

GAIL

The session had three presentations by representatives of GAIL and was chaired by Prof.J Shukla. The session was extremely informative, highlighting the role of natural gas in making a city green and sustainable. Mr.A.K Jana highlighted the unique characteristics of natural gas which makes it an indispensable component of smart city development. Mr.Shantanu Roy elaborated on the brief history of GAIL and provided a nuanced view of what is "smart" in terms of today's technology. Mr.G.S Bisht highlighted the vast infrastructural foundation which GAIL has established over the years, the challenges (physical as well as institutional) which it faces and the opportunities which can be harnessed to provide clean and affordable energy to Indian cities.

Poster Presentations

Besides the oral presentations, opportunity was given to the participants to present their work in the form of posters as well. The poster session was well appreciated. One of the papers attempted to assess the provision of urban environmental services in Burdwan municipality. Evaluation of the services provided by the municipality (its quality, content, consistence and relevant) was designed through a perception survey. The study identified water supply, sewerage, garbage disposal, sanitation, market facilities, road development, street lighting, recreation and amusement as the criteria for assessing the quality and content of municipal areas. Another paper aimed to study the temporal variation in literacy in Jharkhand during the census period 2001 and 2011 using GlS software (Arc GlS 9.3 version). An attempt was also made to identify the spatial variation in literacy for 2001 and 2011 for rural and urban, male and female using the census data. In 2001 census, the districts with high rate of literacy comprised Ranchi, East-Singhbhum, Dhanbad, Bokaro, Ramgarh and Hazaribag. The medium rate of literacy was found in Simdega, Gumla, Deogher, Kodarma, Giridih, Khunti, Jamtara, Dumka, Garhwa, Chatra, and Latehar. West Singhbhum, Godda, Sahibganj, Pakur district had the lowest rate of literacy. Ranchi, E.Singhbhum, Dhanbad, and Ramgarh had highest rate of literacy in 2011. One paper focussed on the agricultural diversification and productivity of Bankura District, West Bengal with the help of crop diversification method by Ayyar and crop yield and crop concentration indices ranking co-efficient technique of Jashbir Singh. The analysis indices showed that people in the high diversification area are much more dependent on agriculture at subsistence level. Therefore, they are not confined to one crop for the associated economic risk.

Cultural Programme

Cultural programme on Day 1 was mesmerising and featured beautiful performances. The first performance was of *ghazals* beautifully sung by Ustad Zamir Ahmad. This was followed by Kuchipudi dance performances by the pupils of Kuchipudi exponent Padmashri Jayarama Rao. The Odissi performance by Kalyani Behera held the undivided attention of the audience. Kathak performance by Guru Ghanshyam Kheechee left the audience spellbound and drew the curtains on the first day of the Congress.

The second day's cultural programme began with a performance by the Orchestra by the students of Tagore International School, Vasant Vihar, New Delhi. The young talents played instruments like table, synthesiser in a blend of traditional and modern music. This was followed by a mesmerising tabla performance by CSRD, JNU Scholar; Laxmikant Prem Prakash. The next performance of bharatnatyam by Ms.Mayuri enthralled the audience. The performance by the group Pagol para was unique as the members sang Rabindranath Tagore's songs' Urdu translation interspersed with verses. Revolutionary songs were sung by the Music Club JNU. Students of SSS, JNU performed the "Flavours of India", a medley of different folk dance forms of India. The medley commenced with a contemporary dance themed on violence against women. The other dance performances included Bihu from Assam, Kalbelia and Ghoomar from Rajasthan, Bhangra from Punjab, Lavani from Maharashtra, folk dance from Goa,a fusion of Bharatnatyam and contemporary dance form. The performances enthralled the audience and brought the second day to a close.

Valedictory Session

The rapporteur's report was presented in this session and the best paper awards were distributed. The best paper award was presented to Laxman Singh and Surbhi Gaur

Recommendations

The Congress was attended in large numbers by participants from across the country. The Congress witnessed the amalgamation of eminent senior scholars, young research scholars and students. The young scholars specifically benefited a lot from the Congress. Diverse studies within the ambit of the main theme were presented during these three days.

The various recommendations that emerged from the Congress comprised a need to focus on recent perspectives of cartography, active role of the Government in popularising GIS through training and education in GIS. There were also suggestions that maps be produced in local languages to popularise them among the local population and promote their use. Similarly maps should be made for the blind so that they can independently use them. A concern was also raised that there is a large gap between government agencies and academicians due to which the mutual benefit gets limited. There were also suggestions to popularise free ware for GIS so that the benefits would be for everyone and not be dependent on income.

Recommendations also included popularising cyber cartography in order to make maps more dynamic and allow integration of data from various sources, also to personalise the symbols of maps. A need was also felt to promote innovation in cartography so that it can meet the contemporary needs. A healthy assimilation of mapping technology into society needs to be encouraged. A concern was also expressed about the disappearance of geographers and a need to promote geography.

Inaugural Function- Lighting of Lamp

Release of the Souvenir

Participants in the Inaugural Function

Todarmal Memorial Lecture by
Prof. László Zentai

Prof. S.P. Chatterjee Lecture by
Dr. P. Nag

Speaker of Plenary Session I

Speaker of Plenary Session II

Technical Session 1:
Paper Presentation in Progress

Technical Session 2:
Paper Presentation in Progress

Technical Session 3:
Paper Presentation in Progress

Technical Session 4:
The Chairperson Addressing the Presenters

Technical Session 5:
Presentation in Progress

Technical Session 6:
Presentation in Progress

Gender Atlas Session:
Panellists Listening in Rapt Attention

Technical Session 8:
The Chair Listening in Rapt Attention

Technical Session 9:
Presentation in Progress

Technical session 10 :
The Chairperson Guiding a Research Scholar Presenter

Technical Session 11:
The Chairperson Laying Down the Rules

Session on Disaster Research Programme

Session on Disaster Research Programme

Technical Session 13:
Session in Progress

Technical Session 14:
Session in Progress

Technical Session 15:
Session in Progress

Technical Session 16 : Session in Progress

Technical Session 17 : Session in Progress

Presentation by Ms.Seema Joshi, Division Head – Strategic Presales & Technology Solutions

GAIL Panel Discussion

Poster Session in Progress

First Prize for Best Paper Presentation being Awarded

Kuchipudi Dance Performance

Odissi Dance Performance

Orchestra: Students of Tagore International School

Tabla Performance

MEMORIAL LECTURES

TODARMAL MEMORIAL LECTURE

Modern Cartography according to the ICA: towards cartography 2.0

-Prof. László Zentai

Today, maps can be created and used almost for any purposeby any individual having only modest computing skills at any location on Earth. In this new mapmaking paradigm, which we can even call modern cartography or cartography 2.0, users are often present at the location of interest, and they produce maps that address the needs arising instantaneously.

The successful development of modern cartography requires integrated interdisciplinary approaches from domains such as information technology, communication science, human-computer interaction, telecommunication sciences, cognitive sciences, geospatial information management and cartography. It is those interdisciplinary approaches which make sure that we work towards human-centred application developments by applying innovative engineering methods and tools in a highly volatile technological framework. A number of important technology-driven trends have a major impact on what and how we create, access and use maps, creating previously unimaginable amounts of location-referenced information and thus put cartographic services in the centre of the focus of research and development. The paper focuses on the information technology background of this process and the effect of this development on the cartography and the International Cartographic Association itself.

While the above advances have enabled significant progress on the design and implementation of new ways of map production over the past decade, many cartographic principles remain unchanged; the most important one being that maps are abstractions or models of the reality. Visualization of selected information means that some features present in reality are depicted more prominently then others, while many features might not even be depicted at all according to the theory of generalization, which is well-known for experienced cartographers; however, this can be absolutely obscure for the ordinary users. Abstracting reality makes a map powerful, as it helps to understand and interpret very complex situations very efficiently. Maps are most efficient in enabling human users to understand complex situations. Maps can be understood as tools to order information by their spatial context.

Cartography is essential in many aspects of human societies. Modern cartography enables the general public to participate in the modelling and visualizing of the risks their neighbourhood may suffer from on a voluntary basis. Modern cartography also helps to quickly disseminate crucial information.

In this sense, cartography is most relevant. Without maps we would be “spatially blind”. Knowledge about spatial relations and the location of objects is most important for handling disasters and crisis situations or just to be able to bring good decisions. Cartography is also most contemporary, as new and innovative technologies have an important impact on what cartographers are doing: they are inventing cartography 2.0.

About Prof. László Zentai

Prof. László Zentai is a Professor at the Department of Cartography and Geoinformatics, Eötvös Loránd University, Budapest, Hungary. Born in 1959, he pursued M.Sc. in cartography from Eötvös Loránd University, Budapest in 1984. He was awarded Ph.D. in cartography, Eötvös Loránd University, Budapest in 1995 and D.Sc. Hungarian Academy of Science in 2005.

He was a Lecturer at Eötvös Loránd University, Budapest from 1988–1992, Assistant Professor from 1992 to 1996, Associate Professor from 1996 to 2006 at the same university. He is the Head of Department since 2005 and Professor since 2006. He teaches the subjects of Digital cartography, Web cartography, Topographic maps, Representation of relief, Orienteering maps at his university. He is also a member of several associations such as Hungarian National Committee of ICA, Commission on Maps and the Internet (1999–2003), Commission on Education and Training (1999–).

S.P CHATTERJEE MEMORIAL LECTURE

DEVELOPMENT OF THEMATIC CARTOGRAPHY IN INDIA

-Dr Prithvish Nag

The name of Professor Shiv Prasad Chatterjee is synonymous with thematic cartography in India. Independence of the country in 1947 brought new dimensions and meaning to cartography. It was felt that maps prepared for the purpose of security, defense and offence, do not exactly meet the requirements of development, reconstruction and planning of the newly born nation. This was the time when Prof Chatterjee, the doyen of Indian geography and thematic cartography, brought out the famous book entitled, Bengal in Maps. This atlas like publication concerning undivided Bengal now covered present day West Bengal and Bangladesh. Several themes were included which were related to the administrative setup, basic geographical features like topography, drainage, soils, agriculture, population, industries and the like. Theme specific maps were new to India; and this was the origin of thematic cartography in the country. Meanwhile, Prof. Chatterjee made following contributions :

- Le Plateau de Meghalaya, Paris, 1936
- Bengal in Maps, Calcutta, 1949
- Physiography in Gazetteer of India
- World Atlas of Agriculture, Novara, 1973
- Economic Geography of Asia, Kolkata, 1986
- Bharatiya Rashtriya Atlas, 1957
- National Atlas of India, 1982
- Irrigation Atlas of India, 1972
- Atlas of the Damodar Valley Region, 1969

The above publications were the basis on which geography inspired cartography was developed. Nevertheless, there were several issues when he was finally asked to prepare the National Atlas of India – the true beginning of thematic cartography in India. These challenges were :

- Find a uniform background map series (IMW 1:1M)
- Generalize and map the topical information collected in a uniform way to serve as working document
- Produce uniform overviews maps 1:6 million for optimal communication for national trends
- Overcome organisational challenges of massive data-collection and processing in a pre-computer age

Prof Chatterjee considered models of several countries in order to develop the National Atlas Organisation in particular, and thematic cartography in general in India. Some of these were : (a) French National Atlas model of bringing out a national atlas of the country for the first time with German map calligraphy (Royal German Hand Atlas); and (b) On the lines of the institutes of the then socialist countries to establish an Institute of Geography. In the latter case, the Institutes of Geography in Socialist Block were not entrusted with the preparation of National Atlases. Further, the Institutes of Geography were established under the aegis of the Soviet Academy of Sciences and Polish Academy of Sciences. Professor Chatterjee chose to integrate both the approaches, *i.e.* to have an Institute of Geography entrusted with the preparation of the National Atlas of India. In fact, NAO was tilted towards the east European model of the Institutes of Geography where the cartographic exercise was driven by geographical researches. Prof Chattterjee's target was to develop an institute with either of following names :

- National Institute of Geography
- Research Institute of Geography
- Institute of Earth Sciences

As these digital atlas products will be increasingly used in an isolated viewing and earning situation, now, more than ever, we should atlas user by providing map commentaries such as have been developed and extended by Professor S.P. Chatterjee. To learn to use atlases is more than learning to handle the buttons or the interface, it is also learning to look with 'geographer's eyes'. In this connection, a new project named Golden Map Service was launched in NATMO using all sorts of modern geoinformatic technology and its integration with IT, ICT and web technologies. The whole *objective* is to shift focus from small scale to large scale thematic cartography and to provide services based on such soft infrastructure. The project can also be a basic for implementing national project on Digital India.

About Dr.Prithvish Nag

Dr.Prithvish Nag is the Vice-Chancellor of Mahatma Gandhi Kashi Vidyapith, Varanasi. Dr. P. Nag holds a PhD degree from Banaras Hindu University. He has also done Post Doctoral Research from School of Oriental and African Studies, University of London (1982-83).He has occupied the coveted posts of the Director-National Atlas and Thematic Mapping Organisation and Surveyor General of India, Survey of India in his illustrious career spanning nearly 40 years. He is the President of Professor S.P Chatterjee Memorial Foundation.

Recent Trends in Cartography for Development Planning

LAND SURFACETEMPERATURE ESTIMATION FROM SATELLITE IMAGES USING ENVI 4.7

Ajay SURESH V.[1], Suresh. S.[1] & K. MANI[2]

ABSTRACT

Land Surface Temperature (LST) is the skin temperature of the ground. Theoretically LST is the temperature felt at the ground aperture irrespective of landscape, road, footpath, structural building and surrounding natural vegetation of any given area. As Land Use/ Land Cover of every urban area over the globe is changing the climate in urban area are also changing. The purpose of this paper is to make an attempt to estimate the Land Surface Temperature of Thiruvananthapuram City Region, Kerala, India. The fast growing urban centre and related Land cover/Land use changes of the study area can generate climatic phenomena like the Urban Heat Island. So, to monitor and mitigate the extremes of Urban Heat Island the LST plays a vital role. The data and methodology is at the courtesy of USGS LANDSAT 7(TIRS) images and USGS LANDSAT Handbook. The image processing, detection, estimation and assimilation are carried out using ENVI 4.1. ENVI 4.1 is image processing software. In this study the LST was estimated using the Single Window Algorithm method using the LANDSAT 7 Optical Land Imager (OLI) of 30 m resolution and Thermal Infrared Sensor (TIRS) data of 100 m resolution. The output revealed promising results with higher heat signatures in core of the urban areas and lower heat signatures to outer portions of the urban area.

Keywords: *Land Surface Temperature, Urban Heat Island, Split Window Algorithm, ENVI, OLI, TIRS.*

INTRODUCTION

Land Surface Temperature (LST) can be defined as the temperature felt when the land surface is touched with the hands or it is the skin temperature of the ground (1, 2, 3). Thermal Infrared remote sensing provides a unique method for obtaining LST information at the regional and global scales since most of the energy detected by the sensor in this spectral region is directly emitted by the land surface(4). Land Surface Temperature can provide important information about the physical properties and climate which plays a role in many environmental processes (5). In this study the data used is from the LANDSAT 7. The Split Window (SW) algorithm is the methodology enunciated for obtaining LST from satellite images using ENVI 4.7.

OBJECTIVES

The objective of the study is to Estimate the Land Surface Temperature from Satellite Images.

STUDY AREA

The study area chosen for the purpose is Thiruvananthapuram City Region (8.4874^{0}N 76.952^{0}E) viz. Thiruvananthapuram Municipal Corporation and the adjacent panchayats (Figure 2). The current area of the study area is of 296 square kilometres vastness and does not have a predefined political boundary since urban outgrowths are constituted. The aim to carry out this study in the given area is credited with the fast pace of urbanisation characterised and the related climatic extremes. The area under study has rapidly increasing built-up area and other infrastructural advancements carried out simultaneously.

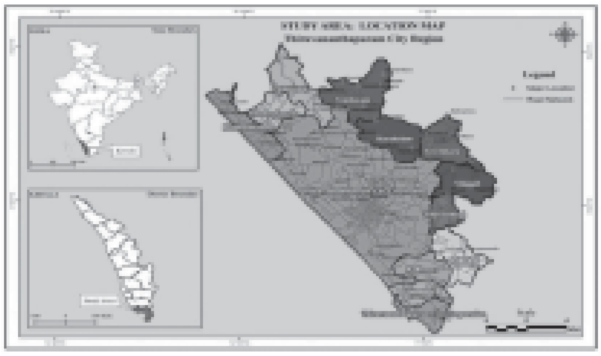

Fig. 1: Location Map: Study Area- Thiruvananthapuram City Region, Thiruvananthapuram District, Kerala, India.

DATABASE AND METHODOLOGY

The data used in the study is from the LANDSAT 7. It can be downloaded via the USGS at: Glovis: http://glovis.usgs.gov.in, Earth Explorer: http://edcsus17.cr.usgs.gov/earthexplorer

Downloaded via the GLCF at: GLCF: http://landcover.org/index.shtml

The main sets of images downloaded are from band 6 of LANDSAT 7. The appropriate usage of the satellite images and the image processing is at the USGS LANDSAT Handbook's courtesy.

The LANDSAT 7 images are processed for retrieving LST using ENVI. ENVI or Environment for Visualising Images is image processing software

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designed by the Exelis Visual Information Solutions exclusively for image processing. The processing is carried out by a five step scenario.

1. Converting LANDSAT TM and ETM Thermal Bands to Temperature

   The LANDSAT Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM) sensors acquire temperature data and store their information as digital number (DN) with a range of 0 to 255. It is possible to convert the DNs to degree Kelvin and in turn convert these Kelvin values to degree Celsius values. This is five step processes carried out in two parts. The first part is to convert the DNs to radiance values using the bias and gain values specific to the individual scene you are working with. The second part converts the radiance to Kelvin and in turn into Celsius.

2. Convert DN to Radiance

Step 1 Start ENVI 4.7→File→Open External File→ Landsat→ GeoTIFF with Metadata.

In the now appearing window of ENVI available bands → select ETM+Meta (Band61).

Step 2 ENVI main menu→Basic Tools→ Preprocessing→ Calibration Utilities→ Landsat Calibration→Select the second file with .txt extension→Press OK.

In the now appearing window of ENVI available bands'!Choose Calibration Type Radio as Radiance, then choose the memory to save the converted file and save it as B6-RADIANCE in a separate folder. Then press OK in the ENVI available bands window.

3. Convert Radiance to Kelvin

   After the above mentioned steps the radiance file is selected for further processing, and it will be mentioned as TM Cal (ETM+Meta (Band 61).

Step 3 ENVI Main menu→Basic Tools→Band Math→ Enter Expression [(1282.71/alog (((666.09*0.95)/ B6)+1)]→Add to List→Click OK.

The computer or ENVI 4.7 understands like this,

T (Kelvin) is the Kinetic Surface Temperature in Degree Kelvin

K1 and K2 are constants.

E is Thermal Emissivity (Typically 0.95)

$B6_{Rad}$ is Radiance Band.

Table 1
Temperature Constants of Landsat TM and ETM+ Bands

	Landsat TM	Landsat ETM+
K1	607.76	666.09
K2	1260.56	1282.71

A processing will be carried out for the conversion of radiance to Kelvin. After the process, in the appearing window of ENVI Available bands select the file TM Cal (ETM+Meta (Band61)) and choose the memory to save the converted file and save it as B6-KELVIN in the same folder(B6-RADIANCE) and press OK. Select the first Band Math file from the B6-KELVIN directory and click Load Band. A processing will be carried out.

The Degree Kelvin temperature (KINETIC SURFACE TEMPERAURE IN DEGREE KELVIN) image will be generated.

4. Convert Kelvin to Celsius

After the above mentioned steps the Kelvin file is selected for further processing and it will be mentioned as B6-KELVIN Band Math1. This file is selected.

Step 4 ENVI Main menu→Basic Tools→Band Math→Enter Expression (B6-273.15)→ Add to list→Press OK.

Again selected the processed Kelvin file from the ENVI available bands window and in the now appearing window of ENVI variables to band pairing choose the memory to save the converted file and save it as B6-CELSIUS in a separate folder. Then press OK in the ENVI available bands window.

A processing will be carried out. Select the Band Math (B6-273.15) from the B6-CELSIUS directory in the ENVI Available bands window.

The Degree Celsius temperature (KINETIC SURFACE TEMPERATURE IN DEGREE CELSIUS) image will be generated.

5. Colour Mapping

After the above mentioned steps the processed Degree Celsius file is to be selected for colour mapping. Select the Band Math (B6-273.15) from the B6-CELSIUS directory of the ENVI available bands window and press LOAD. The degree Celsius image will be displayed.

Step 5 Band Math Window→Tools→Colour Mapping→ENVI Colour Tables→Red Temperature.

After completion of these steps, save the output as:

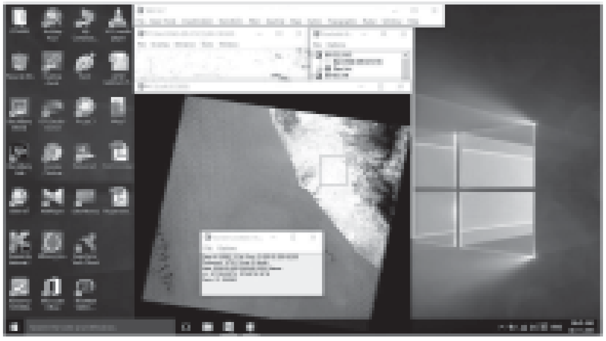
ENVI Main Menu→File→Save File As→TIFF/ GeoTIFF.

The desired output would be as follows.

After careful inspection, processing and editing of the saved image using Arc GIS 10.2. The processed image is seen in the next page.

DISCUSSION AND ANALYSIS

The Climate in and around the cities and the built up areas are altered due to changes in the Land use/



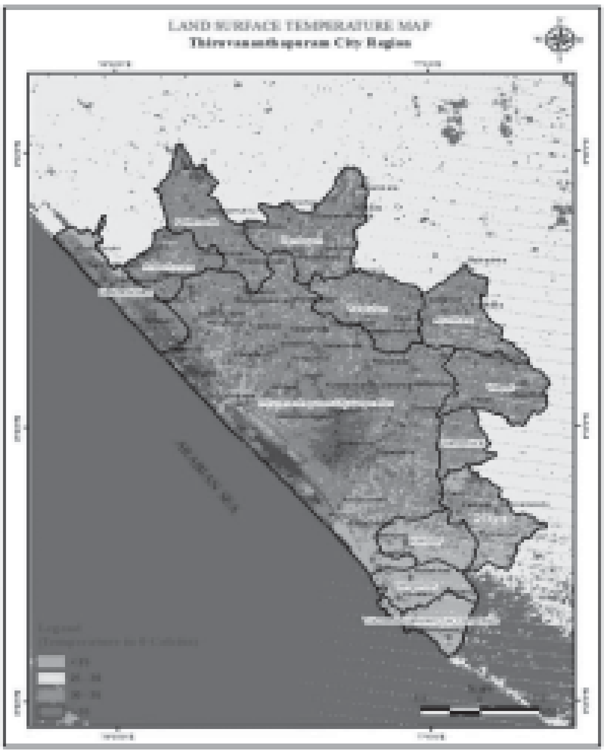


Fig. 2: **Land Surface Temperature Map of Thiruvananthapuram City Region.**

Land cover changes and most anthropogenic activities of urbanisation. Land Surface Temperature is sensitive to vegetation and soil moisture; hence it can be used to detect land use/land cover changes (6). In this study an attempt has been made to estimate Land Surface Temperature of Thiruvananthapuram City Region, Thiruvananthapuram, Kerala, India. The thermal energy responses of different land use types and soil types in the study area indicate the variation in the surface temperature in different surface patterns which is evident from the resultant Land Surface Temperature map. This land surface temperature is the key factor controlling the surface heat and water exchange with the atmosphere which in turn contributes to climate change. The Land Surface Temperature and the related Land cover type helps us to improve the urban environment quality and strategies to mitigate the heat island effects.

CONCLUSION

We incorporated the Single Window Algorithm method for the LST retrieval using ENVI. The method is more than satisfactory since it shows correlation with the temperature collected from the Indian Meteorological Department weather stations (calibrated and fully functional) at different parts of the study area. For the investigated sites and scenes the results shows that the LST derived from the single window algorithm method using LANDSAT7. Future work should focus on theoretical evaluation of the effect for input parameters errors on the estimated LST. Since the limitation of validation sites and scenes, the range of ground temperature in this study is relative heterogeneous. More land surface types and different temporal scenes should be tested to verify the investigated method for LST estimation from LANDSAT 7 ETM+ imagery.

Notes :

Ajay Suresh.V is the principal author of this work. Ajay Suresh.V and Suresh.S worked on the methodology and the processing of the LANDSAT 7 ETM+ image. Dr. K. Mani participated in the interpretation of the results and the final version of this contribution.

REFERENCES

1. Dousset & Gourmelon (2003), Weng, Lu & Schubring 2004.
2. Jimenez-Munoz.J.C, Sobrino J.A,(2008): "Split Window Coefficients for Land Surface Temperature retrieval from low resolution thermal infrared sensors", IEEE.Geosci.Remote Sens. Lett, 5, pp 806-809.
3. Mallick J, Kant Y, Bharath B.D (2008): "Estimation of Land Surface Temperature over Delhi using Landsat 7 ETM+", J.Ind. Geophys. Union, Vol.12, No.3, pp.131-140.
4. http://www.springerreference.com/docs/html/chapterbid/327143.html
5. http://earthobservatory.nasa.gov/GlobalMaps/view.php?di=MODIICI_M_LSTDA http://www.ltrs.uri.edu/research/LST_page/LST_page.html

SENSOR MODEL BASED STEREO-VISUALISATION OF CARTOSAT-1 SATELLITE IMAGERY IN VIRTUAL REALITY ENVIRONMENT

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ABSTRACT

Stereo imagery of Cartosat-1 provides an opportunity for directly collecting 3D information of earth surface features by its analysis and visualisation. The visualisation of cartosat-1 stereo images in a virtual reality environment is always a matter of concern because of pushbroom mode of imaging geometry where the image scenes are formed by stitching the one-dimensional (1D) scan lines captured as the sensor moves. Ideally the parallax between the stereo images should be in one dimension (1D) for better visualisation of stereo images. In case of frame camera the stereo images are oriented in epipolar geometry for getting one dimensional parallax only. Epipolar resampling aims to generate rectified images so that the stereo disparities are parallel to one of the image axes. As is well known, epipolar resample is a well-established procedure for images captured by a frame camera, as the rigorous epipolar geometry can be easily defined and the epipolar lines are in a simple, straightforward linear style. However Cartosat-1 satellite payloads (Fore and Aft) are linear array pushbroom scanners and are characterized by their particularly distinct imaging principle and their diverse, complex physical structures in comparison with conventional frame cameras. Stereo visualisation of radiometrically corrected Cartosat-1 images requires epipolar image generation which can be created either through the sensor model for establishing relationship in object and image space or through the stereo correspondence in image space only. This paper describes a methodology to create optimum epi-polarity between the Fore-Aft (stereo) images using hybrid model which includes RPC based sensor modelling and tie Points (stereo correspondence) between the stereo images.

Keywords: *Stereo, Cartosat-1, RPC, Epipolar*

INTRODUCTION

One of the main challenges in virtual augmented reality applications design is understanding how our perception of reality can be beneficial for different GIS applications and how this augmentation can be made to fit seamlessly with the user's interaction with the world.The use of satellite imagery for collecting geographic information has become more frequent with the advancement of image processing and remote sensing systems. Satellite imagery was first used for reference backdrop for collecting and editing the geographic information. Most of the geographic information collected either from geo-corrected imagery or from ortho-rectified imagery is limited to the 2D. To accurately represent the Earth and its geography, the information must be obtained in 3D, regardless of application. Stereo imagery provides the solution for directly collecting 3D information by its analysis and visualisation.

Cartosat-I Satellite was launched on May 2005, providing along track stereoscopy with two cameras namely Fore and Aft at +26 degree and -5 degree in normal mode operation. The spatial resolution of the images is ~2.5 m and radiometric resolution is 10-bit. The imaging geometry of the payloads is ideally suited for extraction of 3D features and Digital Elevation Models (DEM). The visualisation of the stereo images in a virtual reality environment is always a matter of concern because of pushbroom mode of imaging geometry. Ideally the parallax between the stereo images should be in one dimension (1D) for better visualisation of stereo images. In case of frame camera the stereo images are oriented in epipolar geometry for getting one dimensional parallax only. Epipolar resampling aims to generate rectified images so that the stereo disparities are parallel to one of the image axes. As is well known, epipolar resampling is a well-established procedure for images captured by a frame camera, as the rigorous epipolar geometry can be easily defined and the epipolar lines are in a simple, straightforward linear style. However, Cartosat-1 satellite payloads (Fore and Aft) are linear array pushbroom scanners and are characterized by their particularly distinct imaging principle and their diverse, complex physical structures in comparison with conventional frame cameras. In the pushbroom scanner, the image scenes are formed by stitching the one-dimensional (1D) scan lines captured as the sensor moves (Wolf and Dewitt, 2000). It is almost impossible to rigorously define the epipolar geometry of linear pushbroom satellite imagery, primarily because the determination of the accurate geometric relationship between object space and image space (i.e., sensor modeling) is difficult due to the adopted multicenter projection imaging mode. On the other hand, the resulting epipolar lines are actually not

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straight lines on the original image scenes, which bring complexity and difficulty to epipolar resampling. As a result, for satellite stereo imagery, the classical epipolar theory and methodology applied to single perspective frame-based imagery will no longer be feasible. Actually, epipolar resampling is the arrangement of epipolar lines based on a specific epipolarity model, so it is theoretically and practically significant to study the epipolarity model of linear pushbroom satellite stereo imagery.

In general the stereo visualisation of pushbroom sensors is created through either using the sensor model for establishing relationship in object and image space or through the stereo correspondence in image space only (Su, 2002). The first method is based on sensor model in which the projection trajectory based epipolar curve definition is most widely known and accepted for linear pushbroom satellite images. In Second method, the most often used model is the polynomial fit model (PFM) which defines the approximate epipolar curves using the conjugate points between the stereo images.

This paper describes a methodology to create optimum epi-polarity between the Fore-Aft (stereo) images using hybrid model which includes RPC based sensor modelling and tie Points (stereo correspondence) between the stereo images. This method is able to produce a qualified epipolar image directly from the provided high-accuracy orientation data of satellite stereo images from the rational polynomial coefficients (RPC) of the rational function model (RFM), well-matched conjugate image points, along with ground control points (GCPs). Finally the epipolar images are generated in a manner similar to the process of digital image rectification.

DATA SETS USED

Cartosat-1 stereo Orthokit Products (Rad. Corr. Image plus RPC) of three different regions are utilised for this study. The regions are Ahmedabad, Hyderabad and Barcelona (Spain). The details of the geographic locations are provided in table 1.

Table 1 : Details of Datasets Used

S. No.	*Location*	*Path / Row*	*Scene Centre*	*Date of Acquisition*
1.	Ahmedabad, India	0508 / 0291	Fore: Lat:22.9496; Lon=72.652 Aft : Lat:22.9495; Lon=72.648	13-12-2005
2.	Hyderabad, India	0544 / 0316	Fore: Lat:17.3264; Lon=78.368 Aft : Lat:17.3270; Lon=78.375	08-06-2005
3.	Barcelona, Spain	0117 / 0208	Fore: Lat:41.3792; Lon=02.095 Aft : Lat:41.3815; Lon=02.107	19-07-2005

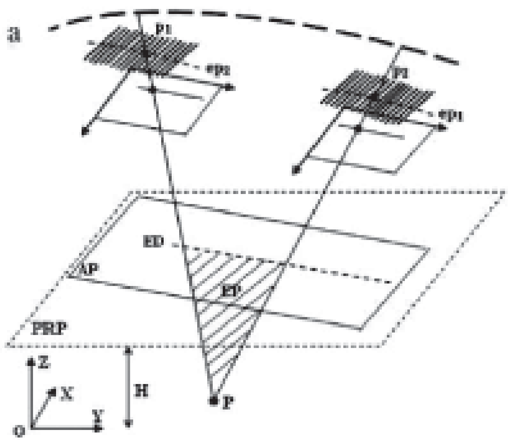

Fig.1: The Projection Reference Plane Based Epipolarity Model of Cartosat-1 along Track Stereo Imagery

PRINCIPLE

The basic principle of epipolar image generation using Projection Reference Plane (PRP) from Cartosat-1 stereo pair has been stated in Figure-1. As shown in Fig.1, O-XYZ is the Local Vertical Coordinate system (LVCs), which is a left-handed coordinate system defined on the reference ellipsoid, with the origin point located near the central part of ground cover and with the Y axis tangential to the reference ellipsoid and pointing in the due-north direction. The PRP is defined as the average elevation plane in object space with elevation value H. Suppose p1 and p2 are conjugate image points on the left and the right image, respectively, and they are intersected at ground point P. Derived from the point based epipolar curve definition, *ep1* on the right image indicates the epipolar curve of point *p1*, while *ep2* on the left image indicates the epipolar curve of point *p2*. Inferred from the orbital stability of the satellite platform and the formerly depicted geometric properties of epipolar curves, *ep1* and *ep2* compose a pair of conjugate epipolar lines by approximation; moreover, if points on *ep1* and *ep2* are projected to the PRP, the projection trajectory will be very close to a straight line named ED. Besides, EP decided by line ED and point P can be regarded as the approximate epipolar plane. The effective epipolar resampling requires sound geo-locating accuracy of the geometric sensor models, so obtaining high quality orientation parameters of satellite stereo images is a prerequisite. Cartosat-1stereo Orthokit images are normally provided to the users with the RPC parameters (RPC file) instead of ephemeris and attitude parameters, as well as sensor information. It is demonstrated that the 0.01 pixel high fitting accuracy is totally possible with the 3rd-degree form of the RFM or RPC, in comparison with the rigorous geometric sensor model (Yang, 2000). Therefore, the RPC is a good replacement for the rigorous geometric sensor model in the epipolar resampling procedure with satellite stereo imagery.

METHODOLOGY

Flow diagram of the methodology adopted has been shown in Fig. 2. The entire methodology is developed using Leica Photogrammetric Suite (LPS) commercial off the shelf software. The robust image matching technique of the LPS was utilised to create large number of conjugate (tie) points between the Fore and Aft images. A model set up was established by creating a project based on Cartosat-1 Fore and Aft stereo image matching (conjugate) points, Corresponding RPCs and the GCPs. Finally epipolar modelling was carried out using the RPC based sensor modelling.

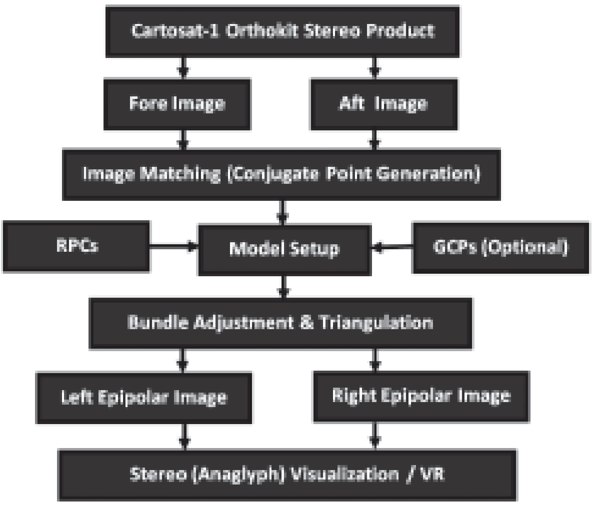

Fig 2: Methodology Adopted for Sensor Model Based Epipolar Image Creation and Visualisation

RESULTS

For proving the feasibility of the projection referenced plane based epipolar image generation, 2.5 m resolution Cartosat-1 stereo-images of three different sites (Ahmedabad, Hyderabad and Barcelona, Spain)

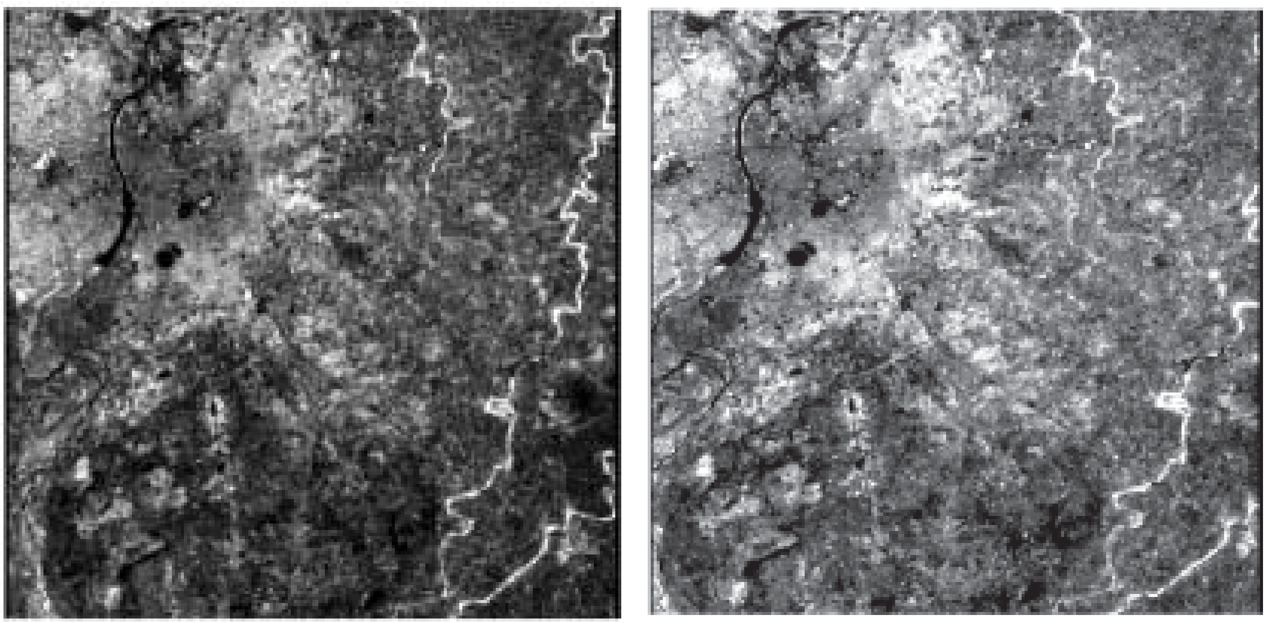

Fig 3: Radiometrically Corrected Fore and Aft Image of Cartosat-1 of Ahmedabad

with different terrain relief were used in this study. Fig. 3 shows the basic radiometrically corrected stereo images of Ahmedabad region supplied in orthokit product. In case of Ahmedabad and Hyderabad 12 GCPs are used with corresponding RPC orientation data and 2000 conjugate (Tie) points for modelling. Fig. 4 shows the conjugate points generated between Fore and Aft images of Ahmedabad region and the same points are used for bundle adjustment. Since no GCPs was available in case of Barcelona, Spain case, a large number of conjugate points (5523) was used with the corresponding RPC orientation data from modelling. Epipolar images for various cartosat-1 Fore and Aft images are produced based on the Projection reference plane based epipolarity model. All the procedures used in this study are implemented through Leica Photogrammetric Suite software. Fig. 5 shows the generated epipolar images

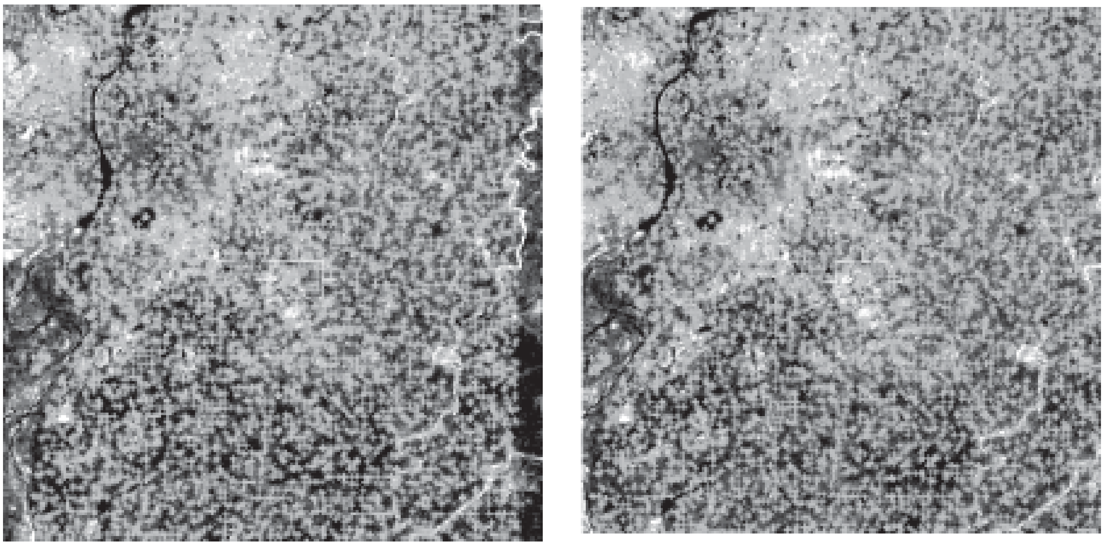

Fig 4: Conjugate (Tie) Points between the Fore and Aft Image of Ahmedabad

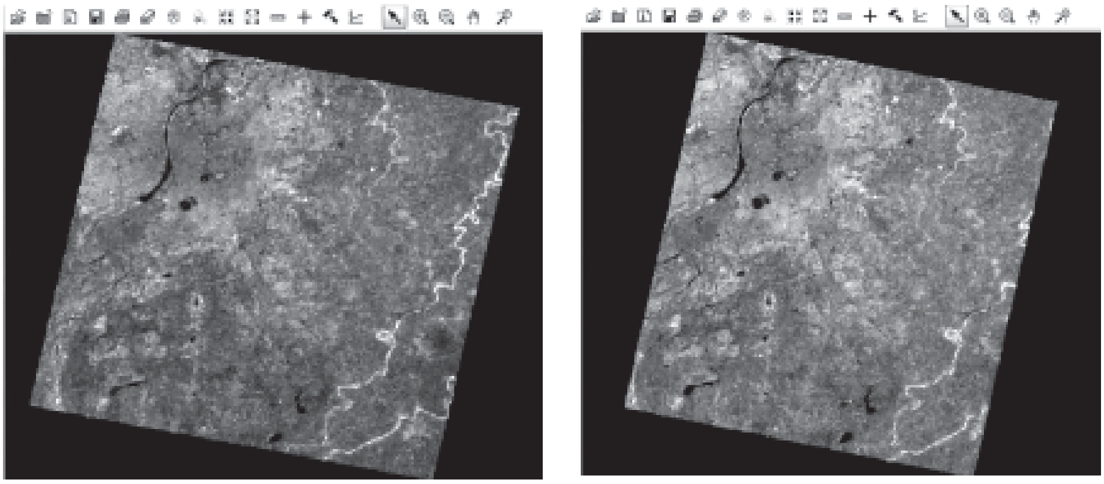

Fig. 5: Epipolar Fore and Aft Image of Cartosat-1 of Ahmedabad

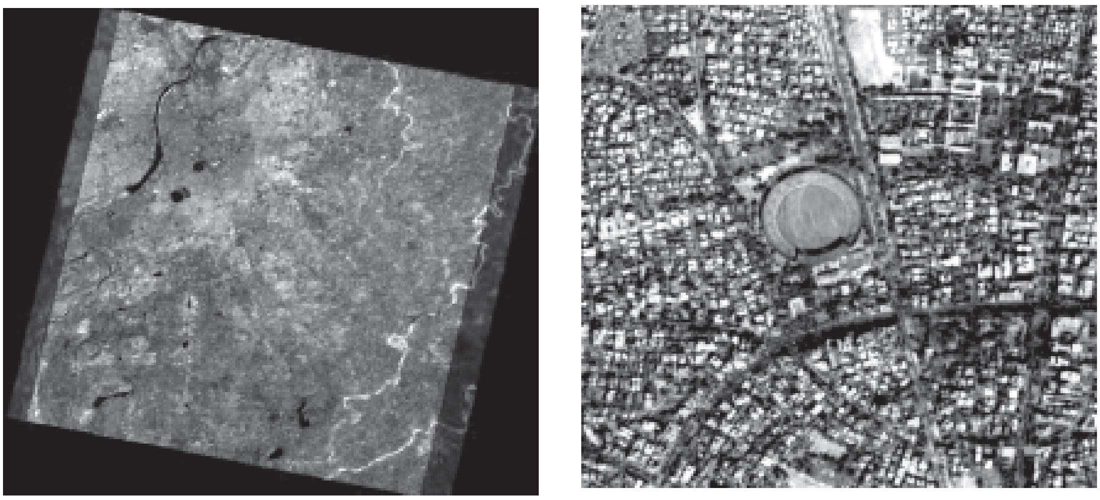

Fig 6: Stereo Anaglyphs Generated from Epipolar Images of Ahmedabad

from the stereo pair. Figure-6 shows stereo anaglyphs and a local zoomed area of the same. In addition, Fig. 7 and 8 shows the output epipolar image generated stereo anaglyph results of Hyderabad and Barcelona areas respectively. It has been observed that the generated epipolar stereo models achieved satisfactory visual effects.

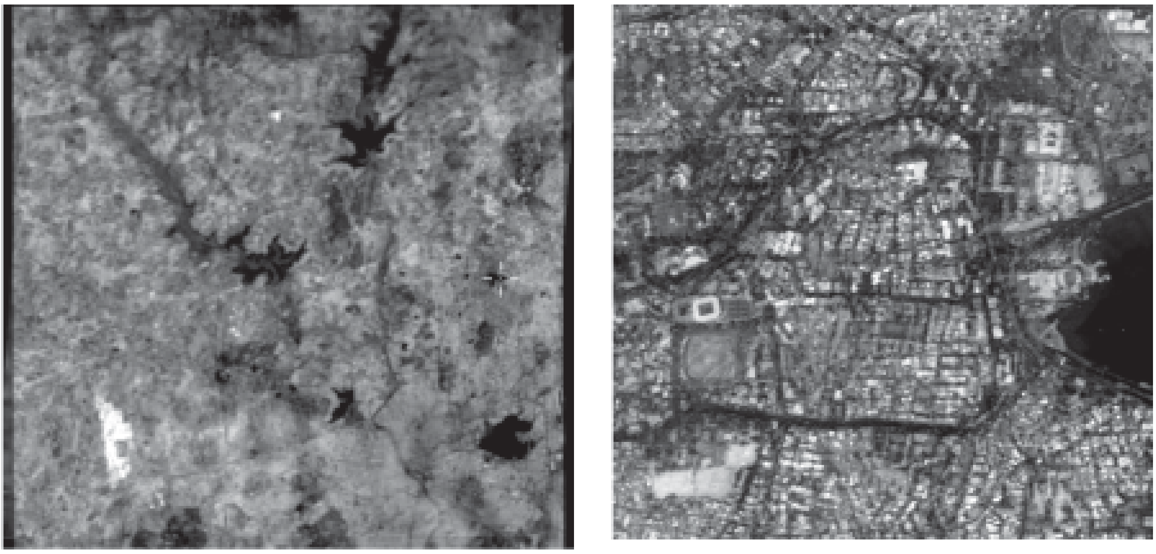

Fig 7: Stereo Anaglyphs Generated from Epipolar Images of Hyderabad Area

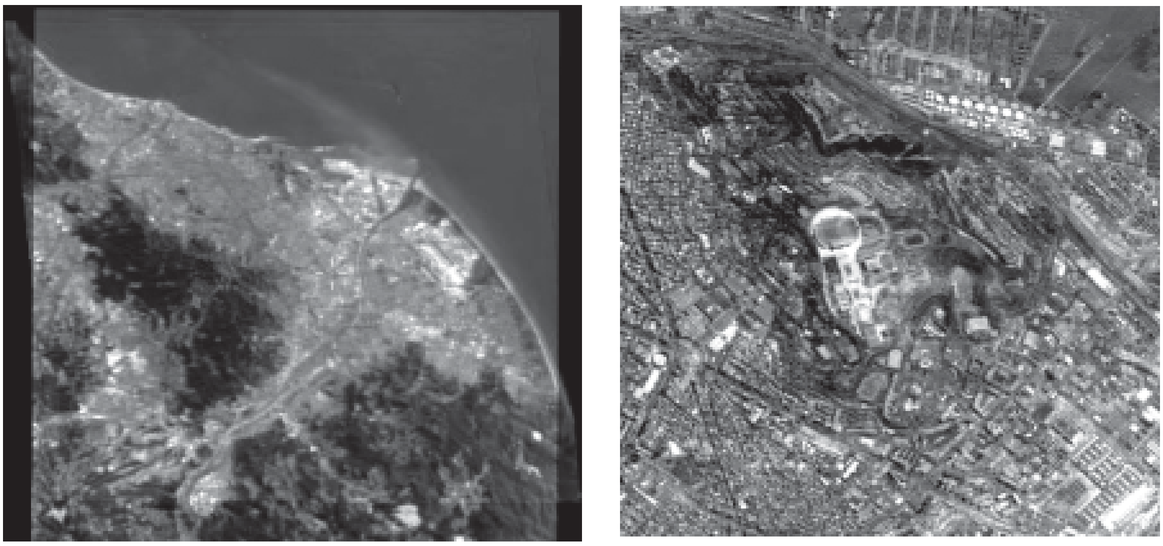

Fig 8: Stereo Anaglyphs Generated from Epipolar Images of Barcelona, Spain Area

CONCLUSION

Epipolar images are the basic requirements of stereo visualisation for long strip of images (large swath) like Cartosat-1. Without epipolar geometry the correspondence between the linear pushbroom scanner images is normally defocused and contains parallax in both the direction. For true stereo representation only one dimension parallax is required between the stereo images. Normally for linear pushbroom satellite images, epipolarity models are created in the image space but this study shows that epipolarity model can be extended to object space also by utilising the projection reference plane model. This study utilised the RPC based orientation parameters, conjugate points between the stereo images and the ground control points for the creation of epipolar images. The successful use of this model can be utilised for the creation of 3D models for virtual reality applications like Urban planning, City modelling, Dam site selection, water resource management etc..

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REFERENCES

1. Su, J.Y. (2002), Study of SPOT epipolar image polynomial fitting based on matching constraint. Remote Sensing Information 0 (4), pp 11–14,

2. Wolf, P.R. and Dewitt, B.A.(2000), Elements of Photogrammetry with Applications in GIS, 3/e. McGraw-Hill, Toronto, pp 608

3. Yang, X.H.(2000) , Accuracy of rational function approximation in photogrammetry. International Archives of Photogrammetry and Remote Sensing 33, (Part B3), pp 146–156

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CARTOGRAPHY – AN INDISPENSABLE TECHNOLOGY FOR 21ST CENTURY

Baisakhi SARKAR[1]

ABSTRACT

The technological revolution in cartography has opened up new dimensions and has improved phenomenally its potentialities for effective use in solving complex natural resources and social planning problems. Modern cartography is perceived as a versatile information communication technology of high potency mapping, with tremendous capability of wide-ranging applications encompassing the entire gambit of real-world problems.

With the advent of satellite technology, satellite data has been providing real-time information for monitoring natural resources, combating natural disasters like flood, earthquake aftermath, etc. High resolution stereo satellite imagery have made a great impact on modern cartography as it eases out terrain modelling as well as contour interpolation. Geographic Information System (GIS) enables integration of various data sets, both spatial and tabular; it facilitates Land Information System for rural development and management of natural resources. The Global Positioning System (GPS) technology helps in maintaining and updating geodetic and atmospheric data. Further, it is indispensable for surface navigation through the road network. GPS is widely used for large scale mapping and real-time mobile mapping.

The Recent development of PC-based workstations with high speed computing capability have brought in powerful and economical methods of data capture and processing. Nowadays, government, as well as private agencies involved in mapping, are putting their best efforts to convert existing maps into digital cartographic vector databases, so that various spatial operations can be performed with greater speed. The advantage of the digital cartographic database is that thematic maps of any design and scale could be prepared quickly. Mapping of the surface of Mars, the moon and other space objects, ocean resource mapping, meteorological research and demonstration of weather phenomena, socio-political problem zone mapping in near real time, all fall under the realm of 21st century cartography. Spatial information of varied nature, whether physical, climatic, agricultural, industrial, demographic or political; or pertaining to specialised discipline like geology, meteorology, botany, archaeology, sociology, defence and a host of other fields that are coming up serially with growing complexities of environment and society, is communicated to a user in a number of ways, and a map is one of the popular forms. Let us hope for a better and wider scope of cartography in coming future.

Keyword(s): *Remote sensing, GIS, Digital Cartography, GPS, Mobile Mapping, Navigation tool, Web Cartography.*

INTRODUCTION

Cartography, the technology of map making, offers a tremendous potential for development as it deals with a variety of information relevant to the 21st century. In this age of computerization, data dissemination through suitable cartographic technique (maps and cartograms) is precise in real time. The technological revolution in cartography has opened up new dimensions and has improved phenomenally, its potentialities for effective use in solving natural resource management and social planning problems.

This discipline has made remarkable progress over time in consonance with expanding information range, advancing technology and growing societal needs. Its outputs are used for a variety of purposes. Maps and diagrams are tools of planning and administration. Graphics are employed for understanding ground realities, preparing blueprints for development action, and monitoring what was envisaged. Modern cartography is perceived as a versatile information communication technology of high potency mapping, with tremendous capability of wide ranging applications encompassing the entire gambit of real-world problems.

REMOTE SENSING AND ITS APPLICATION IN CARTOGRAPHY

Cartography has a key role to play in organising geospatial data. Identification of geo-attributes of a terrain to facilitate their pragmatic utilisation is possible through geospatial data management system. While a ground surveyor has to travel physically for collecting data and there is a limit to the amount of data collection within a short time span, earth resource satellites can inspect a vast stretch of terrain more frequently and in near real time, with more accuracy and precision. Hence maps could be prepared instantly.

Satellite data have been providing ready information for monitoring natural resources, combating natural disasters like flood, cyclone, earthquake aftermath, etc. High resolution stereo satellite imagery have made a great impact on modern cartography as it eases out terrain modelling as well as contour interpolation.

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Most of the problems facing the Earth today are related to those arising out of climate change, problems of adaptation in changed habitat. Satellite images over a period of time could be compared to note environmental changes and accordingly infrastructural development planning could be formulated.

Digital Cartography

Geo-informatics provides a technological tool to capture, manage and analyze all forms of geographic reference data to facilitate analysis and decision making. It includes Geographic Information System, Global Positioning System and Remote Sensing. It is an information system that helps to integrate and present spatial data as per specific project requirement. It deals with how information technology could be used to improve the organisation of earth information.

The advantage of the digital cartographic database is that thematic maps of any design and scale could be prepared quickly. Geo-informatics has taken a quantum leap in recent years in the field of spatial data handling, modelling, visualisation and dissemination thus catering the needs of various applications like natural resource management, infrastructure development, disaster risk assessment and mitigation, biodiversity, climate change and so on.

Some of the thrust areas of geoinformatics science are spatial database management system, mobile and distributed GIS, 3D GIS, voluntary geographic information, geo-web services, location based services, cloud computing, etc.

Indian Space Research Organisation has implemented crowd sourcing as a strong mechanism for collecting field data and integrating these with *Bhuvan* geo-portal for various applications. During the recent Uttarakhand -2013 disaster, extensive field data have been collected by students and teachers for damage assessment using a mobile based application programme sponsored by Department of Science & Technology, Government of India.

Cloud computing, an emerging concept, furnishes technological capabilities – commonly maintained off-premises that are delivered on demand as a service via internet.

Digital Elevation Model (DEM) derived from high resolution CARTOSAT stereo data is used in modelling different environmental processes. Water flow, generation of surface runoff and other hydro-geo-morphological processes depend upon surface topography. Hence, DEM would continue to be a useful tool for watershed management.

Models to forecast floods could help emergency managers to develop contingency plans well in advance of an actual event and facilitate efficient and effective response. Hydrologic models require several types of data as input, such as land use, soil type, soil moisture, river flow, amount of rainfall, DEM, drainage basin shape and size, etc. All these information could be superimposed and visualised with computer aided cartography.

GIS and Cartography

Geographic Information System (GIS) enables integration of various data sets, both spatial and tabular; it facilitates Land Information System for rural development and management of natural resources as well as urban planning.

Establishment of digital image processing laboratories not only generate credibility and authority to cartographic products but in the long run results in better policy making. Geographic Informatics Cell with a remote sensing laboratory helps in the creation of spatial database that could be transferred, described and presented in National Spatial Data Infrastructure format.

The Recent development of PC-based workstations with high speed computing capability have brought in powerful and economical methods of data capture and its processing. Nowadays, government as well as private agencies involved in mapping, are putting their best efforts to convert existing maps into digital cartographic vector databases, so that various spatial operations can be performed with greater speed.

GIS could analyse existing health service infrastructure also. Geographical distribution of disease, affected population, surrounding environment, medical facilities available - all could be registered under a GIS set up.

Mobile GIS Applications

Mobile application (M-Apps) with GIS and GPS technology provides appropriate software solutions for both urban and rural community. It is helpful in organizing accurate data, real time business decisions and collaborates in outstation and office environment.

Mobile GIS Application Development for Agriculture and Rural Support (MAARS) is now a popular mission. It includes, (a) mobile based field data collection module for village infrastructure mapping and soil sample collection; (b) field boundary drawing module, that uses GPS for digitizing the farmland boundaries; (c) module for loading the stored farm boundary; (d) module for drawing GPS elevation profile; (e) fertilizer recommendation module, etc. Map service provider like BHUVAN and Arc-GIS give the opportunity to develop an open application popular mission. It includes, (a) mobile based field data collection module for village infrastructure mapping and soil sample collection; (b) field boundary drawing module, that uses GPS for digitizing the farmland boundaries; (c) module for loading the stored farm boundary; (d) module for drawing GPS elevation profile; (e) fertilizer recommendation module, etc. Map service provider like BHUVAN and Arc-GIS give the opportunity to develop an open application by a user for the user. The field data input could be used by decision makers at *panchayat* level and plotted over a micro-scale map.

Web Maps and Micro-Level Planning

Decentralized planning requires the proper participation of government, local authority and public. Decision making process thus is transferred to immediate local bodies which hold responsibility and authority to identify, analyze and decide plans for the betterment of locality. The key to the success of effective planning and monitoring of any infrastructure development project primarily depends on the current and relevant information system.

Use of geo-informatics has emerged as a powerful and effective solution to assist decision makers of managing large projects. For example, using geo-informatics for the development of rural roads under *Pradhan Mantri Gram Sadak Yojna* has changed the whole scenario of project implementation. The introduction of the new concept of Core Network to optimize the cost of road construction to connect all eligible habitation by providing basic connectivity has been implemented using GIS analysis. Online data entry from spot location is linked to attribute data of main GIS database putting the whole GIS database updated at every moment. Development of web GIS has allowed transparency in the system and enabled public as well as government officials to know about the updated status of any sanctioned road project by visualizing information on the map along with project report.

Voluntary Geographic Information is used to integrate field data in real time. It allows public to create and contribute geospatial facts of the field; it specifies both spatial and non-spatial information of any particular location.This has been possible with the help of field-based mobile GIS which uses mobile communication network and the internet as the principal communication medium for mobile spatial information service framework.

GPS as a Navigation Tool

Global Positioning System (GPS) technology helps in maintaining and updating geodetic and atmospheric data. It provides correct latitudinal, longitudinal values and altitude of any spot location. Further, it is indispensable for surface navigation through the road network. GPS is widely used for large scale mapping and real-time mobile mapping.

In highways, GPS technology has been providing information to vehicle drivers regarding the direction of navigation, the shortest route to any destination, pockets suffering from the traffic jam and related issues. In future, all the countries will introduce this service to all the major cities and for all major thoroughfares. Thus web cartographic service would be indispensable for navigators/drivers who know little about the route to follow to their destination.

Cartography and Land Information System

Cartography is now an important aid for providing urban amenities in rural areas and smart city development and planning – in providing necessary information and services, restoring database for infrastructural development.

Cartography and Building Information System

Cartography now plays a key role in building design and architectural planning for high rise buildings and would continue to do so in all the mega cities.

Cartography for Ocean Studies

More and more human population would depend on ocean resources for sustaining huge population. Sea surface temperature mapping, sea depth study, Water quality monitoring, assessment of underwater flora and fauna would be common aspects of research. Remote sensing could help a lot to generate real time images and graphics for these environs.

Cartography for Weather Mapping and Forecast

As weather satellites provide information on cloud cover and movement of clouds in near real time, forecast about possible cloudburst and flood could be disseminated to the public. People could be alerted through television channel with the help of graphics/ 3D models showing the distribution of warm front and a cold front, the area under thick cloud cover/ overcast sky, potential areas to receive heavy rainfall, etc.

CONCLUSION

For a developing country like India with rapidly increasing population, urban slums and encroachments, the problem of vehicle parking, need to supply consumables in daily markets regularly, for infrastructure development, environmental management, sustainable development of resources are needed for further progress. By preparing maps, changes in all these issues could be recorded. This is useful for disaster management also. Earthquakes, landslides, areas ravaged by tropical storms, changing coastlines could be monitored by modern technological tools and data could be recorded.

A map is better than a million words. Geographical Information System and geospatial data are poised to give a boost to geospatial thinking. Easy reach of Free and Open Source geospatial software would ease out a generation of digital vectors of spatial data for society. Rapid urbanisation and industrialisation go on side by side. GIS helps in understanding the environment properly and helps in planning remedies for any possible impact on the urban population.

Not only the mapping of earth resources and its geo-political set up, but mapping of surface of Mars, moon and other space objects, spacecraft route mapping, ocean resource mapping, meteorological research and demonstration of weather phenomena, socio-political problem zone mapping in near real time, all fall under the realm of 21st century cartography.

Spatial information of varied nature, whether physical, climatic, agricultural, industrial, demographic or political; or pertaining to specialised discipline like geology, meteorology, botany, archaeology, sociology, defence and a host of other fields that are coming up serially with growing complexities of environment and society, is communicated to a user in a number of ways, and a map is one of the popular forms. Let us hope for a better and wider scope of cartography in future.

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NEW MAPPING TECHNOLOGIES AND SMALL TOWNS – CASE STUDY BALLARPUR (CHANDRAPUR DISTRICT, MAHARASHTRA)

Dipanwita DASGUPTA[1], Namgyal Tshewang BHUTIA[2]

ABSTRACT

Cartography, oldest manifestation of amalgamation of art and science has evolved continually from paintings in Babylonian caves to interactive web maps. However the key to defining the path of progress in cartography is the popularity, availability and adaptability of the product of endeavour - the maps in various formats among its users. For the purpose, an appraisal needs to be made on the available spatial information at all level of urban hierarchy and "cartographic apartheid" if any exists needs to be identified and rectified. The user range for maps is unending. In the Indian context, the common man living in small towns and villages with their numerical majority and improved literacy rates forms a very significant proportion of potential map users and buyers. To harness these probable users, analysis regarding their inclination for maps, the availability of maps of their interest and familiarity with the internet is a pre-requisite. Ballarpur, a class II town in Chandrapur district of Maharashtra is selected for case study on the mentioned aspects. It is an effort to bring to light before the cartographers the quality of spatial data and maps of lesser known towns of India. Different related organisations were contacted and the internet was intensively explored to assimilate the available spatial data and maps of the town for the righteous appraisal. The demand side aspect of maps has also been surveyed and analysed to develop innovative ideas to popularise maps among this population. Around 200 literate adults were randomly sampled (questionnaire survey) in October, 2014 to understand their perspective on maps. Further, they were questioned on aspects like accessibility and adaptability to internet usage and other related aspects to draw a conclusion on user aspirations to guide the cartographers for output generation.

Keywords: *Geoportal, HTTP, PHP, PostGRESQL, Analog*

INTRODUCTION

The focus of research in the field of cartography has been primarily centred on the technological progress in the discipline and application of maps and its attributes by the professionals. However, the research needs to be extended to the appraisal of existing spatial data and maps at grass root level comprising of every small town and villages of India. This database can make significant contribution for national planning and progress. The concept dawned upon the author while participating in the preparation of town maps of Pratapgarh and Sultanpur (Uttar Pradesh) and Bilaspur (Himachal Pradesh). Very little information about the spatial aspects of the towns was available on the internet and the 'town map' provided by the authorities were no better than a sketch and could not be georeferenced. Thus a notable drawback in the aspect of urban mapping is that there exists redundant mapping of certain places by different organisations whereas other places are 'cartographically neglected.' A city like Pune (Maharashtra) has been mapped (or being mapped) with intensive details by MRSAC (Maharashtra State Remote Sensing Agency) and under NUIS (National Urban Information System) apart from private agencies like city map prepared by Eicher, a detailed town map of Burdwan (West Bengal), Port Blair (Andaman and Nicobar), Chandigarh, Dharamsala (Himachal Pradesh), Amritsar (Punjab), Allahabad (Uttar Pradesh) etc has been (are being) prepared by both NATMO and NUIS. These are few examples of places being redundantly mapped with similar objectives. But a large number of underdeveloped 'small towns' and villages in the country are neglected. Limited spatial information is available for these places and information available is often unsuitable for cartographic representation.

Another important aspect that is often overlooked in cartographic research is the popularity of maps among non-professionals especially among the population living in suburban and rural India-where technological constraints are prevalent. Map users are the pollinating agent of maps and so an evaluation needs to the conducted on the users' views and demands from the cartographers.

With this perspective a study was conducted on a class II town, Ballarpur (Chandrapur district, Maharashtra) for analysing the quality and quantity of available spatial database by making an intensive exploration of all possible sources of spatial data for the town. Further a random sample survey of 200 adult, literate population of the town was conducted

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to understand the popularity of maps and related aspect among the masses.

STUDY AREA

Ballarpur town in Chandrapur district, Maharashtra is positioned at 19.83°N and 79.35°E with altitude of 188m and an areal coverage of 16.51 sq km (Fig. 1). The population of 89,995 is housed in 32 wards

Fig. 1: Location of Ballarpur

aggregated into 8 *Prabhag*s. The town is bordered by the Wardha R. in the west, Tadoba Reserve Forest demarcates its eastern limit, south of the town lies the Western coalfield and the northern limits presently nearly fuse with the town of Visapur. The town came in limelight after the Avantha group established their flagship paper factory Ballarpur Industries Limited (BILT).

The town has tremendous growth potential owing to its site on the Maharashtra-Andhra Pradesh border connected by State Highway 264. It is the halting station of every north-south bound train of the central railways. The water supply from the Wardha river, timber, and Gondwana coal seams are the natural endowments to the town. Despite this, the town remains a socio economically backward town in the naxal affected Gadchiroli-Chandrapur belt. It stands as a typical representative of a 'small town' in India with inadequate facilities of public amenities, entertainment, internet connectivity and public transport. Lower middle class and slums dominate the urban residential pattern.

OBJECTIVES

The study was conducted with the following jectives: a) For appraisal of the quality of maps and existent spatial database of the town b) To analyse the popularity and choice of map among the people

DATABASE AND METHODOLOGY

To fulfil the aims of the study the following tasks were undertaken:

1. Town map of Ballarpur by the municipality/ planning office was collected. Government mapping institutes were requested to provide any available map of Ballarpur. Websites were intensely searched to find status of web maps available for the town. The town map (Fig. 2) from the municipality was the only available map.

Source: Balarpur Municipality

Fig. 2: Town Map

2. Large scale map (1:8000) of the town based on Google earth, using Quantum GIS software and Adobe Illustrator was prepared. Attempt was made to make the map more aesthetic, informative and communicative than the available municipal map. For the purpose intense individual field survey was undertaken to assimilate spatial and attribute information about the town land use and town entities. The map (analog) prepared by the author followed the conventions of popular analog maps. The map was colourful, symbolized, labelled, gridded, had index to labelling facilitating easy visualisation and understanding of town environ.

3. Apache server developed by Apache foundation was installed in personal laptop for the laptop to act as an internal web server. Map server for windows was installed in the computer to act as internal map server. Hypertext pre-processor codes (PHP) embedded in html were used as

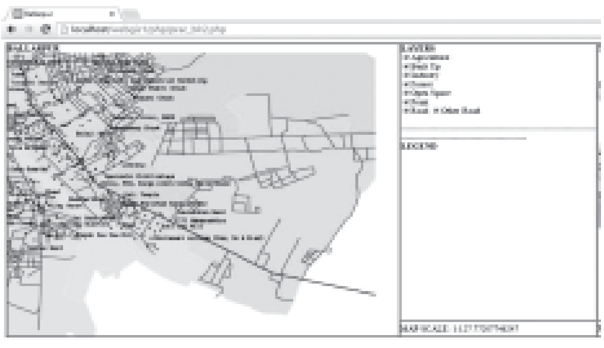

Fig. 3: Excerpt from web map of Ballarpur Town

Application connector to link the shapefiles (.shp) to the map server. PostGRE sql acted as the data storing platform. Thus an interactive web map of Ballarpur embedded in html with visible scale, legend, capable of toggling layers and panning was created and could been seen in the personal laptop.

4. Structured questionnaire regarding knowledge and possession of modern technology, popularity and choice of map of people was made. For the purpose the three kinds of available town map – the municipal map, the hard copy map prepared personally and the web map prepared were shown to the surveyed population (2014). The results of the enterprise are discussed below.

DISCUSSION AND ANALYSIS

The search for maps and spatial data base of the town yielded the described result. The town map obtained from the municipality was a monochromatic hard copy map with existing and extended municipal limits at a scale of 1:5000. No projection was defined. The road and railway lines were drawn. Some important town features were connoted like Ballarpur Industries Limited (factory and colony), Western Coalfields limited, Dadabhai Potteries, MJP College, Dilasagram and Montfort schools etc. No digital database of the map existed. Thus the map left tremendous scope for improvement in aesthetics and information. Most annotations were hardly legible with the features all jumbled. Hence, the map fumbled in both element of science and art.

The quest for a detailed large scale map of Ballarpur in the internet yielded little result. The Google earth search for the town, led one to the town but without much attribution about the features. The town information available from www.wikimapia.com was no better. Searches on the official website of Maharashtra government (www.maharashtra.gov.in) showed .asp based district maps but no detailed town map of small towns of the state. The Maharashtra town planning organisation provided a plan of the town that was similar to the map provided by the municipality except that it was in colours. The authorities clarified that there was no digital spatial database of the plan and the map or plan was manually prepared. Maharashtra Remote sensing agency only showed some maps of Nagpur town, district and taluka maps of Chandrapur, Maharashtra but no town map of Ballarpur. The Ballarpur features nowhere in the list of towns to be mapped by NUIS, project AMRUT of Town and country planning organisation and NATMO.

The next aspect of the study was related to the map awareness, map popularity and technological adaptability of the population. Presented in table 1 are details of the respondents of the survey conducted:

Table 1
Age Profile of Respondents

Age Group	*Respondents*	*Male*	*Female*
18-30	70	45	25
30-45	65	42	23
45-60	45	33	12
>60	20	15	5
Total	200	135	65

Source: Computed from Primary Survey.

In the first part of the questionnaire the focus remained on the popularity of maps, map formats and demands among the users. The following questions were framed for the study:

Have the respondent ever seen the Ballarpur town map? If yes then where and in what format. The reply to the question is summarised in the table 2:

Table 2
Response on Seeing Town Map of Ballarpur

Town map format seen by the user	18-30			30-45			45-60			>60		
	P	M	F	P	M	F	P	M	F	P	M	F
Printed town map from government bodies	17	10	7	20	15	5	25	20	5	9	8	1
On the internet	30	20	10	24	15	9	7	5	2	1	1	0
Both	15	10	5	13	10	3	7	5	2	0	0	0
Never	8	5	3	8	2	6	6	3	3	10	6	4

Source: Computed from Primary Survey.

More than 80 percent, in the age group 18-60 years have seen the town map. About 50 percent of the senior citizens surveyed have seen the town map. 42 percent of the young generation (18-30 years) have seen the cartographic representation of the town in Google and other popular websites, 36 percent in the age group 30-45 followed similar trend. Only 15 and 5 percent of the population in the age group 45-60 and above 60 respectively have seen the cyber version of the map (Google map). On the contrary, more than 50 percent of population above 45 years have seen the analog map available with municipal bodies whereas only 20 percent in the age group 18-30 have seen it. Around 20 percent and 15 percent in the age group 18-45 and 45 to more than 60 have seen both the formats.

With regard to the question related to map use by the respondents more than 60 percent of the population in all the age groups refused to acknowledge the use of maps for other than educational purpose. On an average,15 percent of the population in all groups used maps during tours. The 45-60 years age group particularly use it for the mentioned purpose . Youngsters in 18-30 years age group and a considerable proportion of the population in 30-45 years age group used maps for directional guidance while driving.

When the respondents were questioned?
When does the respondent use map?
Has the respondent ever purchased any map? Why ?

Most of the respondents answered that they have never purchased any maps other than the mandatory school maps and atlases. Only around 20 percent of the population in all groups have purchased maps on non compulsive grounds, the maps being mostly tourist maps at their site of visit or wall maps of India or the world. The third part of the questionnaire dealt with the popular choice of maps. For the purpose four types of map of Ballarpur town –map prepared by the municipal body, analog and web compatible map prepared by the author, Google earth was shown to the respondents to know their map preference. The table below illustrates their response:

Table 3
Map Preference among Respondents

S.No	Sources of Maps	*18-30 years*			*30-45 years*			*45-60 years*			*<60 years*		
		P	*M*	*F*	*P*	*M*	*F*	*P*	*M*	*F*	*P*	*M*	*F*
1.	Map by government body	1	0	1	0	0	0	0	0	0	0	0	0
2.	Map (analog) prepared by the author	32	22	10	29	17	12	25	17	8	19	14	5
3.	Google Earth/ Map	17	11	6	15	10	5	9	7	2	0	0	0
4.	Web Map prepared by the author	22	14	8	21	15	6	11	9	2	1	1	0

Source: Computed from Primary Survey

Thus two genres of analog and digital map were shown to the respondents. From the study of map preferences in the presence of choice, most respondents did not prefer the map prepared by the concerned government authorities. Around half the respondents in the age group 18-45, 55 percent percent in 45-60 years and 90 percent of the senior citizens chose the analog map prepared by the user. Around 24 percent, 23 percent, 20 percent and none of the population in the age group 18-30, 30-45, 45-60 and more than 60 years opted for Google map or wikimapia. 31 percent, 32 percent, 24 percent and 5 percent in the age group 18-30, 30-45, 45-60 and more than 60 years opted for web map prepared by the author. However, the majority (70 percent) claimed that they consider the 'print out format' more authentic. Around 75 percent of the respondents claimed that if they are provided a analog map like prepared by the author at reasonable rates they will purchase it. 65 percent of these 75 percent people claimed the reasonable rate to be around Rs 25 to Rs 50. About 15 percent wanted the rate to be less than Rs 25 and the rest suggested the rates to be between Rs 50 to Rs 100. No one was ready to pay more.

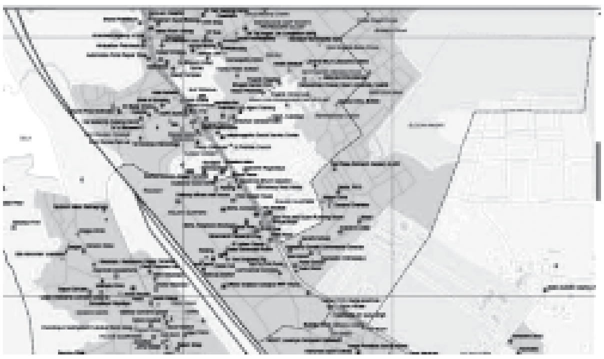

Fig 3: Excerpt from Town Map of Ballarpur prepared by the Author

Finally the respondents were asked about their demands from a map maker. Their replies can be broadly categorised as:

- Maps should be made in the regional language and many have difficulty in reading English.
- More detailed information of the amenities should be presented in the maps.
- The aspect of technological acquaintance and possession was evaluated based on two

questions:

- Knowledge of usage of the internet through computers(desktop/laptop) and/or smart phones
- Personal or family possession (where individual has knowledge is allowed the access) of computers or smartphones

The percentage of surveyed population possessing cyber knowledge declined with increase in age. 92 percent of the population in the age group 18-30 years were technologically sound whereas the proportion of such population declined to 80 percent, 66 percent and 10 percent with increase in age group viz 30-45, 45-60 and above 60 years respectively. Around 45 percent of the population in the age group 18-45 years possessed or had easy access to cyber technology which declined to 36 percent among the age group 45-60 years and was marginal for the retired population. The district census handbook of Chandrapur district (Maharashtra) tabulated that only 5.74 percent of the urban population of sub district Ballarpur (it includes Ballarpur and Visapur towns) possess laptop or computer. Further only 2.77 percent has internet connection.

CONCLUSION

Adequate organised spatial data is the key to creation of a spatial unit with improved standard of living through better traffic management, assured supply of time bound services and provision of security. It is from the spatial data and its representation in the form of map the fallacies in the sector of provision of services can be most conveniently visualised. Further a well designed map published on the web provides an exposure to a town for being analysed as a destination for residence, business or investment. Hence, organised spatial database plays a significant role in town planning and development. However, small towns like Ballarpur which have tremendous potential to develop, have acute shortage of spatial information. So it is the responsibility of the cartographers to identify such places and reduce the 'cartographic apartheid' prepare a comprehensive database of such areas for their development and planning instead of redundant mapping of popular stations. It can be suggested that a list of towns in India should be compiled and the present state of spatial information for each of them should be noted to interrogate the loopholes. Hence necessary corrective measures can be implemented. Let the basics be corrected first.

Summarizing the findings of the second part of the study people visualise maps primarily as an academic object. But, simultaneously inquisitiveness to view the living space is dominant as majority of the population has seen the town in the internet or through town map despite of it being vaguely available, poorly drawn and sparsely informative. This aspect of the thought process of the population needs to be harnessed to popularise maps and study of maps among people. A well sketched town map in both static and dynamic forms should be made easily available to the inhabitants to explore the utility of maps. As soon as the population will start realising the potential of map for exploration, analysis and hypothesis deduction their inclination towards maps and its purchase will improve benefitting the subject of cartography. Another prevalent aspect of psychology of this population is that they consider analog maps as more authentic though web maps are more useful (analytic). Hence there exists demand for maps in both hard copy and web formats and population should be provided easy access to both formats.

Urban India is getting digital and there are intensive research advanced cartographic techniques like 3D mapping and real time mapping. But there exists some basic lapses. This paper is an attempt to highlight one such drawback that be conveniently overcome for the progress of cartography and enrichment of its basic input the spatial data.

"To put a city in a book, to put the world on one sheet of paper — maps are the most condensed humanized spaces of all...They make the landscape fit indoors, make us masters of sights we can't see and spaces we can't cover."

—Robert Harbison, Eccentric Spaces

REFERENCES

1. District Census Handbook of Chandrapur (Maharashtra) India Handbook, 2001 and 2011
2. Ghosh. Sumita(1998). Introduction to settlement geography, Orient Longman, pp. 5-15
3. Haklay, M. (2010). Interacting with geospatial technologies. John Wiley and Sons Ltd. pp 132-145
4. Krishnamurthy, J., Natarajan, S., Krishnaiah, P., Kalyanaraman, K. (2004). Large Scale Mapping using high resolution satellite data. Global spatial data infrastructure, 7th Conference
5. MacEachren, A. (2008). How maps work. The Guilford press. pp 257-260
6. Magure, D.J., Longley, P.A. (2005). The emergence of geoportals and their role in spatial data infrastructures. Elsevier 29 (2005), pp. 3-14
7. NATMO, (1992). Urban studies series 4: Medinipur, Published by National Atlas and Thematic Mapping Organisation, Government of India, Kolkata.
8. NATMO, (1995). Urban studies series 5: Hospet, Published by National Atlas and Thematic Mapping Organisation, Government of India, Kolkata
9. http://bhuvan-noeda.nrcs.gov.in
10. http://chanda.nic.in/htmldocs
11. http://www.citypopulation.de/India-Maharashtra.html
12. http://www.esri.com/software/arcgis/geoportal/live-user-sites.html

PRELIMINARY DATA ANALYSIS OF IRNSS FOR PNT SERVICES

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ABSTRACT

Indian Regional Navigation Satellite System (IRNSS) is an independent regional satellite navigation system fully planned, developed and controlled by the Indian Space Research Organization (ISRO). It is designed to provide a position accuracy of better than 20 meters in the Indian Ocean as well as a region extending approximately 1500 km around India. IRNSS constellation is to consist of seven satellites, out of which four have already been placed in orbit. These four IRNSS satellites are continuously broadcasting the navigation signals and hence autonomous 3D positioning with IRNSS constellation-only has now become possible. IRNSS provides two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorized users. The IRNSS SPS service is transmitted on L5 (1164.45 – 1188.45 MHz) and S (2483.5-2500 MHz) bands.

In the present study, IRNSS receiver (Code only) was setup using a tripod over a base station whose co-ordinates were precisely derived with respect to IGS stations. The IRNSS data is being collected continuously over base station in three modes, viz. IRNSS DF (dual frequency), GPS only and IRNSS DF+GPS Hybrid mode and data has been analysed for positional accuracy and with related to several survey technical aspects such as GDOP, signal-to-noise ratio (SNR), time taking for first fix (TTFF) etc.

Initially one week IRNSS data was processed to derive average coordinate over the base station which was further compared with apriori base coordinates and estimated an accuracy of 7 meter RMS in 3D position. The study is further extended to data collected for various durations i.e., one minute, one hour, four hours and one day for different modes and compared with base station co-ordinates. Poor accuracy has been observed at some distinct times of the day due to the poor GDOP at the time of data collection. The occurrence of Poor GDOP is observed at every 12 hours because of the co-planarity condition of IRNSS constellation. The IRNSS receiver was also used to experiment with kinematic mode, in addition to regular static mode of operation. The results were found to be better than 5m in position.

Keywords: *ISRO, IRNSS, GNSS, TTFF, GDOP, IGS*

INTRODUCTION

Satellite navigation system provides geo-spatial positioning at anytime of the day under any weather condition. Currently, United States GPS (Global Positioning System) and Russian GLONASS (Global Navigation Satellite System) are the only fully operated global navigational satellite systems (GNSSs). China is developing a global navigation system called COMPASS by enhancing their existing regional navigational satellite system Beidou. In addition, the European Union is developing a global navigational satellite system called Galileo, and scheduled to be fully operative around 2020. In addition, countries such as France, Japan and India are developing their own regional satellite navigation systems.

Indian Regional Navigation Satellite System (IRNSS) is an independent regional satellite navigation system fully planned, developed and controlled by the Indian Space Research Organization (ISRO) to provide reliable position, navigation and timing (PNT) services at anytime and in any weather condition over India and neighboring countries.

IRNSS SYSTEM

IRNSS system mainly consists of three segments viz. Ground segment, Space segment and User Segment. The description of these segments is shown in Fig.1.

Space segment: The space segment of IRNSS system would consist of a constellation of seven satellites. Three of the satellites will be located in geostationary orbit at 32.5° E, 83° E, and 131.5° E longitude at 36000 km altitude. Four satellites will be in geosynchronous orbit at 35,786 km with an inclination of 29° to the equatorial plane with their longitude crossing at 55° E and 111.75° E (two satellites in each plane) as shown in Figure-2. Such an arrangement would mean all seven satellites would have continuous radio visibility with Indian control stations.

Ground segment: The ground segment of IRNSS constellation would consist of a Master Control Centre (MCC), ground stations to track & estimate

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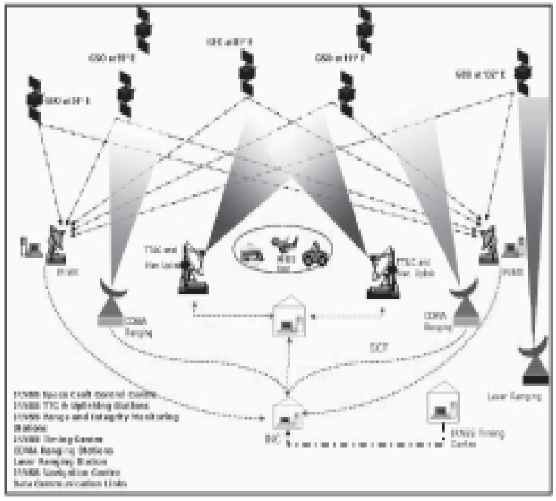


Figure-1: Space, User and Ground segment of IRNSS

predict the position of all IRNSS satellites, calculate integrity, makes necessary ionospheric and clock corrections and run the navigation software. The additional ground stations (TT&C stations) monitor the satellites with the capability of issuing radio commands to them.

User segment: The user segment consists of specially designed receivers. Several types of receivers are planned with single and dual frequency reception capabilities. Single frequency receivers may be provided with capability to receive ionospheric corrections. The user receiver may receive other constellations inclusive of GPS, GLONASS, and Galileo in addition to IRNSS. (Refer ICD document)

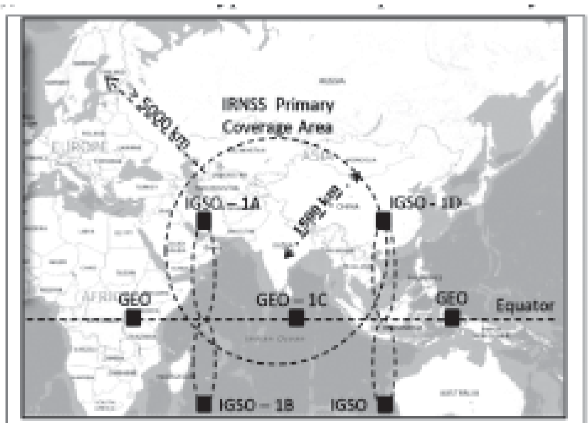


Figure-2: IRNSS constellation coverage

IRNSS provides two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorized users. The IRNSS SPS service is transmitted on L5 (1164.45 – 1188.45 MHz) and S (2483.5-2500 MHz) bands.

It is expected to provide positional accuracies of better than 20 meters in the Indian Ocean as well as for region extending approximately 1500 km around India between longitude 40^0 E to 140^0 E and between latitude + 40^0. The coverage of IRNSS constellation is shown in Figure-2.

Advantages of IRNSS System

- The development of IRNSS increases the self-reliance during militarily disturbed times. The Restricted Service Signal will provide greater flexibility for defence and Aviation users.
- A combination of single frequency Hand-held receivers with low weight and reduced cost along with GAGAN signal, the Indian Satellite Based Augmentation System (SBAS) and real time ionospheric corrections will give more accurate position as compared to dual frequency receivers for civilian users. (A.S.Ganeshan et al., 2015)

Presently out of seven satellites, four satellites namely IRNSS-1A, 1B, 1C & 1D have already been placed in orbit. These four IRNSS satellites are continuously broadcasting the navigation signals and hence autonomous 3D positioning with IRNSS constellation-only has become possible. (A.S.Ganeshan et al., 2015)

OBJECTIVES

The main objective of this study is to analyse the IRNSS data for:

- Positional accuracy with respect to GNSS data.
- Accuracy for different durations – 1 second, 1minute, 1 hour, 4 hours and one day.
- Analyzing GDOP values & patterns produced.
- Potential of the receiver to carry out kinematic surveys.
- Data quality parameters such as SNR and TTFF etc.

IRNSS RECEIVER SETUP

The IRNSS receiver was developed jointly by ISRO and Accord Software & Systems Pvt. Ltd. A typical IRNSS system consists of one antenna, one receiver called as IRNSSUR (IRNSS User Receiver), a battery, receiver and antenna cables and IRNSSUR software on a dedicated laptop which acts as a controller.

Fig. 3 & 4 shows the controller and antenna setup over a base station at NRSC, Hyderabad.

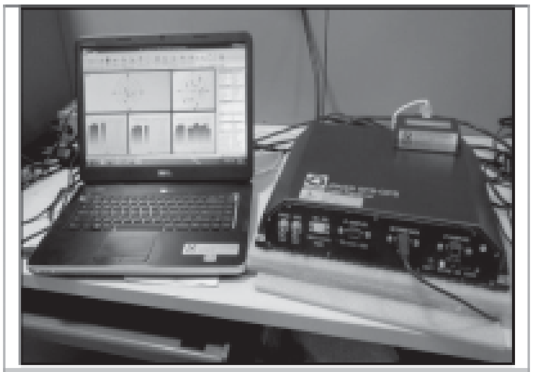


Figure-3: IRNSS controller setup

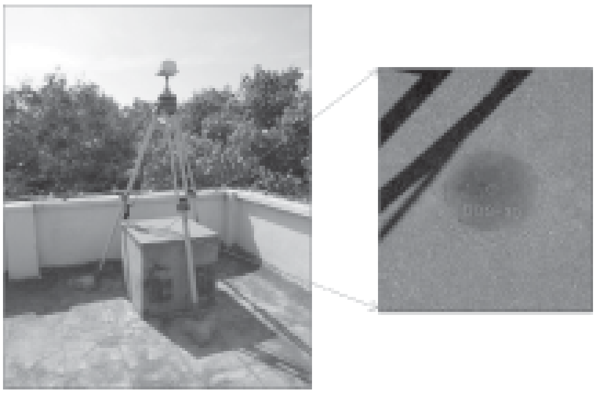


Fig.4: IRNSS antenna setup on monument of base station at NRSC Hyderabad

The IRNSS antenna was setup over a known/base station using a tripod. This base station is a monument point (GCPL Network Zero order station DOS-30 at, NRSC, Hyderabad) whose co-ordinates were precisely derived with respect to IGS stations to an accuracy of 3cm. Tripod is centred and levelled to the zero order point with 3mm accuracy. The IRNSS data is collected continuously over the base station in three modes, viz. IRNSS DF (dual frequency), GPS only and IRNSS DF+GPS Hybrid mode. At present this receiver is capable of receiving only code data and not phase/carrier data.

The IRNSSUR software acts mainly as an interface to log IRNSS and GPS data. In addition to logging, it provides system status, signal strength for each satellite, information of GPS satellites, user position information such as X, Y, Z, HDOP, PDOP, VDOP etc. This receiver is capable of receiving IRNSS and GPS signal simultaneously. Figure-5 shows the skyplot of IRNSS and GPS satellites.

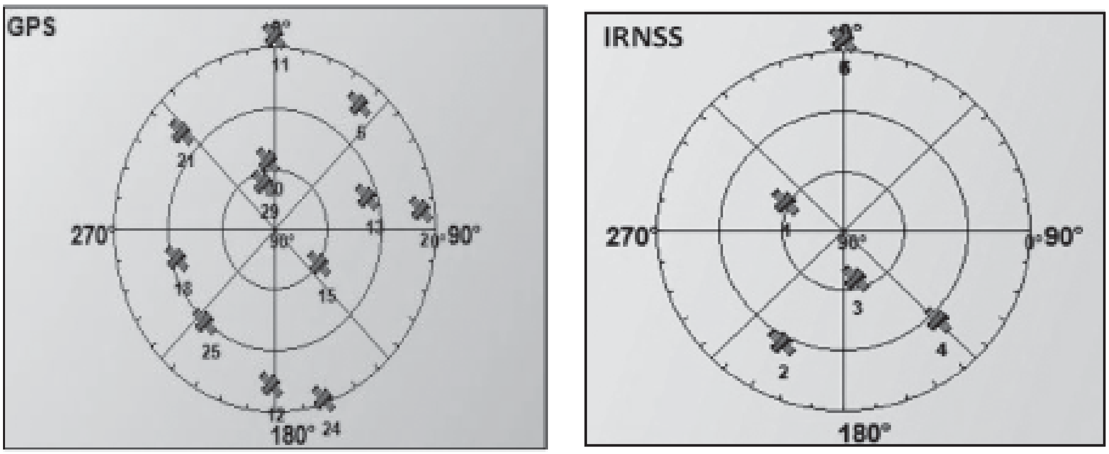


Fig. 5: Skyplot showing position of IRNSS and GPS satellite over base station NRSC Hyderabad, on 05-11-2015 at 12:15 local time

IRNSS DATA ANALYSIS AND RESULTS

The positional accuracy is eventually expressed in terms of UERE (User Equivalent Range Error). The UERE is the combination of the following errors.

- Ephemeris and clock errors
- Atmospheric errors like ionosphere and troposphere
- Receiver errors like rover noise, antenna design
- Site errors like multipath, signal blockage etc.

The one sigma navigation error is calculated by multiplying UERE with GDOP (Geometric Dilution of Precision). The DOP value represents the relative position of satellites to determine the level of precision in each dimension of the receiver measurement. When visible satellites are close to each other in the sky, the geometry is said to be week and DOP values are high. DOP values are low when satellites are far apart. Thus a low DOP value represents a better positional precision due to the wider angular separation between the satellites used to calculate a receiver unit's position.

In general, overall UERE from different error sources is around 5.5 to 6.0 meters and an average GDOP of 2.3 to 2.4 m gives an average UERE of 15.25m.

MATLAB code was used to process IRNSS data and to estimate the position coordinates i.e Latitude, longitude and altitude and 3D RMS of position. IRNSS data is generally logged week by week, so a single log contains data for a whole week in all the three modes. The same MATLAB file is used to analyze the data for 1 day, 4 hours and so on. The MATLAB code allows the user to select the configuration such as only GPS, Only IRNSS, GPS+L5, GPS+S etc.

GDOP Analysis:

It is observed that the GDOP is occasionally reaching maximum up to ~1600 because at present only four satellites available. To understand this better, we analyzed the GDOP values for several logs and observed that GDOP value is reaching to maximum at every twelve hours. It is a recurring phenomenon. The reason for such occurrence of maximum GDOP is due to the occurrence of co-planarity condition in the constellation of IRNSS satellites.

The one hour average of IRNSS only data is compared with base co-ordinates. The average is taken for each hour for 24 hours data. It is observed that the difference is increasing gradually and reaching to maximum at every 12 hours because of increase in GDOP in every 12 hours. It is observed that at 12th hour the GDOP reached to ~1600 and the maximum difference went up to ~10,000m. The Fig. 6 shows the comparison for 24 hours data and Fig. 7 shows the corresponding GDOP variation for the 24 hours.

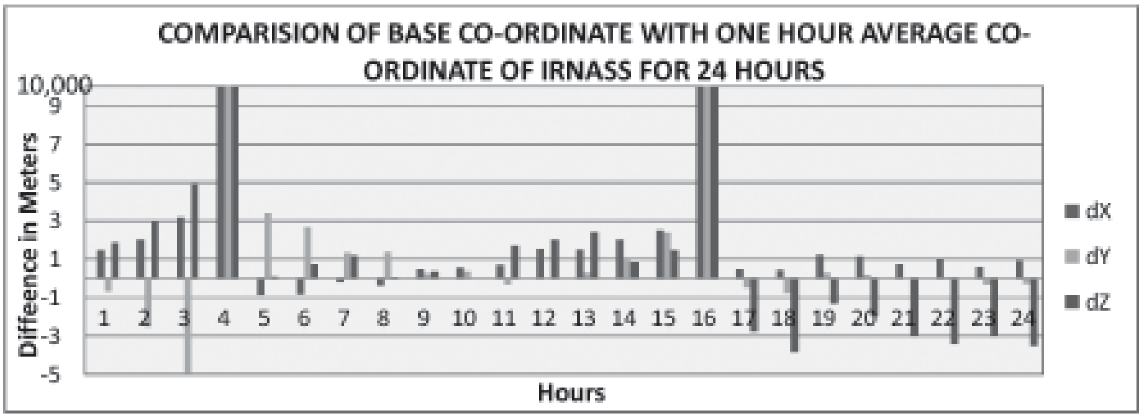


Fig. 6: Positional Variation at Every one Hour in X,Yand Z

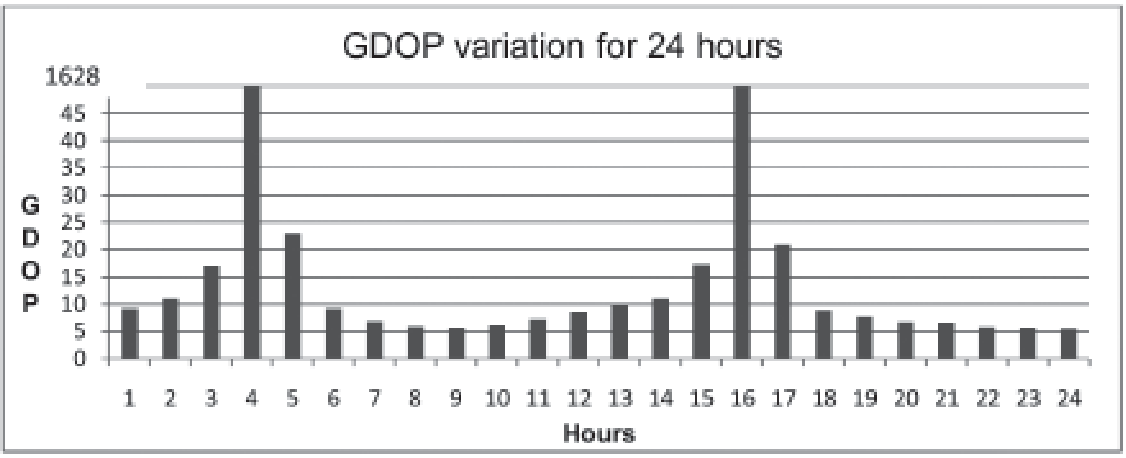


Fig. 7: GDOP Variation at Every One Hour

Analysis for Weekly Data

3D RMS is computed for GPS, IRNSS only (IR) and IRNSS+GPS hybrid (IRGP) data for a log of one week and analysed with known coordinates of DOS-30. During this calculation GDOP value for IR data greater than 15 are not considered. It is observed that the 3D RMS values range in 5m accuracy in GPS, 7m accuracy in IR, 4.5m in IRGP.

Analysis for Various Durations of Data

The 3D RMS is computed for various time durations i.e., 24 hours, 4 hours, 1 hour, 1 minute and 1 second data sets and analysed with known coordinates of DOS-30.

The comparison is done for better and poor conditions of GDOP to understand the least accuracy of the IRNSS receiver. Under good GDOP conditions, 21.6m, 2.4m, 3.2m 5.2m and 7.3m accuracy is observed for 24hrs, 4hrs, 1hr 1minute and 1second respectively for IR data whereas 3.5m, 3.7m, 4m, 5.4m and 5.6m accuracy is observed for 24hrs, 4hrs , 1hr, 1minute and 1second respectively for IRGP data. Under poor GDOP conditions, accuracy of 18.9m, 63.3m, 137.1m, 840.5m and 1570.1m is observed for 24hrs, 4hrs, 1hr, 1minute and 1second respectively for IR data whereas 6.2m, 10.6m, 10.5m 29.6m and 30.2m accuracy is observed for 24hrs, 4hrs, 1hr 1minute and 1second respectively for IRGP data. Fig. 8 and Fig. 9 shows the 3D RMS comparison with DOS-30 for better GDOP and poor GDOP conditions respectively.

DURATION	IRGP 3D RMS	IR 3D RMS
24 hours	3.449	21.656
4 hours	3.649	2.416
1 hour *	4.060	3.237
1 min *	5.441	5.261
1 sec *	5.642	7.393

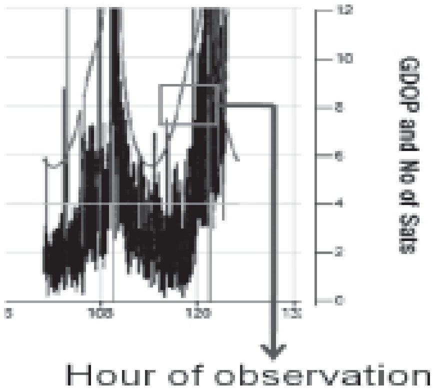


Fig. 8: 3D RMS comparison with DOS-30 – Better GDOP

DURATION	IRGP 3D RMS	IR 3D RMS
24 hours	6.250	18.934
4 hours	10.646	63.338
1 hour *	10.543	137.162
1 min *	29.621	840.579
1 sec *	30.267	1570.143

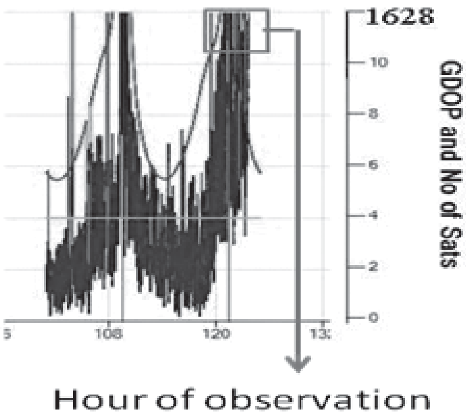


Fig.9: 3D RMS Comparison with DOS-30 – Poor GDOP

It is observed that there are huge 3D RMS values for IRNSS-only data under poor condition. However under the same conditions, good values of 3D RMS can be found since the IRNSS data is augmented by GPS data.

Data Analysis for Kinematic Surveys

In another study, IRNSS receiver's applicability for kinematic surveys is tested. IRNSS receiver is mounted over a vehicle and driven through highways as well as roads which are covered with light to medium dense canopy. The vehicle is driven in different speeds, viz. low (around 10kmph), medium (around 25kmph) and high speeds (more than 40kmph). The receiver on the vehicle acquires data on the same track/road in three different speeds. The epoch rate of the IRNSS receiver is 1 sec. Position information at each second is derived in real time and overlaid on geo rectified image to check the precision of the real-time positional information by IRNSS receiver. Good care is taken while conducting the Kinematic-IRNSS survey to see that GDOP is well within the range of 5 to 6.

In the first trial, the vehicle is driven at the left edge of the Hyderabad-Nagpur highway. Data from IRNSS receiver is so consistent with the geo-rectified image of high resolution data. The positional accuracy, in this case, is well within 5 meters. Figure-10 shows the results of kinematic survey plotted on geo-rectified image for first trail. Data with different speed is plotted in different colors. It is observed that the deviation between epochs for different speeds is very less.

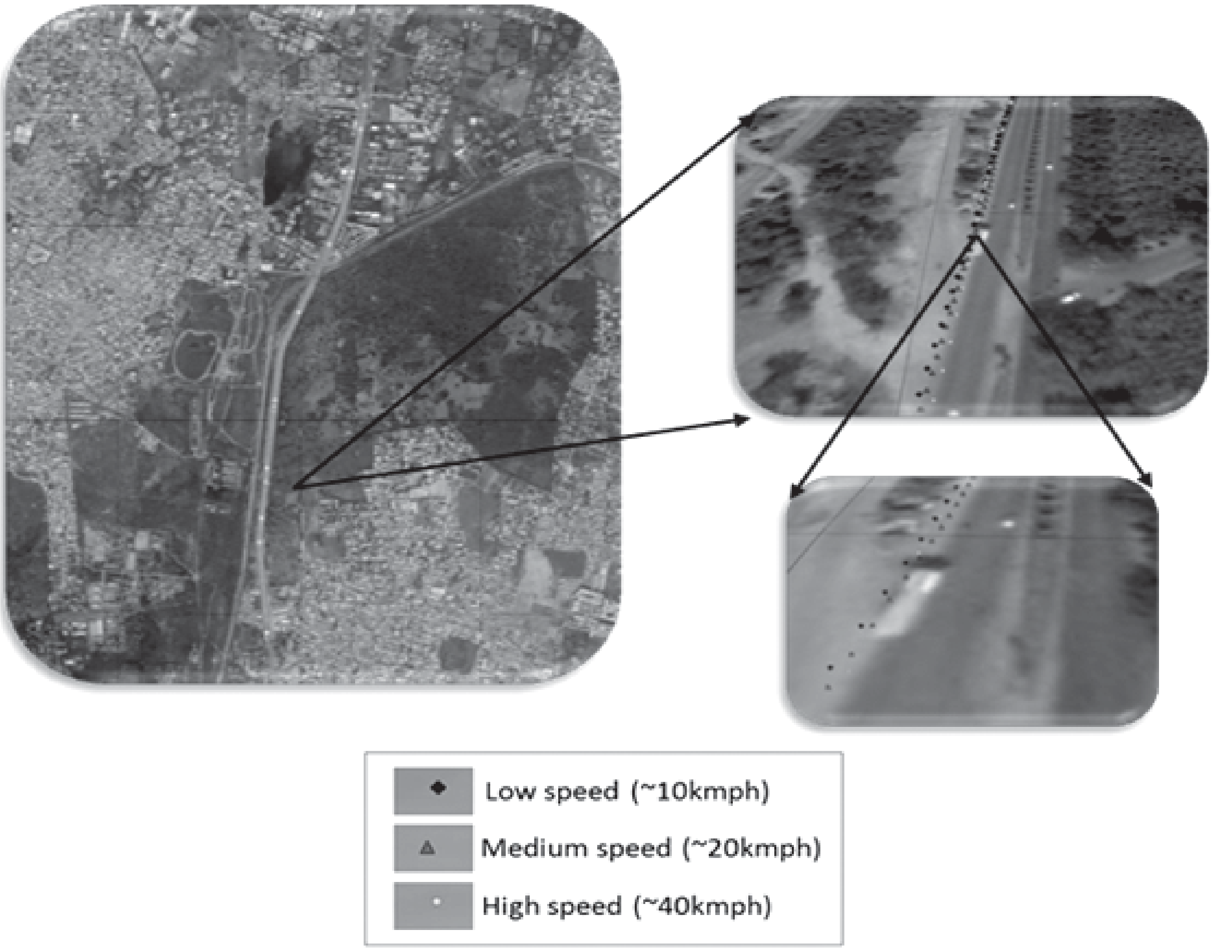


Fig. 10: Results of Kinematic Survey on Hyderabad-Nagpur Highway

In another survey, to further experiment IRNSS receiver in Kinematic surveys, it was driven through the roads that cover light to medium canopy. Here again, it was planned to drive the vehicle in all the three speeds. However, the receiver was able to track the route under light canopy under low speeds but was not able to track during medium speeds. The positional accuracy achieved in such conditions was near to 5 meters. Figure 11 shows the kinematic survey with light to medium canopy. It is observed that the receiver is on and off and it took some time to track the signal again. In the Figure-11 we can observe the gaps between the epochs.

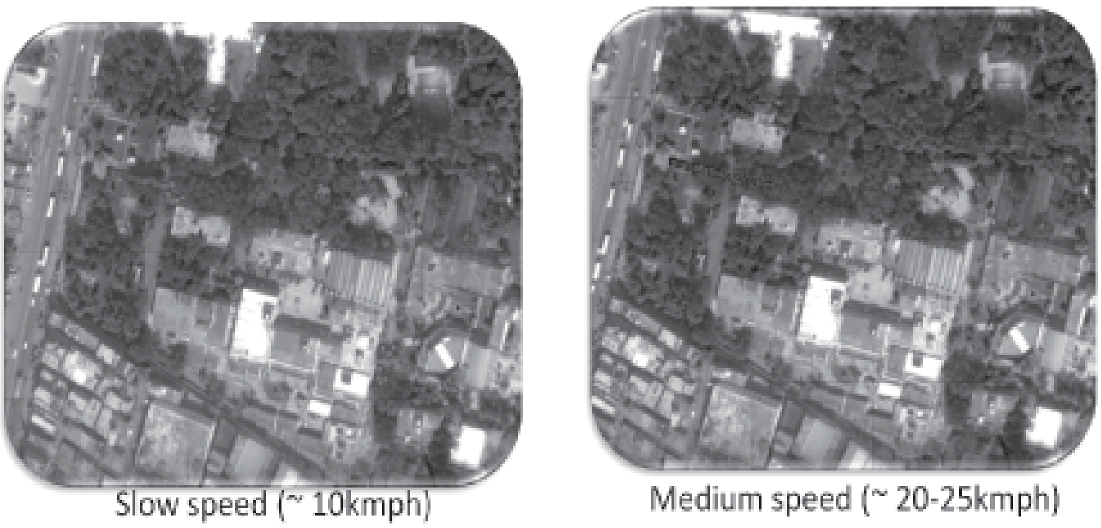


Fig. 11: Results of Kinematic Survey on Road Cover with Light to Medium Canopy

Analysis of TTFF

Time to first fix (TTFF) is the time taken by GNSS receiver to acquire the first satellite signals and to get the position fix. Depending upon the time taken, the start would be called as cold, warm and hot start. It is a parameter by which the ability of the receiver is perceived. IRNSS receiver logs data is analyzed to know the time taken by the receiver to acquire both GPS signals and IRNSS signals separately. A typical GPS receiver takes approximately 22 seconds for hot start and 45 seconds for warm start. The observations tabulated in Table-1 for IRNSS receiver for few logs for IRNSS and GPS constellation.

Table 1
TTFF Observed with IRNSS receiver in IR only and GPS only mode

	IRNSS Receiver	
LOG NUMBER	*IRNSS(sec)*	*GPS (sec)*
1.	84	69
2.	101	98
3.	89	67
4.	53	53
5.	45	40
6.	57	57
7.	67	57
8.	55	58
9.	55	40
10.	66	67
11	79	80

CONCLUSIONS

This study was to understand the functioning of IRNSS receiver and to analyze its positional accuracy, also to understand several of its capabilities and limits. IRNSS receiver is unique in its own way in the sense that the receiver is made capable of acquiring both global and regional satellite signals. The user can also choose the third mode of the data collection of the receiver as IR+GP or L5 or S mode. The IRNSS receiver yields a position fix with a 3D RMS value range in 5m accuracy in GPS, 7m accuracy in IRNSS, 4.5m in IRNSS+GPS. IRNSS data is analysed for GDOP and observed the occurrence of high GDOP values at every 12 hours thereby degrading the positional accuracy at that instance. The reason for this is the co-planarity of the four IRNSS satellites. The IRNSS receiver was also used with kinematic mode, and compared the results with that of kinematic GNSS data and found to be better than 5m in position. Higher TTFF values are observed for IRNSS receiver than those for a commercial GNSS receiver.

Acknowledgements

We are thankful to Dr. V.K. Dadhwal, Director, NRSC and Shri P. Srinivaulu, General Manager, AS&DMA, NRSC for their constant encouragement during the course of study. We are also thankful to SAC, Ahmadabad for providing IRNSS receiver and associated tools

REFERENCES

1. A.S.Ganeshan, S.C Ratnakara, Nirmala Srinivasan, Babu Rajram, Neetha Tirmal, Kartik Anbalagan (2015), First Position Fix with IRNSS, Inside GNSS
2. A.S.Ganeshan, (2015), The complete constellation of 7 satellites of IRNSS will be deployed, July/ August Coordinates Journal
3. IRNSS Signal-In-Space Interface Control Document (ICD) for the Single Positioning Services (SPS).

POTENTIAL EVALUATION OF DEM & ORTHOIMAGE GENERATION USING HIGH RESOLUTION STEREO IMAGE

Sunanda TRIVEDI[1], T. P. SRINIVASAN[2]

ABSTRACT

In today's scenario, orthoimages are much in demand for urban planning, cartography and various GIS application. High resolution orthoimages are available from Indian Cartosat-2(Carto-2) satellite series. Carto-2 provides high resolution panchromatic data in three modes viz. SPOT, Paint Brush and Multi-View. It is expected to generate precise DEM & orthoimage using high resolution data which leads to various applications in the field of cartography. Using multi-view data of Carto-2, DEM is generated and for terrain correction product, C2 orthoimage is generated using this DEM.

Under CartoDEM project, DEM is generated for Indian region using Cartosat-1 stereo images. An exercise is carried out to evaluate the potential of DEM & orthoimage generation using multi-date high resolution C-2 images. Data is selected over Alwar region since appropriate reference data is available for the same region. Input is recently acquired C2 data over Alwar region. Orthokit product is used for this exercise. DEM & orthoimage are generated using COTS software with Cartosat-1 orthoimages and CartoDEM as reference data. Precise control points are used for evaluation of orthoimages. C2 DEM(with 10m grid interval) is compared and analysed with the existing CartoDEM, ASTER DEM and precise aerial DEM. Also, DEM differences are analysed and depicted in terms of histogram, 2.5D, 3D and contour plots. C2 DEM & aerial DEM are found to be comparable in terms of information and accuracy. Further, C2 Orthoimage product is generated using i) C2 DEM, ii) CartoDEM, iii) aerial DEM & iv) ASTER DEM. All the four C2 orthoimages are evaluated with respect to Cartosat-1 orthoimage and precise control points. Evaluation results are tabulated and analysed.

The evaluation and comparative study on C2 DEM & orthoimage reveal that product accuracy better than 3m can be achieved. This technical paper brings out the details on the exercise carried out with the available resources.

INTRODUCTION

Cartosat-2 (C2) satellite provides high resolution panchromatic data using step & stare technique with three different modes of imaging capability viz. paint brush, spot and multi-view. It is a highly agile & high resolution satellite which acquires data in 0.8m spatial resolution with 10-bit radiometric resolution [2]. Generation of precise orthoimage using High Resolution (HR) DEM is one of the major requirements for cartographic applications. In an operational scenario, C2 ortho product is getting generated at NRSC, Hyderabad using Cartosat-1 DEM and reference data. [1]. However, an attempt is made to generate DEM from Cartosat-2 multi-data sets and to evaluate the potential of DEM for ortho generation. For this case study, a multi-date (from multi orbits) data set is selected over Alwar region. An exercise is performed to generate C2 DEM & orthoimage products with this stereo images using COTS software package.

This technical paper describes the C2 DEM & orthoimage generation using COTS package and evaluation of HR DEM and its ortho product. Reference data i.e. CartoDEM, C1 orthoimages & precise ground control points are used for data processing and output product evaluation. DEM generated from C2 is compared with CartoDEM, Aerial DEM & ASTER DEM for the visual & geometrical qualities. C2 orthoimage is generated using all the four DEM sources and the resultant products are evaluated and analysed with reference to C1 orthoimages.

INPUT DATA

As such, Cartosat-2 is not a stereo mission like Cartosat-1, still stereo pairs can be acquired in multiple combinations of various imaging modes. Cartosat-1 provides along track stereo whereas Cartosat-2 can provide in across track & along track. The image pair selected forms across track stereo with B/H ratio is 0.47, over Alwar region acquired in paintbrush mode of imaging.

Cartosat-2 Orthokit products of two different dates are taken as input. Orthokit product contains meta file and RPC file along with the image. Following are the details,

1. sunanda@sac.isro.gov.in, High Resolution Data Processing Division,SPDCG, SIPA, Space Applications Centre, ISRO,Ahmedabad – 380 015
2. tps@sac.isro.gov.in, High Resolution Data Processing Division,SPDCG, SIPA, Space Applications Centre, ISRO, Ahmedabad – 380 015

A. Product ID = 1414051311
Date of Pass = 14MAY13
Orbit No. = 34227

B. Product ID = 1418051311
Date of Pass = 18MAY13
Orbit No. = 34286

Orthokit Data Product

Orthokit product contains a radiometrically corrected image in GeoTiff format. It also contains Rational Polynomial Coefficients (RPC) file. RPC are provided in lieu of detailed sensor and payload parameters, which helps the user to further process and geocorrect the product. The user can use these RPCs to generate a precision (or orthocorrected) product, provided the externally supplies GCPs (and DEM) for the correction.

Reference Data

Carto-1 orthoimage is used as reference data for GCP collection. DEM (Aerial DEM) generated (in 2003, source NRSC) using aerial images with 0.25m resolution (accuracy better than 5m) is used for various exercises and DEM comparison. Precise control points (collected using DGPS) with accuracy less than 1m are used for evaluation purpose.

Cots Package for Processing

ERDAS is a COTS package for digital image processing; it has Leica Photogrammetry Suite (LPS), Terrain Extractor & Editor tool for creating, visualization and editing of Digital Terrain Models (DTMs/DEMs) of earth surface. Sensor information related to remote sensing satellites like IRS-1C/1D, Cartosat-1, Resourcesat-1 are well configured & established in this software. LPS supports the Cartosat stereo image processing with RPC information, i.e. with orthokit data, for DEM & orthoimage generation.

DEM & ORTHOIMAGE GENERATION

For DEM generation, the first model is set up with the input data and reference coordinate system in WGS 84. In LPS commercial software, first images are added with the sensor information and RPC files, which are used in interior orientation. Reference data is required for GCP collection which forms input to the exterior orientation. The work flow for DEM generation is depicted in the Fig. 1.

For C2 DEM generation, Cartosat-1 ortho images & CartoDEM are used as reference data for GCP ground coordinates (X,Y,Z) acquisition. First, a block is generated and inputs images are added, refer to Fig. 2. GCPs are identified precisely using reference image data (refer to Figure-3). Tie points are generated with user defined parameters and distribution criteria. As the name suggests, tie point binds the two images & is a point whose ground coordinates are not known, but is visually recognizable in the overlap area between two or more images. The tie points are generated using image matching which refers to the automatic identification and measurement of corresponding image points that are located on the overlapping area of multiple images. Well distributed tie points assure good accuracy, refer to Figure-2. Triangulation is performed with 20 well distributed control points & tie points; it means setting the relation between image coordinates & ground coordinates. Its RMSE is 0.45 pixel. C2 DEM is generated further with the user defined interval/cell size. DEM is defined as a set of well distributed regular/irregular grid points with precisely known ground coordinates. It can be in ASCII file or raster image. Here DEM in raster & relief shed is displayed for its visual quality check (refer to Figure-4 & 5). ERDAS provides LPS Terrain Extractor and Editor tool for creating, visualization, check and editing of Digital Terrain Models (DTMs) of the earth surface.

C2 Orthoimages with 1 m resolution in WGS 84 datum & UTM projection are generated with various DEM options i.e. C2 DEM, CartoDEM, ASTER DEM & Aerial DEM. Ortho product generated from each DEM source is compared with the other one for the qualitative & quantitative parameters. Orthoimages are evaluated and results are tabulated for the analysis. Further C2 anaglyph product is generated with C2 DEM as shown in the Figure-

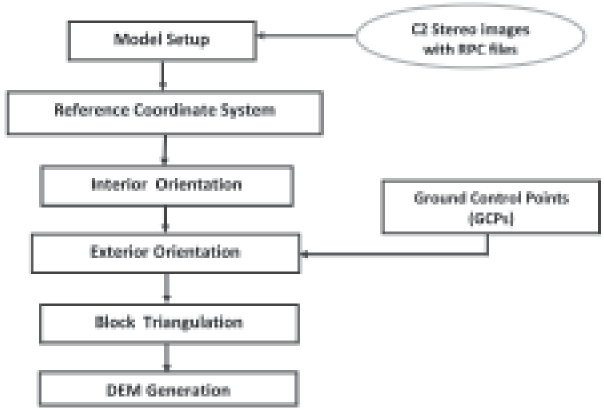


Fig. 1: DEM Generation Work Flow

C2 DEM COMPARISON

As mentioned in section 4, C2 DEM is generated using Carto-1 orthoimages as reference data. This DEM is compared with external DEMs i.e. CartoDEM, ASTER DEM & Aerial DEM. All these external DEMs are old (5-10years) as far as date of generation is concerned whereas C2 DEM is with recent images of

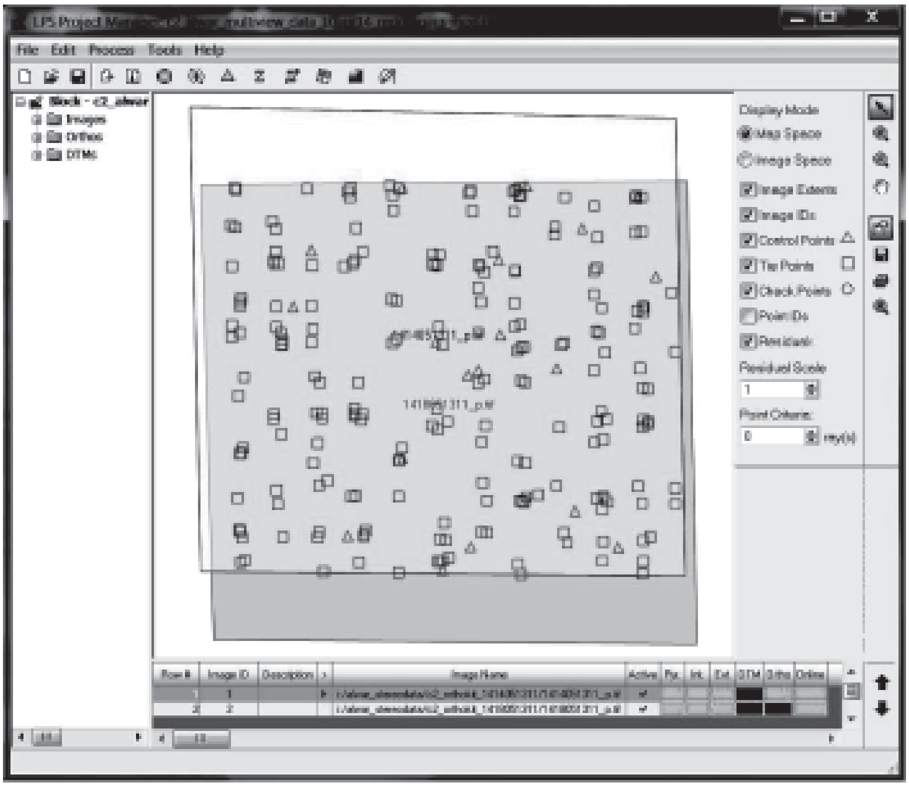


Fig. 2: Block of C2 stereo images with GCP & Tie point distribution

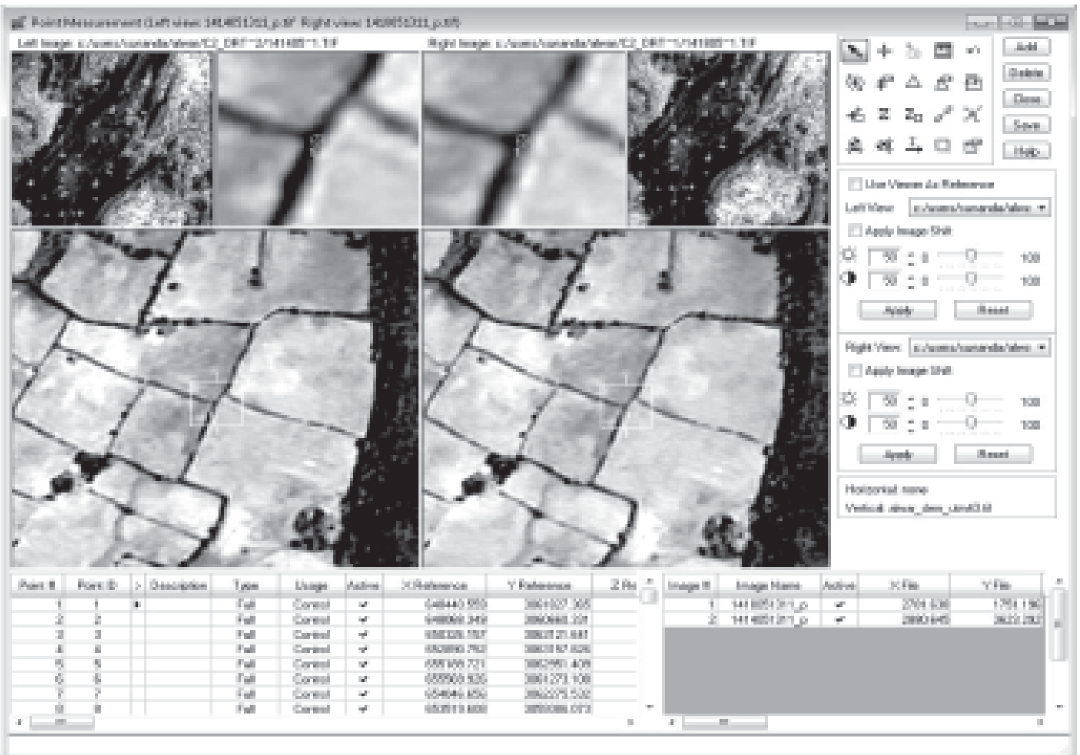
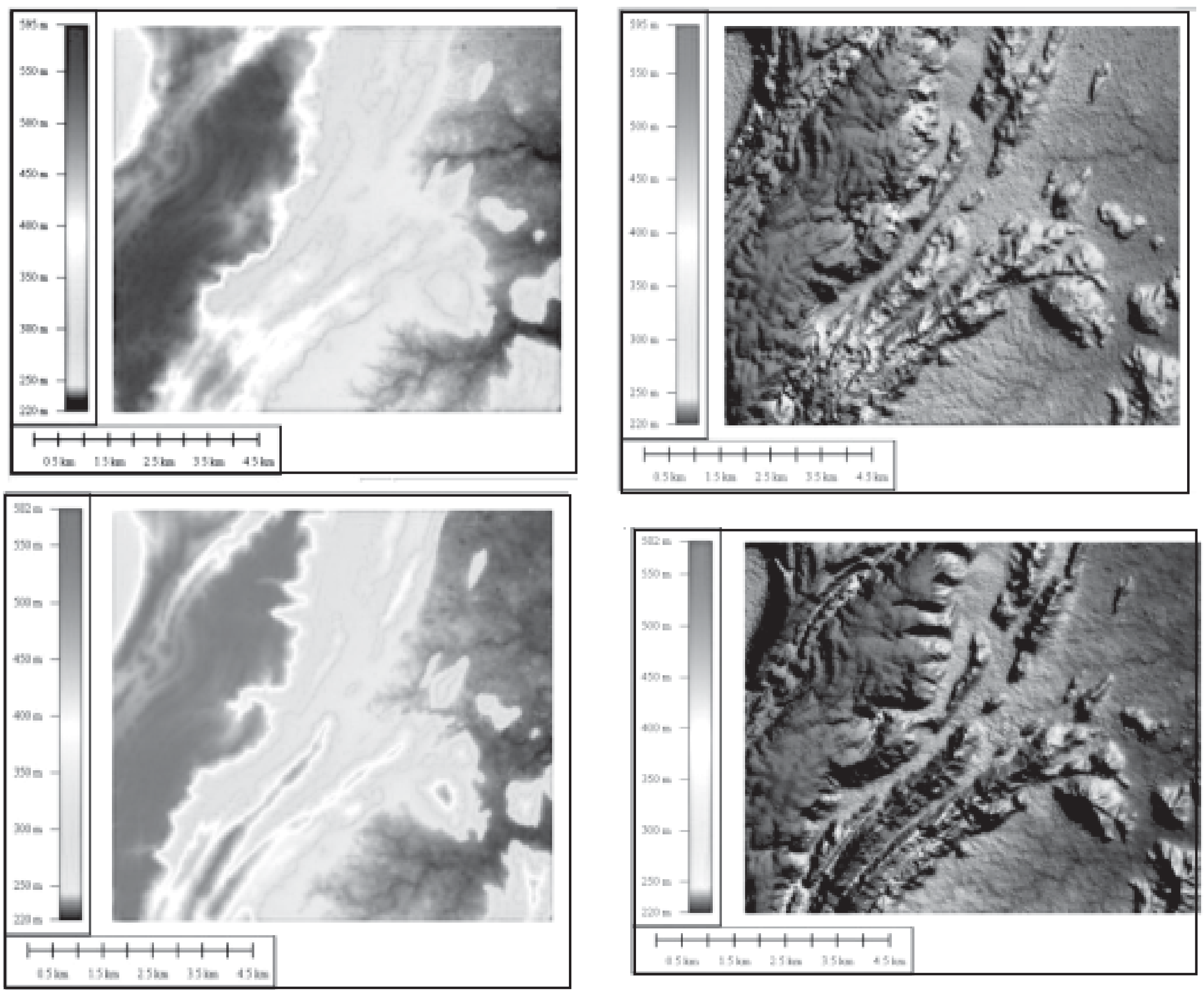


Fig. 3: GCP Identification in Block of C2 Stereo Data

Alwar region. New developments and current undulation effect exists in C2 DEM. It can be noted that C2 DEM & Aerial DEM are quite close as far as terrain undulation effect is concerned. Visual quality differences can be seen in the Figure-4. C2 DEM appears very smooth from the visual quality point of view as compared to ASTER DEM, CartoDEM. Aerial DEM provides detail terrain information since it is generated with high resolution aerial data and it is the main reference for comparison. CartoDEM is generated with relatively poor resolution 2.5m stereo images. Therefore, its visual quality (and feature information) is lesser than C2 DEM. In detail visual quality evaluation, it is observed that as compared to C2 DEM, features are little sharper in Aerial DEM. For detailed visual quality analysis, DEM comparison in B&W, colour, relief shed & 3D view is carried out. Their histograms are also compared. C2 DEM shows precise information in the hilly (top left region) terrain as well as plain terrain (bottom right region).

Statistical DEM parameters of all the four DEMs are given in Table-1 for the quantitative analysis. CartoDEM & Aerial DEM are close (3 years) as far as their temporal difference is concerned, as compared to with C2 DEM (7 years). In Figure-5, dark blue oval ring shows the region where dip in height is noted in the hill range in C2 DEM & Aerial DEM as compared to CartoDEM & the same effect is noted in Figure-7. DEM difference between C2 DEM & Carto DEM in relief shed & raster is shown in Figure-7. The red circle shows small hill peak variation is observed between C2, Aerial & CartoDEM. DEM difference between C2 DEM & Aerial DEM in relief shed & raster is shown in Figure-6. It clearly depicts the height variation which is mostly within < +/- 20m. Whereas in C2 DEM & CartoDEM (Figure-7) difference, variation is from -200m to 150m at various places. Overall in plain region, differences are very less, but in hilly terrain, differences are noted amongst the four DEMs. A profile match over a small hill i.e. between CartoDEM, C2 & Aerial DEM is brought out in Figure-8. It shows the profile of C2 & Aerial DEM is overlapping and CartoDEM profile is at constant height of 320m approximately. This region is depicted in figure-5 showing DEM in 3D, in the red circle. Further raster difference in C2 DEM & Aerial DEM is analysed and shown in Figure-9. It shows that most of the points vary within -20m to + 20m. In the higher



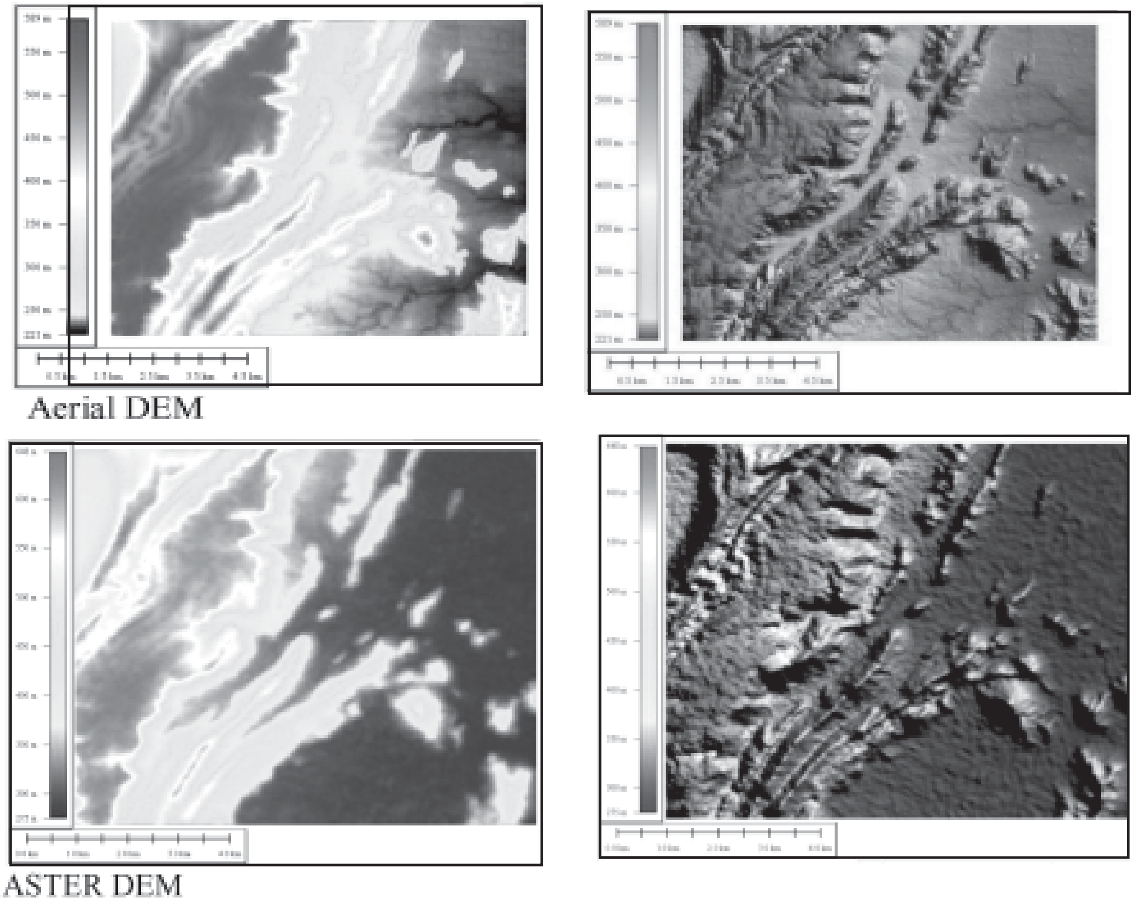
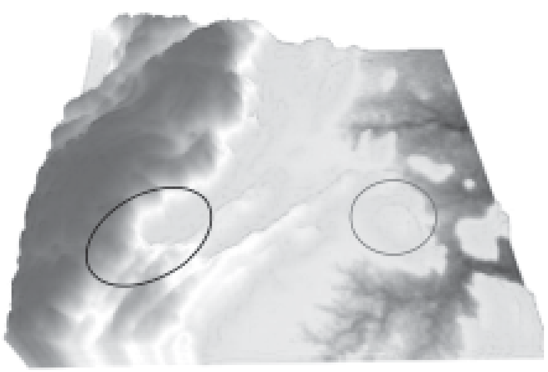


Fig. 4: Comparison of C1, C2, Aerial & ASTER DEM in Raster & Relief shed

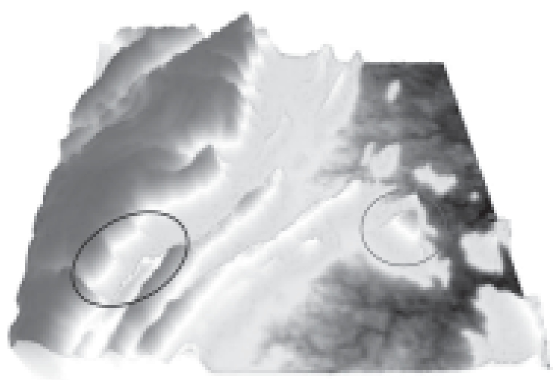
range, 5 to 10 % of points are seen these can be due to the temporal change (aerial DEM is approximately16 years old). Raster DEM differences are carried out and height difference parameters are shown in Table-2.

Table 1
Comparison of Statistical DEM Parameters

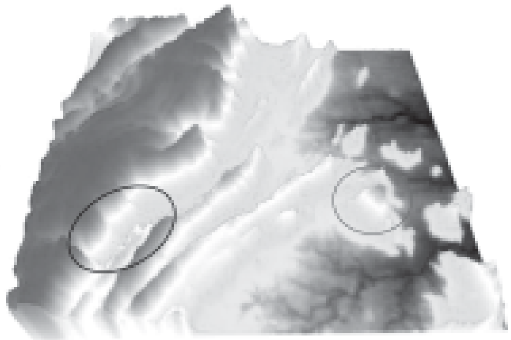
Sr. No.	*Source of DEM*	*DEM Grid interval (m)*	*Mean value (m)*	*Std. Dev. (m)*	*Minimum value (m)*	*Maximum value (m)*	*Mode (m)*	*Median (m)*
1.	C2 DEM	10	353	111	227	580	230	304
2.	Carto DEM	10	350	114	196	595	238	303
3.	Aerial DEM	25	348	115	221	589	233	305
4.	ASTER DEM	30	404	115	275	649	287	364



CartoDEM in 3D view
Fig. 5 (a)



C2 DEM in 3D view
Fig. 5 (b)



Aerial DEM in 3D view

Fig. 5 (c): Comparison of C1, C2 & Aerial DEM in 3D

DEM image related parameters: Mean value of a DEM reports the mean (average) file value. The median value of a DEM provides the median of the file values (the point at which there are as many pixels greater as lesser). Mode value provides the mode (most frequently occurring) among the file values. Elevation values of points above the vertical datum surface are positive, while the elevation values of points below the vertical datum surface are negative. Depth Elevation values of points below the vertical datum surface are positive, while the elevation values of points above the vertical datum surface are negative.

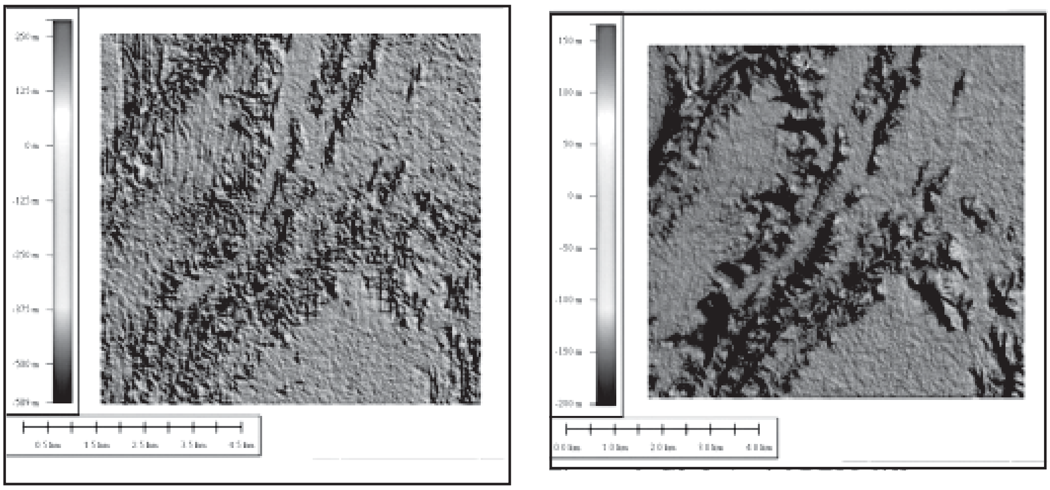


Fig. 6: C2 & Aerial DEM Difference (Relief shed & Raster)

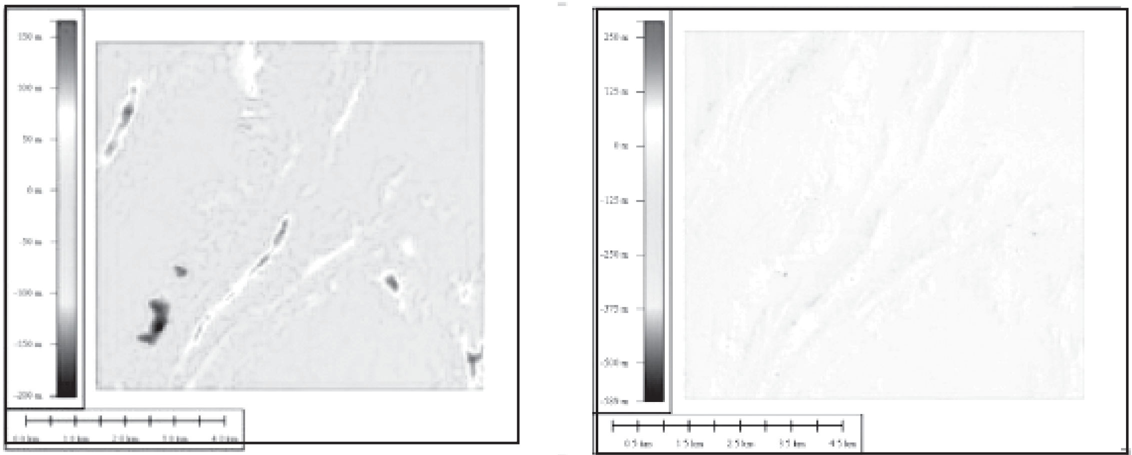
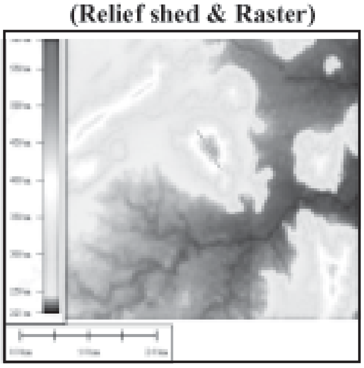


Figure-7: C2 & CartoDEM difference (Relief shed & Raster)



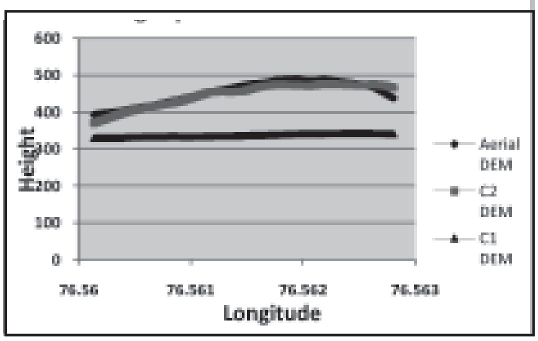


Fig. 8: Comparison of height profile in Aerial, C2 & CartoDEM

Table 2
Height Difference in DEMs

Parameters (m)	*C2- Aerial*	*C2-C1*
Height Mean	-0.5	-2.7
Standard Deviation	10.5	28.8
Median	-3.6	-4.0
Mode	-3.0	-10.0

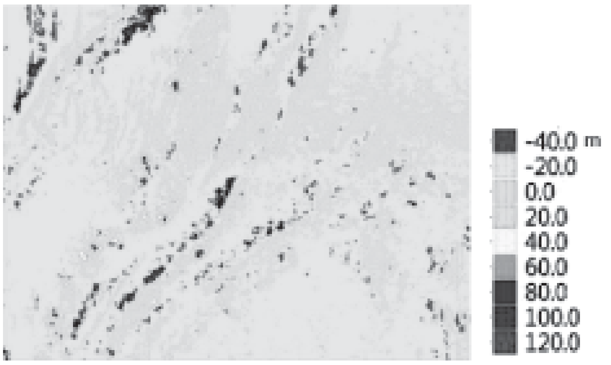


Fig. 9: Aerial & C2 DEM difference

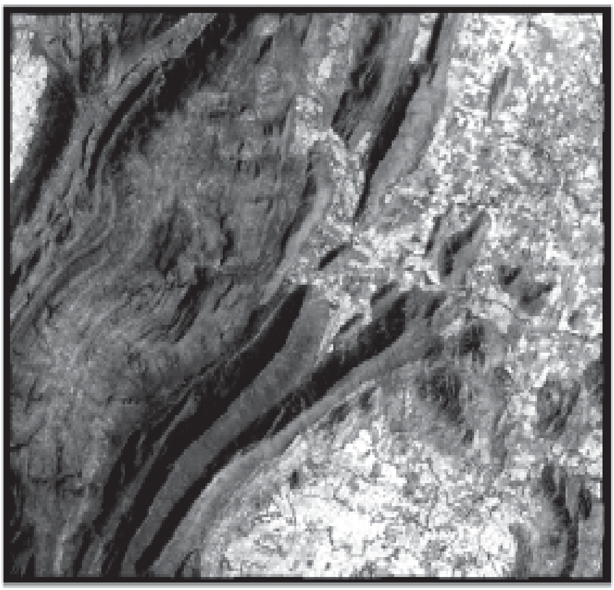


Fig. 10: C2 Anaglyph Product Over Alwar Region

C2 ORTHOIMAGE EVALUATION AND ANALYSIS

Orthoimage is a geometrically corrected image including terrain undulation effect using ground control points(GCP). The input C2 images are used with well distributed ground control points as shown in the data flow diagram Figure-1 and processing is carried out to generate C2 DEM. Orthoimage generation requires DEM as input for terrain correction. In this case study for potential evaluation, C2 orthoimage is generated using C2 DEM, CartoDEM, ASTER DEM & Aerial DEM. All the four C2 orthoimages generated with different DEM sources are compared & evaluated with

(a) C1 orthoimage as reference

(b) Precise control points.

For evaluation, well distributed GCPs are identified in C1 orthoimage and the same feature positions are identified in the C2 orthoimage. That means longitude & latitude of GCP in C1 ortho image & C2 orthoimages are noted. Further RMSE & standard deviation parameters are computed. Similar evaluation exercise is done between C1 ortho and

(a) C2 ortho (generated with CartoDEM),

(b) C2 ortho (generated with Aerial DEM),

(c) C2 ortho (generated with ASTER DEM).

Evaluation results of all the combinations are shown in Table-3. RMSE depicts the location accuracy of the orthoimage and standard deviation gives the internal distortion in the orthoimage. It can be concluded from the evaluation result that as expected C2 orthoimage generated with C2 DEM has planimetry accuracy < 2.5m with respect to C1 orthoimage. C2 orthoimage generated with C2 DEM shows planimetry accuracy < 1.8m with respect to precise control points as shown in Table-3. Carto-1 orthoimages with accuracy specification of 15m in planimetry & 8m in height are used as GCP source. Results can be better if precise GCPs (with accuracy < 1m) are available for DEM generation. As resolution

Table 3
C2 orthoimage Evaluation Results

Sr. no.	*C2 Ortho with*	*Evaluation Ref.*	*RMSE*		*STDEV*	
			Lon (m)	*Lat (m)*	*Lon (m)*	*Lat (m)*
1.	C2 DEM	C1 Ortho	2.06	2.35	2.30	2.69
		Precise pts.	0.76	1.78	0.67	2.05
2.	CartoDEM	C1Ortho	2.83	2.43	3.09	2.66
		Precise pts.	1.64	1.40	1.90	1.57
3.	Aerial DEM	C1 Ortho	2.55	2.54	3.59	2.68
		Precise pts.	2.20	1.30	1.13	1.08
4.	Aster DEM	C1Ortho	10.77	6.56	3.08	3.79
		Precise pts.	10.38	6.37	1.41	2.27

of C2 image is 3 times better than C1 image, its effect is coming out; detailed information is observed in DEM (since it is recently acquired data)

C2 orthoimage generated with ASTER DEM is relatively poor in accuracy due to ASTER DEM accuracy which is very well reflected. Aerial DEM is precise DEM (accuracy-5m) generated using aerial images but it is the old DEM therefore, few temporal changes in terrain undulations are observed.

CONCLUSION

An exercise is performed to study the potential of C2 DEM & orthoimage generation using C2 stereo images of multiple dates. C2 DEM visual quality & geometric quality are compared with C-1 DEM (CartoDEM), ASTER DEM & Aerial DEM products. The C2 DEM visual quality is comparable with that of Aerial DEM in terms of features, terrain undulations and accuracy. Its visual quality is better than CartoDEM & ASTER DEM as depicted in the above figures. C2 Orthoimage with 1m resolution is generated with different DEM inputs (C2 DEM, CartoDEM, ASTER DEM & Aerial DEM). The orthoimages are evaluated with respect to i) C-1 orthoimage & ii) precise control points. The tabulated results show that C2 orthoimage generated with C2 DEM & Aerial DEM are quite close i.e. accuracy in planimetry is less than 2.5m (with reference to Cartosat-1 orthoimages). C2 Orthoimage generated with C2 DEM shows accuracy is less than 2m (with reference to precise controls) in planimetry. The experiments conducted with C2 Alwar data demonstrates that the high quality DEM can be generated with good geometric accuracy. More C2 stereo cases over different terrain will be taken up to generate good quality DEM and ortho images to serve for future HR Carto missions.

REFERENCES

1. Technique for Automatic Orthoimage Generation for Cartosat-2.

   Cartosat-2/DP/SAC/SIPA/SPDCG/HRDPD/TR-13 /Dec. 2012

2. C2 Data products generation system. Design review document Data products s/w June 2006

3. C2 Orthoimage Generation & Evaluation using Precise GCPs.

   Cartosat-2/DP/SAC/SIPA/SPDCG/HRDPD/TR-01 /Jan. 2014

ABBREVIATIONS

Aerial DEM	- DEM generated using aerial photographs
ASTER DEM	- DEM generated using ASTER data
CartoDEM	- DEM generated using Cartosat-1 stereo images
DEM	- Digital Elevation Model
GCP	- Ground Control Point

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QUALITY ASSURANCE ON DEM GENERATION USING CARTOSAT-1 STEREO PAIR DATA

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ABSTRACT

Digital India and e-governance campaigns require a lot of planning where use of Digital Elevation Model (DEM) is inevitable in various engineering and environmental applications. Many recent projects like smart city planning or other rural development projects use DEM as the base layer for any overlaid vector or polygon data in Geographic Information System (GIS).

DEM of 1/3 arc second spacing is generated over Indian land mass using Cartosat-1 stereo data under CartoDEM project. The approach used for Cartosat DEM generation provides dense tie points for reliable estimation of terrain morphology. Ensuring DEM quality is an important factor as any error in the DEM will propagate into the application where it is employed and will lead to incorrect analysis and erroneous results. To produce quality output i.e. DEM, from a process involving series of processing steps, it is necessary to ensure that correct intermediate output is obtained at every step. A set of in-house developed specialized software tools are used to check outputs from intermediate processes in order to ensure production of high quality of DEM. Each significant process where possibility of error due to automatic processing exists is supplemented with a visualization tool which aid to check the intermediate output manually.

Keywords: *CartoDEM, DEM, DTM, Epipolar Geometry, Resection*

INTRODUCTION

Cartosat-1 is the first Indian satellite with stereo viewing capability which is being used for generation of high accuracy DEM over Indian landmass with grid spacing of 1/3 arc sec using indigenously built software system. CartoDEM project initiated with the objective of generating large area DEM in automated manner, has produced version 1 and version 2 of CartoDEM for Indian landmass.

Use of DEM is quite significant in applications like smart city planning or rural development projects which is being demonstrated by Geospatial Delhi Limited (GSDL) Delhi. GSDL with an extremely rich database covering all of the infrastructure and facilities of the city as a custodian of Delhi State Spatial Data Infrastructure (DSSDI), has a vision to transform Delhi into a smart city by providing citizen centric solutions and e-governance (Prasad 2014). Property tax calculation by assessment of floors from building height and PDM applications (Plan-Dig-Monitor) are some of the potential areas where DEM is being used for smart city planning. Terrain parameters such as slope angle, slope aspect, relative relief derived from CartoDEM are primary inputs to applications like drainage network analysis, watershed demarcation, erosion mapping, contour generation, detection of landslides, susceptibility assessment and volumetric analysis.

Ensuring high quality of DEM is the biggest concern for such applications as any error in DEM will propagate into the application where it is employed and will lead to incorrect analysis and erroneous results.

If we look into the background, the term Digital Terrain Model (DTM) was coined in 1958, in the last 50 plus years the research in this field has evolved from scanning stereo pairs from aerial photographs and processing them using Photomapper, to generating DEMs by digitizing contour maps and finally now by acquiring stereo data from space-borne sensors to produce DEMs in an automatic operational manner. DEM user's manual (Maune 2001) is a guide about DEMs; it contains text explaining various DEM generation techniques in detail, along with applications and quality aspects. Digital Terrain Modelling by Li et al. (Li 2005) covers all aspects related to DEMs, strategies regarding data acqui-sition, generation, post-processing and quality of processed data, visualization and infor-mation extraction. A new stereo matching algorithm (Radhika 2007) was developed and used for the CartoDEM project. Peucker et al. (Peucker 1978) proposed the TIN data structure utilized during the project.

Section II describes the overall approach used for the CartoDEM generation using indigenous techniques. Quality assessment and assurance are the part of this procedure. Specialized visualization tools are developed for the data inspection and reporting output of each process for the qualitative and

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quantitative verification. These quality tools are described in section III. Directions for further work are also included in the concluding section.

Automatic Approach – Basic Steps

The overall approach for DEM generation from Cartosat-1 stereo pair images is to process full pass data (individual acquisitions) of cloud-free regions to generate DEMs and Ortho-Images, which are then made into a mosaic and disseminated to end user. Following are the major steps involved in DEM generation using automatic approach.

1. Establishing of Epipolar geometry between image pairs by augmenting the model using Ground Control Points (GCP)
2. Conjugate point pair generation between image pairs by stereo matching
3. Conversion of conjugate points into Latitude (ö), Longitude (ë) and Height (h) by process of intersection and obtaining the Irregular DEM (IDEM)
4. Generation of DEM by structuring the IDEM and interpolat-ing
5. Generation of Ortho-image

A set of indigenously designed and developed software is being used to realize this approach of DEM generation. It includes automatic as well as interactive software components. The outline of the generation process is detailed in figure 1. The process begins with selecting cloud free acquisition of the desired region which is extracted first. Radiometric corrections like Look Up Table (LUT) application and stagger correction are done on the extracted data. For the data handling ease, image pyramids are created before initiating processing. The activity of GCP identification is then initiated in parallel with cloud delineation. Once the ephemeris is corrected an initial estimation of heights is obtained and a mapping between the two images is generated. The cloud masked image and the updated ephemeris are used to decompose the data into scenes which enables the operator to process the segment data in parallel, thus saving time and opti-mizing compute resources. Further on the data is processed scene-wise, generation of interest points being the next process. The initial height estimate and mapping between the two images are used to find corresponding feature in both the images leading to generation of conjugate point pairs. The conjugate point pairs are then processed by space intersection to generate an IDEM. Triangulated Irregular Network (TIN) is used to

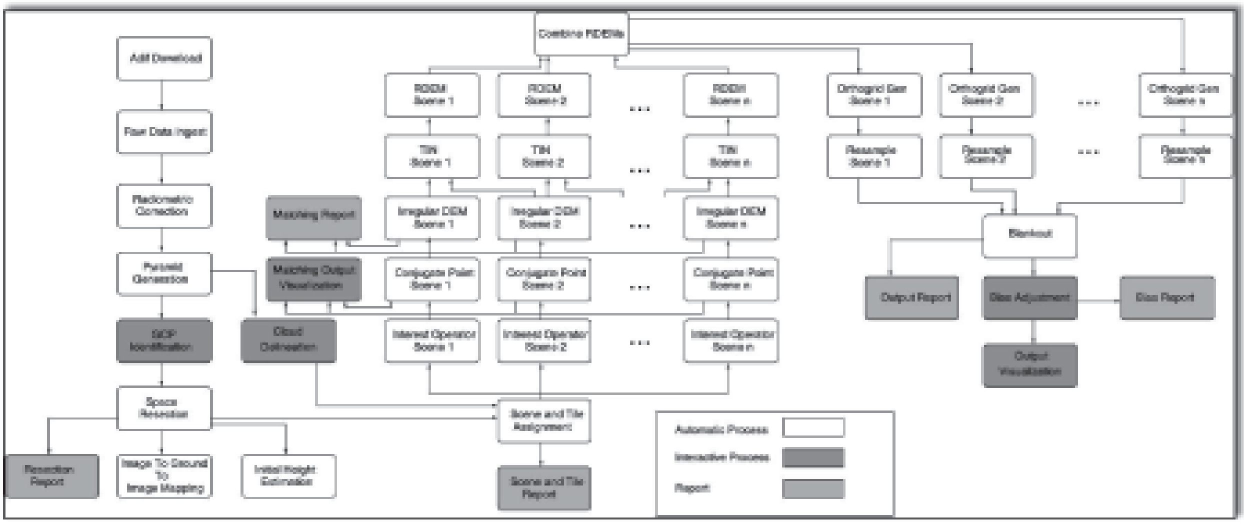

Fig. 1: DEM Generation Flow Diagram

provide struc-ture to IDEM and using interpolation, a Regular DEM (RDEM) is obtained. The generated DEMs are then utilized to generate grid files, which are used to generate ortho corrected images.

The process of blanking out, which performs masking of DEM data corresponding to cloud masked regions, ensures that same region is masked out in Ortho-Image and DEM. The process of bias estimation and correction ensures the removal of residual bias if any. To aggregate the output generated during processing of various segments an incremental mosaic is created as and when the segment is processed. The outputs are archived to database. Figure 2 illustrates the steps followed during the mosaic operation.

Fig. 2: Steps for DEM Mosaic and Archival

Before initiating the mosaic process a visual inspection is carried out to as-certain that the segment output aligns well with the neighboring segments. If the output is found to align well within the limits, then the process of mosaic is initiated. A binary mask file corresponding to the processed segment output DEMs and the tiles available in database is generated. The mosaic process is performed using these masks as the input and after quality validation the data is archived to the database. The entire procedure and the details of each process are elaborately documented in ASST document (Kartikeyan, 2007).

TOOLS FOR ENSURING QUALITY WHILE PROCESSING

The process of DEM generation for a full pass of satellite data is a time intensive process due to the fact that many processes are involved and their complex nature. To ensure quality output at the final stage i.e. at DEM level it is necessary to ensure that correct output is obtained at every step of processing chain. Issues appearing and not getting rectified at intermediate stages leads to un-usable output at the end of the processing chain. Various problems can occur during processing which should be checked and rectified then and there, to avoid re-processing the entire segment. The issues and their identification are detailed out in the subsequent sub-sections.

GCP Identification

Establishment of epipolar geometry between the stereo viewing cameras is a crit-ical requirement for stereo matching. GCP Identification is an interactive software tool specifically designed for this purpose. Figure 3 shows the snapshot for the GCP Identification user interface.

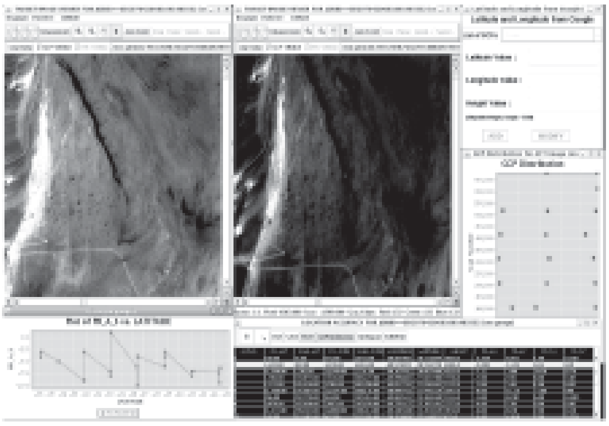

Fig. 3: GCP marking using Google Earth

The tool displays AFT and FORE radiometrically (RAD) corrected data along with a provision to input latitude, longitude and height from Google Earth©. The operator identifies a GCP in both AFT and FORE data and then refines latitude and longitude from Google Earth© and height from hole filled Shuttle Radar Topography Mission (SRTM) tiles (Jarvis, 2008) and Earth Gravitational Model 1996 geoid calculator (NGIA, 1998). The tool has facilities like auto-navigation for aiding the process of identification and also other image handling capabilities like histogram enhancement, zoom, pan etc.

The module computes pre-resection errors for AFT and FORE sensors in both scan-line and pixel direction. It also provides facility for real-time calculation and plotting of all computed residual errors with respect to latitude, for all the GCP points. Deviation in pre-resection error indi-cates an anomaly in manual identification process. Once the identification is completed, Space Resection (SR) is carried out for generating post resection statistics.

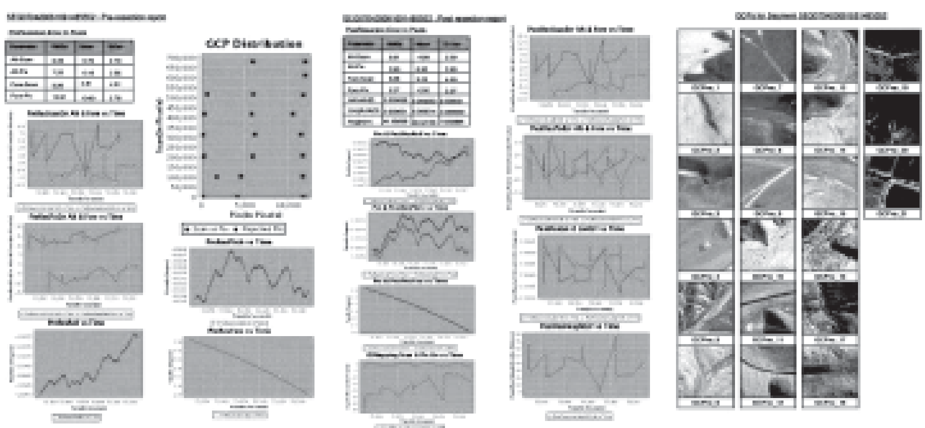

Fig. 4: Output of GCP Identification Process

The report as shown in figure 4 contains details about pre-resection error statistics, post-resection error statistics, plots of pre-resection and post-resection, scan error v/s time, roll/pitch/yaw v/s time, chips of each GCP for verification.

Cloud Identification

Any region in the data containing clouds and left unmasked, affects the quality of resultant DEM. Cloud being a region of high variation may lead to generation of interest points on the cloud boundaries. These points when passed through matching process lead to incorrect match point. A spurious match point will generate incorrect IDEM point which when structured using TIN generation and interpolated using RDEM technique leads to an invalid DEM for that region. The figure 5 shows a region containing clouds marked using a polygon.

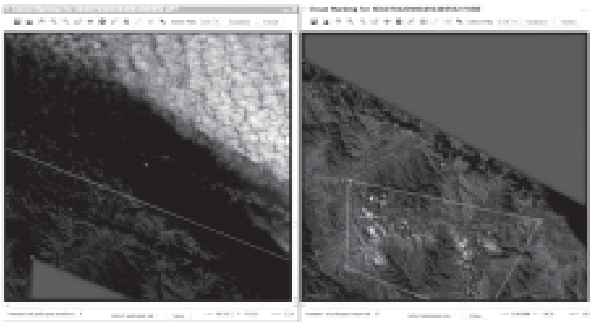

Fig. 5: User Interface for Cloud Delineation

A module is designed and developed for demarcation and masking of clouds. It provides various vector tools like vertex addition, deletion, modification etc. Once the cloud demarcation and the establishment of epipolar geometry are done, the data is partitioned into scenes for parallel processing and later into tiles for ease of dissemination.

The system reports the final allocation of the segment to the operator in the form of a portable document format (pdf) document which as shown in figure 6 contains a down-sampled image of the segment with the scenes, tiles and the cloud boundaries overlaid. Scenes are displayed in red, tiles in green and clouds in AFT and FORE are displayed as blue and yellow polygons respectively. Number adjacent to the image represents the scene number. While marking a cloud, if a polygon has the same width as a scene the entire scene gets discarded.

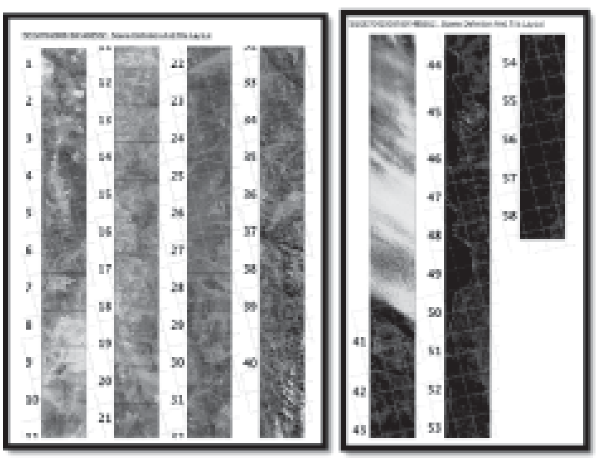

Fig. 6: Sample Report for Scene and Tile Allocation

Bias Estimation and Correction

When DEM is used as an input during any analysis, many a times a mosaic has to be generated. To ensure an error free mosaic from multi-date or multi-orbit acquisitions, a coarse comparison is performed with a reference DEM, SRTM in our case. Using the bias value of each tile a bias surface is generated. Any out-lier is discarded and the bias surface coefficients are applied back to the segment to generate a bias-corrected output. Fig. 7 shows the user interface of bias estimation module.

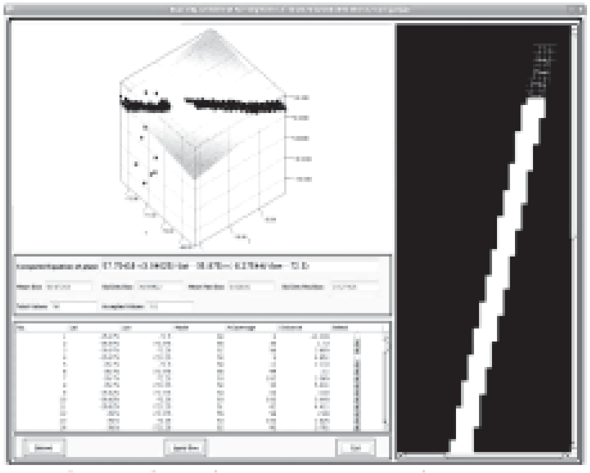

Fig. 7: Bias estimation and correction User Interface

The 3-D plot shows the residual bias for each tile and the bias surface computed by the module. The table shows the bias for each tile, the fitting error of each tile when compared to the bias surface, percentage of tile filled and a handle to remove the tile. The removal option can be exercised if the bias value appears to be an outlier due to presence of stray clouds, water body etc. Once the bias is applied to the entire segment output, a report containing statistics about the bias estimation and correc-tion process is generated for the entire segment and for each tile. This report also contains a colour coded segment image generated by comparing the output of the bias correction process with SRTM data indicating the residual bias present (fig. 8).

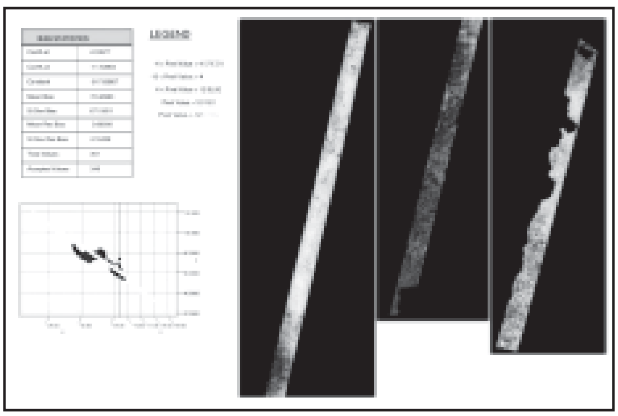

Fig. 8: Bias Report

Output DEM Evaluation Tool

DEM along with the Ortho-Image are the deliverable outputs of the project. A mod-ule is designed for visual inspection and quantitative evaluation of the outputs before disseminating to the end user. The tool helps in identifying issues if any and taking necessary corrective action. The salient features of the module are

i. Display of DEM, AFT and FORE Ortho-Images overview and full resolution.

ii. Contour generation and display for DEM.

iii. Profile generation tool for DEM and Ortho-Image.

iv. Display of pixel data values.

v. Display of AFT and FORE Ortho-Images as Red-Green-Blue (RGB) composite.

vi. Provision to make a remark in case any issue is observed during visual inspection.

vii. Various other image handling capabilities like histogram, enhancement, zoom etc.

Fig. 9 shows the User Interface (UI) screen of the module. The AFT Ortho-Images of the en-tire segment are shown as a virtual mosaic for a quick overview. The AFT clouds are displayed in green and FORE clouds in blue. Scene boundaries are also overlaid.

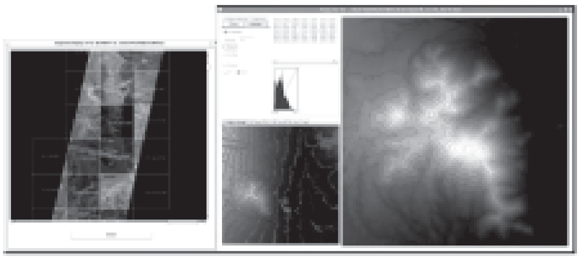

Fig. 9: Segment Visualization with Contour overlay

Selecting a tile from the mosaic displays the tile for evaluation. Qualitative inspection and tasks like generating profiles, contours can be performed. Contours can be used to estimate the quality of the DEM and help to identify local peaks and sinks if present. Module provides facility to overlay the contours on DEMs generated at various resolutions. Figure 9 also shows contours generated at an interval of 30 m and overlaid on a DEM tile.

The AFT and FORE Ortho-Images getting generated using the DEM should exactly match each other if the DEM used is correct. An RGB image containing AFT data in red and blue bands and FORE data in green band is displayed to the user. Any mismatch between the two images, due to issues in DEM appears as distinct colour as shown in fig. 10.

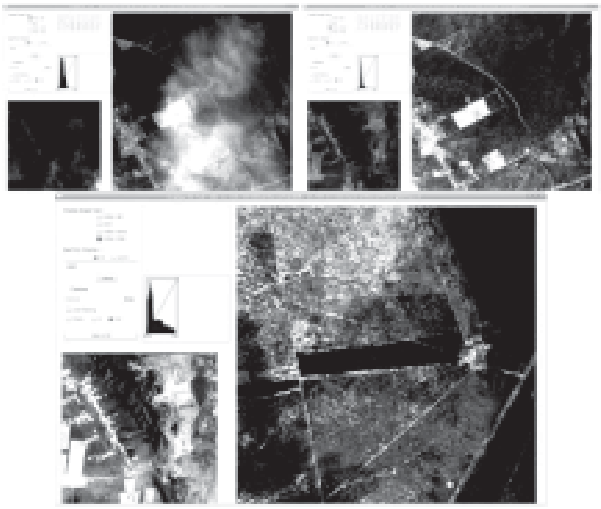

Fig. 10: Mismatch in AFT and FORE Ortho-Images

Another technique of DEM quality evaluation is by displaying the DEM and Ortho-Image in 2.5D with the Ortho-Image draped over the DEM shown in fig. 11. This helps the operator to visually identify problems with the DEM like spikes, sinks etc. The module can create and display this DEM-Ortho drape for any tile for inspection.

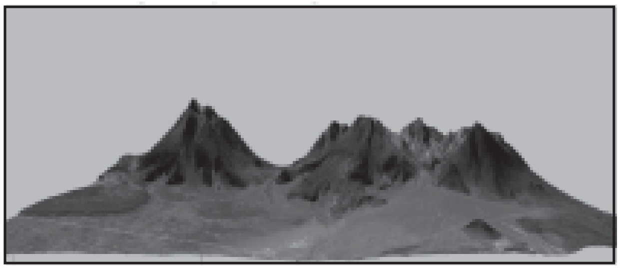

Fig. 11: DEM-Ortho drape

For a quick verification of the quality of the output generated after processing of a seg-ment, a report is created which contains a mosaic of all the Ortho-Images and DEM tiles generated, fig. 12.

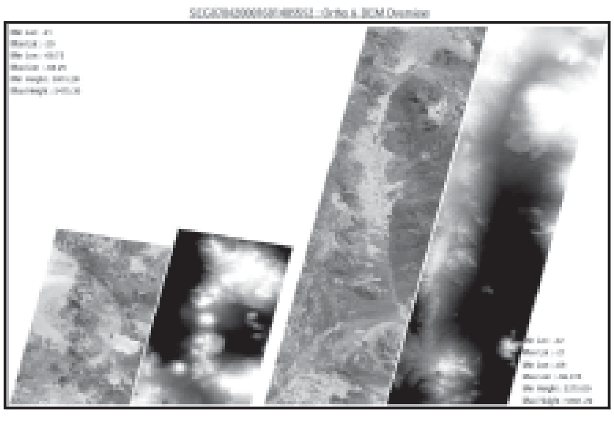

Fig. 12: Mosaic report of segment output

CONCLUSION AND FUTURE SCOPE

Due to the complex nature of DEM generation process, production of quality DEM in an automated manner is a challenge. To ensure specifications are met in the data gen-erated, processes have been introduced at intermediate stages to monitor the output of automatic processes. These processes ensure corrective action is taken immedi-ately when a problem is noticed and not at the end when the issue leads to degraded quality of the output DEMs. As the generation process takes a lot of time and compute resources, intermediate checks also help to save precious amounts of time and other resources. The various reports are examined to identify any trend that exists in the various underlying processes like resection, matching and bias estimation and correction. The trends can then be modelled and corrected during processing of the remaining cases and archived for future reference. The processes of GCP identification, cloud delineation, matching visualization and output visualization, bias correction have helped in generating usable quality products with the aforementioned advantages. A comparative evaluation of DEMs has been carried out by Murlikrishnan et al. (Murlikrishnan 2013) wherein it is observed that the elevation values supplied by Cartosat-1 DEM when compared with ICESat data, SRTM and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) DEMs are well within specifications. Another comprehensive examination of the DEMs (NRSC 2014) has been performed at National Re-mote Sensing Centre (NRSC) wherein qualitative and quantitative evaluation are car-ried out and usability of DEMs for various applications was also analyzed. The report clearly brings out the various merits and de-merits of the end product and it was noted that the DEMs are meeting specifications and are in agreement with other reference DEMs available, in most of the regions.

This is a work in progress and a lot of work still needs to be accomplished in the domain of post-processing of the output, for making it directly usable for various applications. Post-processing facilities like introduction of break-lines, hydrological conditioning, flattening of water bodies and rivers need to be developed and deployed to operations.

REFERENCES

1. Prasad K.J.V.S, Vasanthkumar N., Singh Surender (2104): "Delhi gears up to be a Smart City", India Geospatial Digest.
2. Maune David F. editor (2001) : "Digital Elevation Model Technologies and Applications:
3. The DEM Users Manual", ASPRS.
4. Li Zhilin, Zhu Qing, and Gold Christopher (2005): "Digital Terrain Modelling, Principles and Methodology", CRC Press.
5. Radhika V. N., Kartikeyan B., Gopala Krishna B., Chowdhury S., and Srivastava P. K. (2007): "Robust stereo image matching for spaceborne imagery", IEEE Transactions on Geoscience and remote sensing.
6. Peucker T., Fowler R., Little J., and Mark D (1978): "The triangulated irregular network", In Proceedings of Digital Terrain Model symposium.
7. Kartikeyan B., Gupta Amit, Prakash Shilpa et al. (2007): "Cartodem project: Augmented stereo strip triangulation (ASST) software analysis and architectural document", Technical report, Space Applica-tions Centre.
8. Jarvis A., Reuter H. I., Nelson A., and E. Guevara (2008): "Hole ûlled SRTM for the globe Version 4", http://srtm.csi.cgiar.org
9. National Geospatial-Intelligence Agency. NGA EGM96 Geoid Calculator (1998): http://earth info.nga.mil/GandG/wgs84/gravitymod/egm96/ intpt.html
10. Muralikrishnan S., Pillai Abhijit, Narender B., Reddy Shashivardhan, Venkatara-man V. Raghu, and Dadhwal V. K. (2013): "Validation of Indian National DEM from Cartosat-1 Data", *Journal of the Indian Society of Remote Sensing*.
11. CartoDEM Version-2.0 evaluation team (2014): "Evaluation of Indian National DEM (Version-2) from Cartosat-1 data", Technical report, NRSC.

Spatial Aspects of Governance for Urban Local Bodies

UNDERSTANDING THE CONTEMPORARY CITY THROUGH MAPPING ADMINISTRATIVE AND PERCEPTIVE SPACES

Apala SAHA[1]

'Ideas about cities are not simply formed at a conscious level; they are also a product of unconscious desires and imaginations.' (Bridge and Watson 2000: 7).

ABSTRACT

The 'city' and the 'urban' though conceptualised differently are not as layered as they are often imagined to be. The city must pertain to the standards of what is understood by urban – the lifestyle, the progress and the crisis as well. Similarly, the urban cannot sustain only as a feel or as a philosophy, it requires the realities of a city. A city, therefore, is as metaphorical as it is real. One generates images of utopia which changes shades with each human mind. In fact, there are as many images of a city space as there are 'city'zens. The other confines one within the boundaries of an administrative unit such as a ward, which generate no imagination at all, yet emerges as the seat of all analyses and implementations. A simultaneous dichotomy and overlap of realities and imaginations have never remained unknown to a city; in fact it is possibly this that creates and sustains the aura and the enigma that the city personifies. This twin conceptualisation of the city and the urban has gained a renewed momentum and therefore needs a re-thinking in this era of neoliberal urbanisms, when as a nation the target, as Rohan Shivkumar wrote in popular daily, is set to arrive into 'a space of infinite light…a techno-utopian imagination' (2015: 1).

Maps are one of the most (un) conventional images of a city, precisely pertaining to a more technical representation of information. Maps using data from surveys on conditions of human existence and represented through using graduated colours reveal social realities most objectively thereby re-asserting the need for spatial governance. However, the spirit of the urban over and above the city along with the everyday lived human spaces or the more macro imageries of city spaces like a South Delhi or a North Calcutta thus remain uncaptured in such attempts.

The precise objective of this paper is to use the city of Kolkata as a case along with data provided by the Census of India (2001 and 2011) and bring together the flipsides – the city and the urban, a city dweller and a cartographer, choropleth maps and mental maps and so on. The justification lies in the understanding that for an average city dweller, a city must be able to confer all conditions of comfort, good services, good governance along with innovation, security, satisfaction and so on. The requirement includes the yellow lights of a supermarket and the blues of a water body along with rich and extensive greenery – basically a package. A smart city inhabitant is aspiring to experience the objectivities of a city and the subjectivities of the urban which would have the urban pace with the rural peace. The study is therefore directed towards an understanding of these neo-urban spaces.

Keywords: *City, Urban, Spaces, Mapping.*

INTRODUCTION: THE CITY AND THE URBAN

The 'city' and the 'urban' though conceptualised differently are not as layered as they are often imagined to be. The city must pertain to the standards of what is understood by urban – the lifestyle, the progress and the crisis as well. Similarly, the urban cannot sustain only as a feel or as a philosophy, it requires the realities of a city. A city, therefore, is as metaphorical as it is real – one generates images of utopia which changes shades with each human mind. In fact, there are as many images of a city space as there is 'city'zens. The other confines one within the boundaries of an administrative unit such as ward, which generates no imagination at all, yet emerges as the seat of all analyses and implementations. Lesser than wards are other administrative boundaries like a supervisory circle and then an enumeration block (with respect to the city of Kolkata for example) which are also as blank as wards as far as imaginations of inhabitancy and belongingness are concerned.

What is still relevant is the idea of a neighbourhood, which has grossly been agreed upon as the space of neighbouring or establishing a face to face contact. Therefore, to each is a different perception of this space of contact building and social interaction. Thus neighbourhoods do not and rather cannot be demarcated. Therefore, taking them from a de facto experience to a de jure entity seems rather difficult and sometimes inappropriate as well. Welfare associations working at this level or lower – mostly exist and work at a level that is more exclusive. Having said this, it is important to clarify that a simultaneous dichotomy and overlap of realities and

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imaginations have never remained unknown to a city; in fact, it is possibly this that creates and sustains the aura and the enigma that the city personifies. With respect to the city of London, Pamela K. Gilbert writes, 'while there are an infinite number of other Londons, there are no Londons other than those of the imagination' (2002:1).

Same is true for Kolkata as well or any other city for that matter. There isn't just one image of the city, but there are multiple and the truth lies split in all of it. Of imaginations that have defined the city through time, the white and the black towns of British India, north, south and central Kolkata later on and an emerging East Kolkata during the more recent times have occupied the popular space of imaging the city. Only talking about visions can never be complete unless they can be visualised. Hence the visualisations from at least one city seem inevitable. In this paper, an attempt has been made to use the city of Kolkata as a case alone to bring to life the visions. The twin conceptualisation of the city and the urban has gained a renewed momentum and therefore needs a re-thinking in this era of neoliberal urbanisms, when as a nation the target, as Rohan Shivkumar wrote in a popular daily, is set to arrive into 'a space of infinite light…a techno-utopian imagination' (2015: 1).

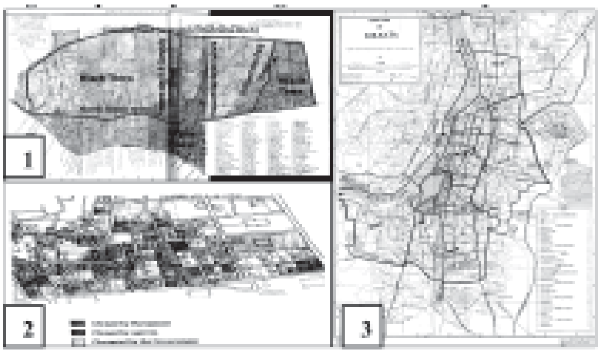


Fig 1: Popular Spatial Imaginations of the City of Kolkata through Time

Map 1 in Fig. 1 shows the broad colonial divides of the Black and the White Towns (Source: Tapas Mitra et al. "Imageability Continuum and Discreteness: Older Residential neighbourhood Areas of Kolkata"), originally it is Mark Wood's Plan of Calcutta, 1784, Original Source: NATMO Atlas [2].Map 2 shows an old plan of the Chowringhee area of Kolkata with land plots owned by the Europeans, the Natives and the Government (Source: Swati Chattopadhyay. "Blurring Boundaries: The Limits of "White Town" in Colonial Calcutta", *Journal of the Society of Architectural Historians*, 59, No. 2, (2000): 158, 154-179.Map 3 shows the more contemporary divides of North, South, Central and East Kolkata (Source: Google images).

The **objective** of the paper is, therefore, to understand the contemporary city within the space-time context of Kolkata within India in 2015, the way it has come to exist at this point through time using a parallel

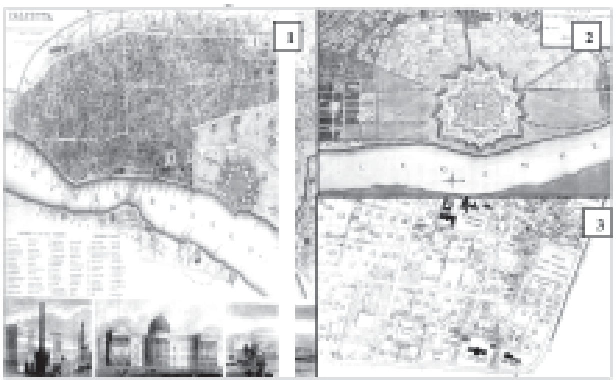


Fig 2: Some Of The Old Plans Of Colonial Calcutta

Map 1 of fig 2 shows 'Calcutta published under the Superintendence of the Society for the Diffusion of Useful Knowledge, 1842'; Map 2 shows 'the Plan of Fort William and the Black town and its surroundings belonging to the English in Calcutta 1779', cited source: 'Reproduced in Jean-Marie Lafront, Citra: Cities and Monuments of Eighteenth Century India from French Archives, OUP, New Delhi, 2001'; Map 3 shows 'A Section of the map Calcutta surveyed under the during the years 1887-1894. Published under the direction of Major General C. Strahan, Surveyor General of India, May 1897' (Source: KeyaDasgupta, *Mapping Calcutta: The Collection of Maps at the Visual Archives of the Centre for Studies in Social Sciences, Calcutta*, (Calcutta: Centre for Studies in Social Sciences, Calcutta and the Ford Foundation, India, 2009).).

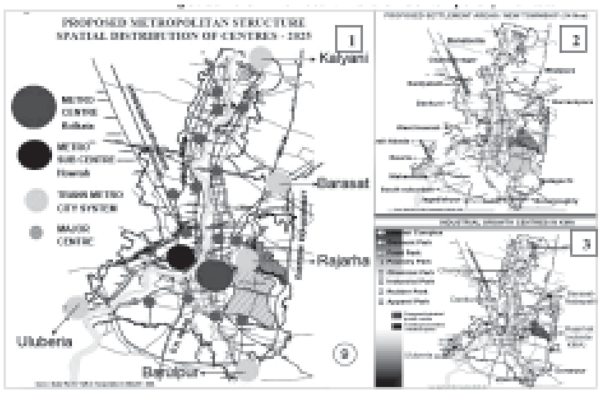


Fig 3Some Of The Recent Plans Of Contemporary Kolkata

Fig 3: Map 1 of fig. 3 shows a hierarchy of the major urban centres within KMA; Map 2 shows the distribution of proposed townships and Map 3 shows the industrial growth points. (Source: Comprehensive Mobility Plan, 2001-2015, Kolkata Metropolitan Area).

understanding and evolution of city maps. The method used includes generalised conceptualisations through specific visualisations using documented information, existing and choropleth maps and popular images as **data**.

CITY REPRESENTATIONS: MAPS

According to Pamela Gilbert, 'Abstract representation is the mode by which the city can be produced as an object of knowledge.' (2002:17). Mapping of cities is an age old exercise performed by humans. In an attempt to document expressions, human beings arrived at images first and later more technical and modified images gradually attained popularity as maps. Therefore, given the desirability, the complexities and the details of cities, technical representations suited them better as compared to the more informal images; cities, maps and city-maps are all evidence of more evolved and complicated human thinking and knowledge building defining that stage when humans realised the utility of planning their inhabited space. David Buisseret documents, 'Town plans…are probably the oldest form of a map and have been produced in great numbers...The oldest way of delineating towns is through the use of a more or less vertically seen plan...Many of these plans eventually found their way into the first great printed treasury of city images.' (1998: ix). The vertical view was followed by the bird's eye view of the city from above and the profile view from ground level.

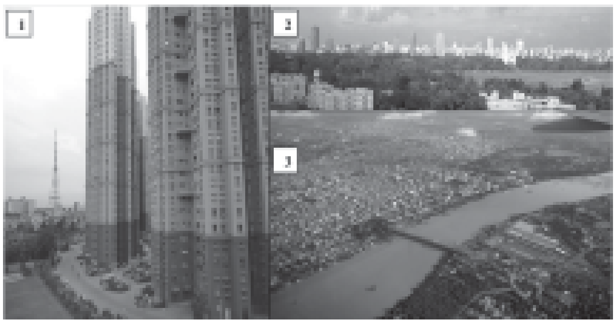


Fig 4: Multiple Views of Kolkata

Map 1 of figl 4shows a vertical view of Kolkata, Map 2 shows a profile view of Kolkata and Map 3 shows a bird's eye view of Kolkata (Source: Google Images)

Therefore having evolved from images themselves, maps started adding to the accumulation of the very images after having reached a certain level of precision and a simultaneous deviation from what are more simply comprehended as images. Buisseret further clarifies that these basically have been the 'ways of delineating the city on paper or on stone. But if, as we believe, a map is a representation of a locality, and not necessarily only a graphic representation, then we ought as well to consider models' (1998: ix). He says basically the authors of 'the various types of representation try to…show the city "the way people want to see it."' (1998: ix). These special maps called plans were somewhere expected to be technical and neutral so to say, they were supposed to be scientific documents, but that was a seldom reality. A similar expectation was attached to cities themselves, they were meant to be unbiased and inclusive and that as well was seldom the reality. Because cities were manifestations of power relations themselves, the essence of the same percolated to the maps that represented them and thus they ceased to be scientific and imbibed social complexities. Pamela Gilbert is of the opinion that specifically 'What the map does…is to redefine a space, usually an urban space, by relating a certain human experience' (2002: 19). Sometimes the motive refuses to remain a vision alone and attempts to become a selling point of the concerned city. Buisseret adds more flesh to Gilbert's explanation through his assertive statements, he believes that a map is 'produced so that the reader would be not only convinced by the text but seduced by the image. [In fact] No matter what technical means of representation is adopted, the actual envisioning of the city owes everything to the motives of its patrons' (1998: xiii), who are humans with identities. What is intriguing is, just like cities, even maps are made by humans and if maps that represent the cities, in turn, are represented by the 'city'zens, it is only human imaginations that get circulated and produced, re-circulated and re-produced.

Understanding (Questioning) City Maps

Are maps the most accurate representations of cities?

Is a map therefore only the most (un) conventional image of a city? When one imagines a city, which is the more prominent image that flashes into one's mind most immediately? Is it one that is perceptive or one that is administrative – is it like a photograph or a plan? However, an absolute dichotomy between the two can be debatable. Taking a very simple example, the spirit of the urban over and above the city along with the everyday lived human spaces or the more macro imageries of city spaces like a South Delhi, or a North Calcutta that grossly remain uncaptured in maps can represent stronger human imaginations. This is not to forget, when the imagination widens to such an extent that no concrete image formation is possible anymore, the map forms the most convenient alternative then; for example, 'India' – an imagination so diverse that it often fails to generate any one image and thus the map of the country is the most obvious image perceived more often than not. However, as it has already been discussed at length that just like all human perceptions, all maps are organically subjective.

What or whom do Maps Represent within Cities?

Though circulation of human imaginations cannot be traced back in time, yet history as documented by Gilbert, is of the viewpoint that, 'During the Enlightenment, maps came to embody the power of the objective, scientific gaze construct – or reflect – an accurate description of the geographic environment' (2002, 11). She simultaneously writes that however through time, humans have also come to acknowledge that 'All maps are rhetorical. That is, all maps organize information according to systems of priority and thus, in effect, operate as arguments, presenting only partial views which construct, rather than simply describe, an object of knowledge. Most maps flatten the terrain, offering a view of space as homogeneous and equivalent. Maps rarely account for time, differences between day and night or the seasons, for example. In any case, these constraints don't make for bad maps, only inevitably, ones which are limited by the purposes for which they are intended. Thematic maps – maps intended to illustrate a particular data set or argument, usually having to do with human actions or experiences in space – are, of course, persuasive in intent' (2002: 12). Statements like *maps flatten the terrain*, make space *homogeneous and equivalent* and do not account for *time* would remain highly underestimated if interpreted only literally.

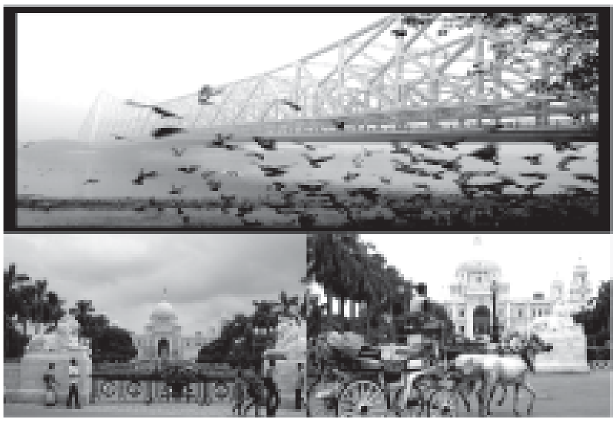
Are maps subjective or objective realities of cities therefore?

Evolution is not necessarily unidirectional. This is because a cartographer probably cannot assertively conclude whether maps followed from images or vice versa. And what is it like in the present context. The idea is not to establish a forcible conflict between the two when there are more evidence of complementarity. Maps today are criticised for being manipulative and deceptive. And if there has been an attempt to differentiate them from images and establish a conflict, it has been to conceal the deception. In an attempt to map the Chinese city, Nancy Shatzman Steinhardt formulated the opinion that 'Every map is someone's way of getting you to look at the world his or her way' (1998:15) and images (photographs, imageries and others) on the contrary possibly remain less interruptive and allow for more individualistic interpretation and vision. Eventually she attains the conviction that, 'Philosophical thoughts concerning the nature of maps is important because it dictates how we think about, use and produce maps; it shapes our assumptions about how we can know and measure the world, how maps work, their techniques, aesthetics, ethics, ideology, what they tell us about the world, the work they do in the world and our capacity as humans to engage in mapping. Mapping is epistemological but also deeply ontological – it is both a way of thinking about the world, offering a framework for knowledge, and a set of assertions about the world itself...The emphasis upon map as representation is often strongly associated with the quest for a general explanation, with a progressive search for order... The mind–body distinction is often a fundamental influence on how people think about the world... However, mapping is still about revealing truth through a scientific approach reliant upon...technologies of vision' (1998:15-16, 25). Therefore if maps are a kind of 'geovisualisation' which is tainted in every way possible, they are also representatives of the stains made in such visualisations. Justice lies not in concentrating all the blame on map makers alone, for readers must have a share which however is not equal. In fact, maps like books are platforms where human minds exchange imaginations.

MAPS: POWER: CITIES

Drawing from Nancy Shatzman Steinhardt's conviction yet again, the paper argues that simply because'maps often reinforce the status quo or the interests of the powerful' (1998:27), their relevance to city societies is of special interest.

'Harley (1989) drew on the ideas of Michel Foucault among others to argue that the process of mapping is not a neutral, objective pursuit but rather was one laden with power. He contended that the process of mapping consists of creating rather than simply revealing knowledge…In contrast to the scientific view that positions maps in essentialist terms. Harley cast maps as social constructions; as expressions of power/knowledge…Others…have extensively demonstrated this power/knowledge revealing the ideology inherent in maps…and how maps 'lie'…due to the choices and decisions that have to be made during their creation, and through how they are read by users…This social constructivist critique sometimes also articulated structural explanation for mapping, which sought understanding beneath the apparent surface of observable evidence', writes Steinhardt (1998:27). Even if maps speak for people, their makers want them to and the space and time from where they are being made, yet their social relevance cannot be denied. However, both cities and maps have failed to be the ideal – the neutral – equally for one and all and instead they have succumbed to power to speak the truth that is either partial or even inverted. This is no coincidence, in fact, most expected because both maps and cities, apart from representing each other represent humans given the social perspective one is detailing into. This is however, not to deny that there could exist maps dealing with the



Source : Google Image

Fig 5: The Way Kolkata is Popularly Perceived

physicality of cities which could be relatively less manipulating. But whether it is devoid of the human (or power) element or not is debatable, for maps are human made for humans alone.

Fig 6: Social Maps

Map 1 of fig. 6 shows ward wise slum concentration in Kolkata, 2001; Map 2 shows ward wise scheduled caste concentration in Kolkata, 2011; Map 3 shows ward wise state of household amenities, 2011; Map 4 shows ward wise percentage of households with no assets, 2011; Map 5 shows ward wise child sex ratio, 2011 and Map 6 shows ward wise sex ratio, 2011. (Source: Prepared using data from the Census of India, 2001 and 2011).

Steinhardt, therefore, opines that 'Social maps' however 'visibly represents invisibility – in Milton's phrase, "darkness visible"…The language [in such maps] is replete with metaphors' (1998:17). Therefore when one comes across maps that use information from both surveys and universes on conditions of human existence and are represented through graduated colours or otherwise, one must not study them uncritically and subscribe to the social realities they most objectively promise to reveal; this realisation is of specific importance today when governance is largely spatial governance.

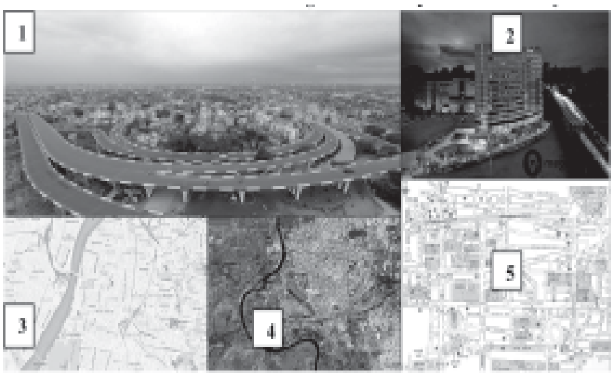
CONTEMPORARY CITIES: SPATIAL GOVERNANCE: SMART MAPS

Having established the relevance of maps with respect to cities or city societies, it is now relevant to understand the relevance of cities with respect to maps. It is needless to mention that just like maps and to some extent with them and of course independently as well, cities have evolved to this day. Therefore, every time the term 'contemporary city' is mentioned, it carries with it a certain temporal (probably also spatial) context and a historical journey to this point.

Because Kolkata has contributed to the vision so far and beyond, India, therefore, lends context to the following section. This is to say that the visualisation of Kolkata as a city that is (or is attempting to become) smart should be understood more at a theoretical and conceptual level rather than like an objective reality. The Smart Cities India Brochure proclaimed that 'As India's population continues to grow, more citizens will move to cities…people will migrate every minute to major Indian cities...To accommodate this massive urbanization, India needs to find smarter ways to manage complexities, reduce expenses, increase efficiency and improve the quality of life' (2015:2). Smart cities are therefore to be perceived as an expected solution to India's existing urban problems. Precisely, it offers 'smarter solutions for a Better Tomorrow' as the brochure claims (2015:1).When our cities become smart, they will have smart energy, smart environment, smart transportation, smart IT & Communications, smart buildings, smart health, smart education and Smart Governance.

In fact, given the nature of urbanisation in this country, spatial governance has become a natural necessity so as to ensure smart governance. To ensure efficiency, decentralisation becomes obvious and spatial governance becomes both an aspect and a manifestation of the same. Two points find relevance in terms of city representations, mapping, planning and so forth. First, the kind of city that is emerging today is increasingly making way for spatial governance which invariably makes spatial plans or maps important. Second, city expansions, which are very much a part of this process of emergence fails to retain cities within administrative limitations. What is being stressed at is the dichotomy yet again; One that calls for a more scientific, rule-bound spatial planning through mapping and the other to a break through towards mapping that is more perceptive and less administrative, more lived and less planned. Today is a point in time when as much as the age old dichotomy re-surfaces, almost parallel is the need to arrive at a mid-point. This is because the contemporary city is increasingly reaching that mid-point between the city and the urban, a city dweller and a cartographer, choropleth maps and mental maps and so on. They are becoming smart. And for an average city dweller, a city must be able to confer all conditions of comfort, good services, good governance along with innovation, security, satisfaction and so on. The requirement includes the yellow lights of a supermarket and the blues of a water body along with rich and extensive greenery – basically a package. A smart city inhabitant is aspiring to experience the objectivities of a city and the subjectivities of the urban which would have the urban pace with the rural peace. The attempt is therefore directed toward the attainment of these neo-urban spaces. Therefore, if maps have argued to be the city representatives, what kind of maps would represent a smart city? Simple, a smart map possibly. What is exactly a smart map therefore?

'Smart Maps are critical tools to accelerate progress toward India's social and economic development agenda…Smart Maps use cutting-edge technology to enable users to quickly and effectively achieve their day-to-day and long term goals…smart Maps have a range of applications across sectors and regions …The broader economic and social benefits of Smart Maps for citizens, businesses, and the government are likely many times greater…Smart Maps identified a realistic improvement based on cross-country comparisons of map improvements…With the second-largest smartphone market in the world and one of the fastest-growing internet economies, India is in a unique position to tap into the value of Smart Maps. India needs a...mapping policy that encourages innovation and scalable solutions can help...create a world-class mapping and GIS industry that benefits Indian citizens, businesses, and government', claims the dalberg group promoting these very smart maps for India (2015:4). One must understand at this point is, a city that is smart must have citizens at the heart of its affairs and that in turn represents a space-time context when the utility of a map has spilled beyond the expertise of cartographers and geographers and is increasingly becoming a tool for one and all. Maps today are made not just to understand but to interact and communicate with the world one inhabits.



Source: Google Images

Fig 7: Smart Maps and Smart City

CONCLUSION

The basic objective of the paper as suggestive in the title was to finally understand the *contemporary (smart in context and concept) city*. Maps have been a parallel focus of the study. They are largely tools to understand the city, which is the general truth for maps are made not for their own sake but for understanding another truth. It is through the evolution of maps, the different types of them that represent cities (the way they look and the people they are homes to), their contrasts and closeness to images, photographs and the likes and finally their status, use and manifestations today, the attempt has been to understand cities (with Kolkata as the visible example) through maps and not maps per se. Therefore, an evolution of maps helps an understanding of the evolution of cities as well and the fact that power manipulates maps is symbolic of the fact that even cities get manipulated by power and both maps and cities represent power. And if maps reveal what they are made to, cities also get perceived the way one wants to, no matter how distorted and distant it might be from reality. This is because both maps and cities are objective realities where human subjectivities interact. Therefore, when one is mapping cities, both objective spaces (that confine social realities within administrative boundaries) and perceptive spaces (that are embedded in those realities and within the identities and the biases of the maker and the reader of a map) find expression. And it is these complicated yet wholesome expressions that enable wholesome though complicated comprehension of cities.

REFERENCES

1. Buisseret, David (1998): *Envisioning the City: Six Studies in Urban Cartography*, Chicago: University of Chicago Press.
2. Bridge, Gary; Watson, Sophie (2000): *City Imaginaries*, UK: Blackwell Publishers.
3. Chattopadhyay. Swati (2000) "Blurring Boundaries: The Limits of "White Town" in Colonial Calcutta", *Journal of the Society of Architectural Historians*, 59, No. 2, pp 154-179.
4. Dasgupta, Keya (2009): *Mapping Calcutta: The Collection of Maps at the Visual Archives of the Centre for Studies in Social Sciences, Calcutta*. Calcutta: Centre for Studies in Social Sciences, Calcutta and the Ford Foundation, India.
5. Gilbert, Pamela K. (2002): *Imagined Londons*, U.S.A.: State University of New York Press.
6. Shivkumar, Rohan (2015): *Utopian Chimeras of the Future*, New Delhi: The Hindu, Sunday, July 26, The Sunday Magazine, Weekly Edition 2, V.I.S.I.O.N.
7. Steinhardt, Nancy Shatzman (1998): *Mapping the Chinese City: The Image and the Reality*, Chicago: University of Chicago Press.
8. Smart cities India 2015: Smarter Solutions for a Better Tomorrow, Exhibitions India Group (www.smartcitiesindia.com).
9. Smart Maps for Smart Cities: Smart Maps for India, Conferation of Indian (www.dalberg.com)

PATTERN IN PRIVATE SECTOR INVOLVEMENT IN URBAN WATER SUPPLY IN INDIA: A SPATIO-TEMPORAL ANALYSIS

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ABSTRACT

The link between water and poverty is internationally well recognised, evident by the commitment of the Millennium Development Goal (MDG) of halving the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 and subsequently the Sustainable Development Goals (SDG) building on the MDG. Involvement of the private sector in service provision is considered as one of the options to meet the challenge. Post-liberalisation, the environment has become more conducive for Public-Private Partnership in the infrastructure sector in India. Citing the urgent need to increase population coverage and improved services in the water sector, some state and city governments are presently availing the services of private companies. On one hand, the journey has been mired in controversy with several of the projects being abandoned, while on the other hand, some projects have been declared as successful ventures. Past studies, although sketchy, suggest that while active public-private partnership in water started in the 1990s, it became more popular in the late 2000s and early 2010s. Spatial and temporal pattern of the private sector involvement initiatives primarily in water supply across India have been explored in the present paper.

The analysis is based on secondary data compiled from the Census of India, reports, newspaper articles and official utility websites, websites of private companies engaged in water supply and distribution. Findings suggest that the per capita income of the state, city size, political will, role of Central Government, role of international agencies etc have a bearing on the award of Public Sector Participation (PSP) projects in the urban water sector.

***Keywords**: Public Water Supply and Distribution, Public-Private Partnership, Spatio-temporal Pattern*

INTRODUCTION

Clean freshwater is limited in quantity making it the most precious natural resource. Drinking water supply has traditionally been the responsibility of the Government owing to the basic and indispensable nature of water. But in recent times, scarcity of freshwater has prompted a change in attitude. There has been a gradual shift of management of utilities and services from the public sector to the private sector all over the world. In India, till the early 1990s, the economy came to acquire a large public sector especially in infrastructure and basic industries and came to be known as the mixed economy. Post economic liberalisation, reforms have been undertaken including opening for international trade and investment, deregulation, initiation of privatisation, tax reforms among others. Among utilities, urban water supply has also undergone reforms in many cities of India with varying degrees of participation of the private sector.

In the present paper, an attempt has been made to explore the spatio-temporal pattern of private sector participation in water supply across the states of India in terms of the award of projects. This has been done with respect to certain correlates such as development level of the states (per capita income of the state), size of the project location, nature of implementing agency, political alliance in power and source of funding of the PSP projects.

OBJECTIVES

The present paper aims to understand the regional variation of the private sector involvement initiatives in water supply and distribution across India and the various select correlates that may have played a role in the award of projects.

DATA AND METHODS

PSP in water supply is still at a nascent stage in India and the projects have been experiencing setbacks at various stages, such as pre-award, post award and post commissioning. In this paper, only those projects have been considered which have been awarded. They might have run into trouble and got discontinued post award. Thus, the number includes projects at various stages including stalled and delayed projects. Total number of 73 projects was selected. The selection was largely based on availability of information in the public domain. The data sources include Census of India, 2011, Economic Survey 2015-16, official websites of water utilities and websites of private water companies.

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DISCUSSIONS

Background

Water supply and distibution systems all across the world were privately owned till the early 20th century. Access to the poor and water quality concerns led governments of many countries to take over the water supply and distribution systems. Since 1990s, there has been a spurt in privatisation of water supply utilities with Britain (1989) being the first to completely privatise. In the next decade, services were privatised in Austria, Belgium, Canada, Chile, Denmark, Holland, Italy, Jamaica, Japan, Malaysia, Singapore, Sweden and USA. The 1990s witnessed the spread of privatisation in the 1990s in the Latin American Countries; Bolivia, Brazil and Argentina. Following two popular uprisings against water privatization, the first in Cochabamba in April 2000 and the second in La Paz/El Alto in January 2005, the two concessions were terminated. In Argentina, tariff increase in change in original contract eventually led to remunicipalisation. Around the same time, private companies made a foray into Asian Cities; Manila, Jakarta, cities of Cambodia etc.

In India, the British brought with them State owned, centralised water supply through an established distribution network of pipelines. The main focus was to provide safe drinking water to the British officers, families and their troops stationed in towns. The model continued well past independence with the Government being responsible for provision of water in urban areas.Over the years, the water utilities have fallen into disarray with mounting debt and their inability to recover even operation and management costs, leave alone capital costs. These utilities have been largely surviving on Government grants. The condition of the physical infrastructure has also deteriorated and it has become a vicious circle of high capital costs and inability to support the costs resulting in poor household coverage, exclusion of the poor and marginalised, poor water quality , erratic and low quantity of water etc. In India, only 31.9 percent of all households and 62.4 percent of the urban households have access to treated tap water compared to 58 percent and 79 percent respectively for the world.

Among other factors, the Millenium Development Goals (MDG) was a key driver for expediting the improvements in water and sanitation.They were launched in 1990 with a time frame of 15 years. The MDG drinking water target was set as halving the proportion of population without access to safe drinking water by 2015. The target for water supply has been achieved in 2010 (WHO, 2016). In 2015, 17 Sustainable Development Goals (SDG) wee adopted by countries across the world to take forward the MDGs. The 1990s, after the launch of MDGs, was also the time when there was pressure on the governments of the developing countries including India, from the international donor agencies to improve the financial and institutional capacity of the water utilities. This was also the decade when India's economy had been liberalised, reforms were being undertaken.Various arrangements such as setting up of parastatal organisations were experimented with. Since the mid 1990s, private players have entered the Indian urban water space, but it was only post 2005 after the launch of Jawaharlal Nehru Urban Renewal Mission (JNNURM) that contracting out of different water supply functions to private players has taken off. Unbundling of water supply has been an important aspect of the process in order to attract the private players. The National Water Policy (draft), 2012 suggested the reassessment of the role of the state as the service provider and encouraged public private partnerships.

Private Sector Participation can be at various levels. It usually varies from service contracts to full divestiture. Service Contracts have the least extent of private sector involvement in terms of financial responsibility while in full divestiture, public sector has no involvement. Fig. 1 presents a typical extent of private sector participation.

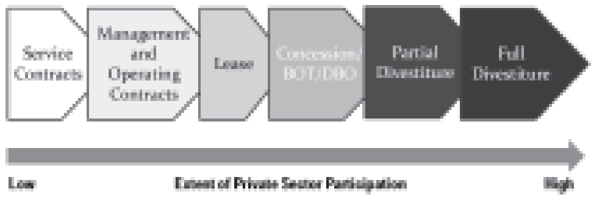


Fig. 1: Spectrum of Extent of Private Sector Participation.

Types of Public-Private Partnership agreements are outlined in table 1.The table shows the types of contract vis a vis asset ownership, capital investment, O&M, commercial risk and duration.

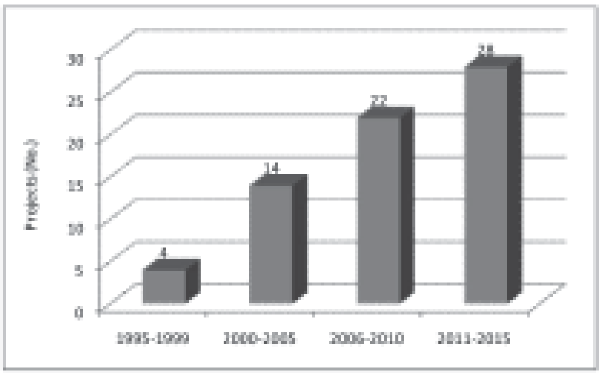
Table 1
Types of Public-Private Partnership Agreement

Types of Contract	Asset Ownership	Capital Investment	O&M	Commercial Risk	Duration
Service Contract	Public	Public	Private and Public	Public	1 - 2
Management Contract	Public	Public	Private	Public	3 - 5
Lease	Public	Public (with limited private)	Private	Shared	8 - 15
Concession	Public	Private	Private	Private	25 - 30
Divestiture	Private or Private & Public	Private	Private	Private	Indefinite

Source: Toolkits for Private Participation in Water and Sanitation, World Bank, 1997.

Trend of Public Sector Participation in Urban Water Supply

An analysis of the selected projects reveals that the period 2005-2010 and 2011-2015 witnessed the highest number of the PSP projects getting awarded in the urban water sector (Fig. 2). This can also be attributed to the launch of JNNURM in 2005 which



Source: Compiled from official websites of water utilities and private water companies

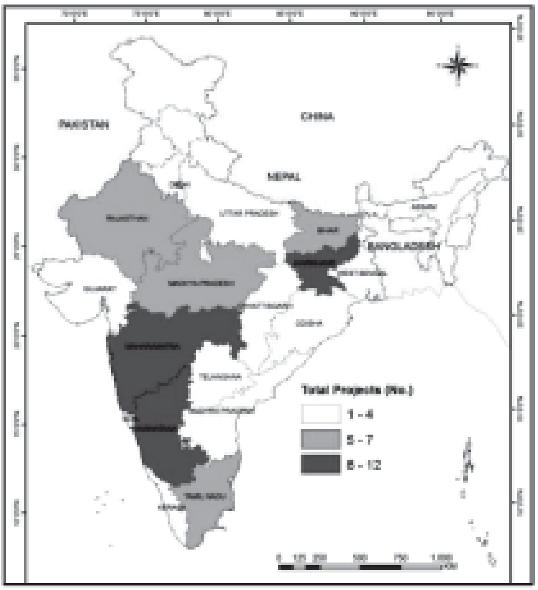
Fig. 2: Trend in PPP in Public Water Supply:1995 – 2015

pushed for PPP in the infrastructure sector with an aim to improve service delivery. The PSP bent continues in AMRUT. The number of projects remained high in 2011-2015 as the tempo of PSP in urban water supply picked up. The year of award is not available for 5 projects.

Out of the 68 projects for which data was available, 73.5 percent (50) of the projects were awarded after 2005, the year in which JNNURM was launched. Least number of projects (5.8 percent) were awarded between 1995 and 1999. This reiterates the commitment of JNNURM to promoting private sector involvement in the water supply sector. While the number of projects in the urban water supply has increased manifold post JNNURM, the distribution across states has not been the same. The next section explores the distribution of projects across states in different time frames.

Spatio-Temporal Pattern of PSP

There is much variation in the number of awarded projects among the states as seen in fig. 3. Overall, Maharashtra, Karnataka and Jharkhand have the highest number of awarded projects in the urban water supply sector followed by Rajasthan, Madhya Pradesh, Tamil Nadu and Bihar. The findings are surprising with a mix of high income and low income states. A further analysis of the temporal pattern helps in better understanding of the spatial pattern. The year of award also varies in these states as seen in fig. 4. Karnataka, Maharashtra, Andhra Pradesh and Goa were the early birds (1995-1999). Projects, though few in number, were awarded in these states initially. These states also have had a history of active institution building through engagement with donor agencies.



Source: Compiled from official websites of water utilities and private water companies

Fig. 3: Regional Variation of PSP in Water Sector in India

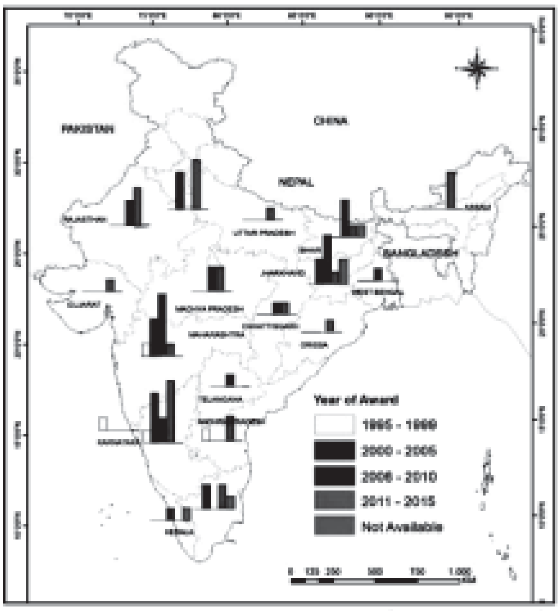
The investment environment might have been conducive in these states for the private companies to be stakeholders in the water projects. There was a spurt in projects after the year 2000. Projects were awarded in Maharashtra, Karnataka, Delhi, Jharkhand and Tamil Nadu in the period 2000-2005. In the period, 2006-2010, immediately after the launch of JNNURM, there was a surge in projects in the earlier states (Maharashtra. Karnataka, Jharkhand) , but PSP in water sector was introduced in new states (Rajasthan, Madhya Pradesh, Chhattisgarh, Kerala, Telangana- Andhra Pradesh at the time of award, West Bengal and Bihar) as well. Many of the urban projects have been largely pilot projects encompassing 10 to 20 percent of the total city population. The pilot project in Nagpur was upgraded to a full city scale project in 2012.

Correlates of Private Sector Participation in Urban Water Supply

A certain pattern is observed in the private sector participation in water supply across the states in India. Correlates of PSP in water supply have been explored in this section.

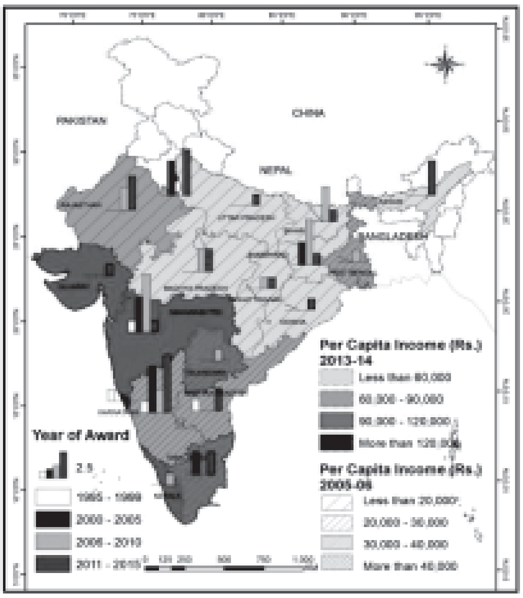
Per Capita Income of the State

Literature and past studies show that there is a positive relationship between per capita income of the states and the level of infrastructure. The association between per capita income of the states and the year of award has been analysed to



Source: Compiled from official websites of water utilities and private water companies

Fig. 4: Spatio-Temporal Pattern of PSP in Water Sector in India



Source: Compiled from official websites of water utilities and private water companies, Economic Survey 2015-16.

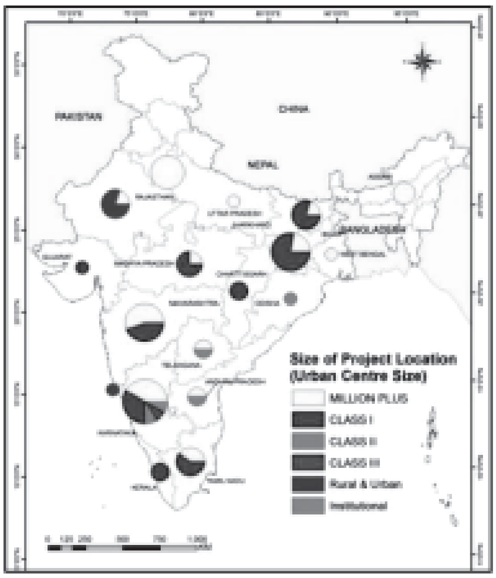
Fig. 5: Per Capita Income of the State and Year of Award of PPP Projects.

understand the role played by the economic status of the states in promoting PPP in the water sector.

It is evident from the map (fig. 5) that PPP in the water sector was initially introduced in states with higher per capita income. Per capita of states has been taken for two years; 2005-06 and 2013-14 at current prices (2014). Although the absolute state per capita income has significantly increased, the ranking has remained similar. States such as Maharashtra, Goa, Andhra Pradesh and Karnataka witnessed the initial activity in private sector involvement in India. The second phase of expansion was also primarily restricted to high per capita income states, barring Jharkhand. Jharkhand features in this phase due to the presence of Jamshedpur which has been under TATA Steel and erstwhile TELCO since inception but JUSCO was formally launched in 2004, thus it has been included in the time phase 2000-2004. The third phase which is the post-JNNURM (2005-2010) phase witnessed a flurry of activities in PPP in the water sector front. PPP in the water sector was introduced in the middle and lower per capita income states such as Rajasthan, West Bengal, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand during this phase. It may be attributed to the importance and the subsequent impetus given by the JNNURM programme to private sector participation in infrastructure development. PPP projects in the water sector came up in almost all the states, barring West Bengal, under consideration in the last phase of 2011-2015.

Size of the Project Location

The size of the project location in terms of the size of the centre where it is located has been analysed (Fig. 6). PSP initiatives in almost all the selected states are restricted to the Million Plus and Class I cities. This may be attributed to the focus of JNNURM mainly on Million plus and class I cities and also the willingness of the private players to operate in the big cities. Goa, Rajasthan and Karnataka are the only states where single projects involving both urban centres and rural areas have been awarded. Out of



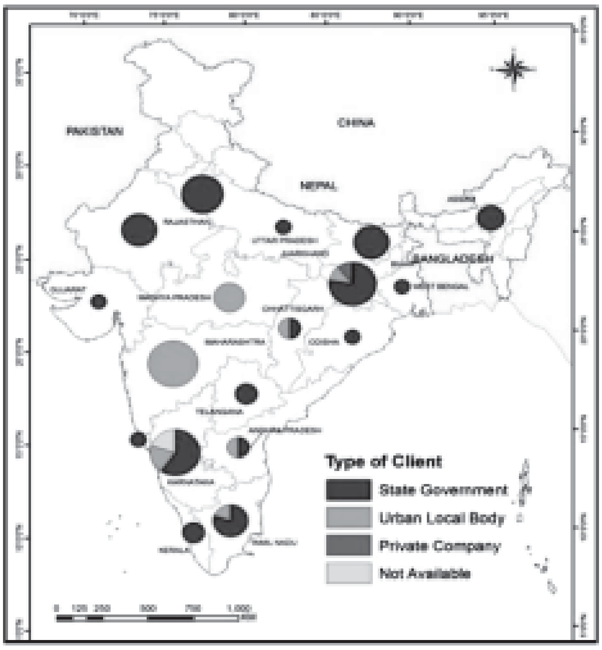
Source: Compiled from official websites of water utilities and private water companies

Fig. 6: Size of Project Locations.

all the states, Karnataka has the highest diversity in type of project locations.

Nature of Implementing Agency

The type of dominant implementing agency or the client is also a reflection of the present dismal status of implementation of the 74th Constitutional amendment (Fig. 7). Out of the 73 projects awarded, state government was the implementing agency for 48 (65.7 percent) of them. ULBs were the client in only 27.3 percent of the cases. This could also mean that the state governments are better facilitators of PSP as compared to ULBs.

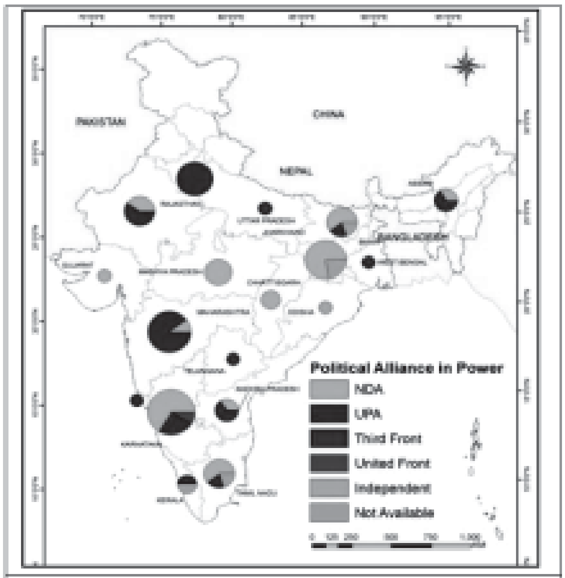


Source: Compiled from official websites of water utilities and private water companies.

Fig. 7 : Nature of Implementing Agency

Political Alliance in Power

Political will plays an important role in the award and implementation of projects. In PPP projects, since "privatisation" is involved, ideology of the political parties also comes into play. Kerala and West Bengal being classic examples of such a case, where very few PSP projects have been awarded in the water sector despite both the states being high and medium income states. Overall, nearly equal number of projects has been awarded under both United Progressive Alliance headed by Indian National Congress and National Democratic Alliance headed by Bharatiya Janta Party despite INC being a party with centre left leaning while BJP has a right leaning (Fig. 8).

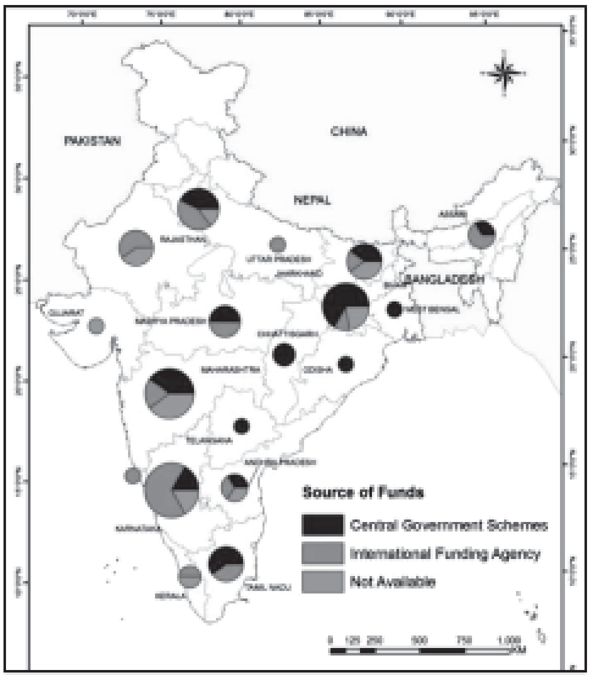


Source: Compiled from official websites of water utilities and private water companies

Fig. 8: Political Alliance in Power during the Award of Project

Projects funded by JNNURM/UIDSSMT and International Funding Agencies

The pivotal role played by the Central Government initiatives such as JNNURM/UIDSSMT and the multilateral/bilateral funding agencies in promotion of PPP is clear from fig. 9. Out of the 73 projects, information regarding the source of fund was not available for 11 of the projects. Overall, the share of



Source: Compiled from official websites of water utilities and private water companies.

Fig. 9: Source of Funds of Projects.

PPP projects being funded by JNNURM/UIDSSMT (41 percent) and international funding agencies (38 percent) are nearly equal.

It is also interesting to note that the loans from the international funding agencies are limited to certain states. Karnataka and Rajasthan seem to have particularly benefited from funds from donor agencies.

CONCLUSION

Private Sector participation in the urban water sector is being seen as a viable solution to the present dismal situation of urban water supply and distribution. The involvement is largely in the form of contracts with the public entity still the owner of the infrastructure. The contract period varies from 3 to 30 years. Several Indian cities have engaged the services of private companies, largely for either bulk water supply or distribution; involving both construction and operation and management. The trend has been towards increasing involvement in distribution of water.

Analysis of the spatio-temporal pattern of PPP projects in the urban water sector in India revealed that such projects are concentrated in certain states and the driver for the awarding of the projects have been different across various time frames. The initial projects were awarded in the higher income states. JNNURM gave an impetus to the private sector participation in the urban water sector and the post JNNURM phase witnessed award of many such projects in the lower income group states as well. The awarded projects have been largely concentrated in class I cities with 42 percent of the projects in million plus cities and 41 percent in the other class I cities. Most of the projects have also been awarded by parastatal agencies highlighting the irony of the present Indian governance. Many of the parastatal agencies were formed in the late 1990s to counter the poor performance of ULBs in the urban water sector. The same agencies have now passed on their responsibility to private companies. The political allegiance also doesn't seem to have too much bearing on the award of projects negating the ideological differences between political parties. While the present paper focuses primarily on the spatio-temporal pattern of PSP awarded projects and its possible correlates, there is a lot of scope for further research on the reasons for successes and failures in this sector.

REFERENCES

1. World Bank (1997), Toolkits for Private Participation in Water and Sanitation
2. http://orissadiary.com/CurrentNews.asp?id=54513
3. http://timesofindia.indiatimes.com/city/nagpur/Pench-IV-WTP-likely-to-be-commissioned-on-Saturday/articleshow/46668856.cms
4. http://timesofindia.indiatimes.com/city/patna/Rs-426cr-water-supply-project-fails-to-take-off/articleshow/38226772.cms
5. http://www.business-standard.com/article/companies/us-bribery-case-smc-infra-spml-joint-venture-executed-goa-water-project-115072000021_1.html
6. http://www.cised.org/wp-content/uploads/hubli.pdf
7. http://www.hindustantimes.com/delhi/jal-board-staff-smell-a-scam-in-bhagirathi-plant/story-uOh8XTdf1oUMI5QO4e9qcJ.html
8. http://www.ndwml.com/
9. http://www.newindianexpress.com/states/kerala/Degremont-Feels-Let-Down-by-KWA/2014/01/31/article2028827.ece
10. http://www.projectuday.nic.in/Indore.htm
11. http://www.telegraphindia.com/1120610/jsp/jharkhand/story_15590157.jsp
12. http://www.telegraphindia.com/1120610/jsp/jharkhand/story_15590157.jsp
13. http://www.thehindu.com/news/cities/Visakhapatnam/water-projects-gvmc-favours-ppp-mode/article4999220.ece
14. http://www.veolia.in/ilkal-karnataka
15. http://www.worldbank.org
16. https://infrastructureindia.gov.in
17. www.cseindia.org/userfiles/fullstory_final.pdf

DISPARITIES IN URBAN FACILITIES & SERVICE UTILITY OF BARASAT TOWN, WEST BENGAL, INDIA

Debdip BHATTACHARJI[1] & Sukla HAZRA[2]

ABSTRACT

Disparity is a vital issue in urban centre of developing country like India. The socio-economic development is well related with the accessibility of facility-utility services. Here utility can be defined as the ability of particular stakeholders to use different services and satisfy own needs. Only availability of facility does not indicate the development of an area, unless and until these facilities are adequately accessible for stakeholders of all classes of society. Disparities in facilities are measured by analyzing the gap of utility levels. The coexistence of developed and underdeveloped localities within a single town leads to underutilization of resources. Such disparities are not conductive for urban development. The present study is based on empirical observations focused on ward-wise variation of availability and accessibility of facilities and its utility services to measure the ward-level disparity in Barasat town of West Bengal. Here the facilities have been categorized in health, education, recreation, financial and other sectors. All kinds of data are collected from questionnaire survey separately from different classes of the society in Barasat town and degree of satisfaction is measured by computing Composite Satisfaction Index (CSI). Finally, Principal Component Analysis (PCA) has been done to find out the main factors responsible for the development of Barasat town.

Keywords: *Ward level disparity, Stake holders, Facility-Utility service, Composite Satisfaction Index (CSI), Principal Component Analysis (PCA).*

INTRODUCTION

The importance of socio-economic infrastructure in economic development, trade, employment and in reducing disparity within the country/region has been acknowledged by many scholars (Iqbal and Suleman 2010). Availability of adequate infrastructure facilities, especially the physical infrastructure is the pre-condition for sustainable economic and social development (Satish 2006; Kurian 2000), and often, the development of a region is disturbed by the low quality and limited accessibility of infrastructure (Klytchnikova and Lokshin (2011). It is also understood that the investment in infrastructure projects involve huge capital, long gestation periods, high incremental capital-output ratio, high risk and low rate of return on investment and non-rivalry in nature. All these factors make private sector entry difficult. As a result of which, infrastructure services, world over, are generally provided by the public sector (NBARD 2004; Dayley 1996). In the study of Rainey *et al*. (2003) found that the communities with well-managed and good quality public services are more likely to be successful in sustaining stable and growing economic bases. In other words, poor infrastructure leads not only to underutilize the region's economic resources but also fails to market the domestic produces at the fullest level in developing countries (Neogi 2010; Ghosh and De 2004). In India too, economic development with regional equality has been a prime objective in country's economic policy since the beginning of planning period.

In the Third Five Year Plan (1961-'66) a separate chapter was devoted to balance regional development (Chapter IX). Policies for the development of backward areas, at the centre and state levels; identification of backward areas and indicators of development for different sector etc; all the efforts were made based on Pandey Committee, Chakraborty Committee and National Council for Development of Backward Areas (NCDBA) recommendation right from the Third Five Year Plan (Kumar, 2009). Despite different efforts being undertaken, India still has been experiencing a wide inter as well as intra-regional both at macro and micro level disparities in socio-economic and cultural development Several studies on the examination of the magnitude of regional inequality have been made in abroad and India as well.

Different scholars like Mathur (1983) and Dadibhavi (1998) tried to access the regional disparities in socio-economic development using per capita income as a measure of development. Mallikarjun (2000), Hassan (2007) and Paul (2012) attempted to focus on the leading factors of regional disparities of different socio-economic development by adopting Principal Component Analysis and Composite Index techniques. Sao Suman (2007), Paul and Dasgupta (2008), Rahaman and Salauddin (2009) and Deepika Varshney et al. (2010) tries to find out the nature of and determinants of disparities of urban utility-facility services in intra-ward variation of urban centers.

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STUDY AREA

Barasat Municipality was born on 1st April 1869 but up to 1882, it did not have any independent existence. Total Barasat municipal area was divided into 32 Wards. Previously, there were 4 Wards and after that 18 Wards under Barasat Municipality. Barasat town is the districts headquarter lies within the jurisdiction of Kolkata Metropolitan Development Authority (KMDA) of North 24 Parganas district and junction corridor of North Bengal and Bangladesh. The growth of the population of this town is very high that is 3.5% per year. This town is located between 88°27′ east to 88°31′ east longitude and 22°40′58" north to 22°44′44" north latitude. The total area of this town is 31.41 sq. k.m. There are 32 wards in Barasat Municipality town. As per the provisional reports of Census of India, the population of Barasat in 2011 is 283443 of which male and female population is 143732 and 139711 respectively. Barasat has a population density of 9023 persons per sq. k.m. This town experienced 115.3% of population growth during 1991 to 2001 whereas West Bengal (urban) had 19.88% which was much less than this town. Barasat also had a higher growth rate in comparison to that of all India (urban) rate of 32.60% (Fig 1).

After the partition of India volume of the population has been increasing. Migrated people from the erstwhile East Pakistan were added to the population of Barasat town. Barasat town it well connected with roads to Kolkata, North Bengal, Bangladesh and other towns of West Bengal. The two National Highways (NH 34 & NH 35) and one State Highway (SH 2) run through Barasat town; Barasat is also well connected by railway with Sealdah, Bongaon and Basirhat. The railway company has decided to develop Barasat station as a super model station, for which work has already started. There is a proposal of new bypass way along Barasat to Roychowk which connects North 24 Parganas district with South 24 Parganas district. Also, the proposals of development and widening of National Highways are in existence.

OBJECTIVES

Having known the theoretical framework of the growth of infrastructure and economic development, the present study is the modest attempt to analyze inter-ward disparities of facility-utility infrastructure, socio-economic characteristics and degree of satisfaction among the dwellers. The specific objectives of the study are given below:

i. To verify the inter-ward facility-utility infrastructural disparities in Barasat town;
ii. To portray the importance of facility-utility infrastructure on town's development;
iii. To identify the leading factors of socio-economic disparities;
iv. To analyze the degree of satisfaction among dwellers;

DATABASE AND METHODOLOGY

With the help of CMIE (Centre for Monitoring Indian Economy) methodology of District Infrastructure Index (DII), the *Ministry of Development of North Eastern Region* (DoNER), Government of India, has developed a composite NER District Development Index (DII) using 2001 census data to give ranking to all the 80 districts. For the present study, with a slight modification from the methodology of the above organization, a three stage development index called '*Composite Index of Development*' (C.I.D.) of the wards of Barasat town has been constructed on the basis of 17 broad indicators of socio-economic infrastructure. The 17 indicators (Fig 3) which are used for the computation of '*Composite Index of Development*' (C.I.D.) are named below:

i. % of Ward wise population to total municipality population (x^1),
ii. % of ward wise literate population to total municipality population (x^2),
iii. % of ward wise male literate population to total male population (x^3),
iv. % of ward wise female literate population to total female population (x^4),
v. % of ward wise worker population to total population (x^5),
vi. Number of ATM/'000 Population (x^6),
vii. Number of health centers/'000 Population (x^7),
viii. Number of bank/'000 Population (x^8),
ix. No. of school/'000 Population (x^9),
x. Number of hotel/'000 Population (x^{10}),
xi. Number of park/'000 Population (x^{11}),
xii. Road density (x^{12}),
xiii. Number of post office/'000 Population (x^{13}),
xiv. Number of cinema hall/'000 Population (x^{14}),
xv. Number of factory/'000 Population (x^{15}),
xvi. Number of petrol pump/'000 Population (x^{16}),
xvii. Number of college/'000 Population (x^{17});

The Composite Development Index (CDI) of infrastructure has been constructed in the following steps:

- $\boldsymbol{C.D.i. = (Pi/PI)\times 100}$
- $\boldsymbol{C.I.D. = \Sigma C.D.i.^{1\ to\ 17th}/N}$

C.D.i = Co-efficient of development for variable 'I',

Pi= Percentage of variable 'I' in the unit,

PI= Mean percentage of variable 'I' of the study area,

C.I.D. = Composite Index of Development,

$\Sigma C.D.i^{1 \text{ to } 17th}$ = Summation of C.D.i. values for 1 to 17^{th} number of variables,

N= Number of variables;

To measure the ward-wise variation of availability and accessibility of facilities and its utility services x^6 to x^{17} factors have been chosen. All kinds of data are collected from secondary sources and questionnaire survey separately from different classes of the society in Barasat town and degree of satisfaction is measured by computing Composite Satisfaction Index (CSI). Finally, Principal Component Analysis (PCA) has been done in SPSS statistical software environment to find out the main factors responsible for development of Barasat town.

The research approach involved conducting a spot, telephonic, mail and through social networking site survey with a random and proportionate sample of 194 adults in Barasat town, West Bengal, India. The questionnaire was based on a five point scale (1, 2, 3, 4, and 5). The negative and positive questions are aligned so that the remarks are ranging from strongly agree (5) to strongly disagree (1). The total number of questions with an answer against each response is calculated and authors used the following formula to calculate the *'Composite Satisfaction Index'* (C.S.I.). It includes three separate steps.

First, *Total score received = (total number of responses of 5*5) + (total number of response of 4*4) + (total number of responses of 3*3) + (total number of responses of 2*) + (total number of responses of 1*1);*

Second, *S.I. = (Total score received/Maximum possible score)*100*

C.S.I = (Health facility Satisfaction Index+ Education Facility Satisfaction Index + Financial Facility Satisfaction Index + Recreational Facility Satisfaction Index + Other Facility Satisfaction Index)/N

Accessibility of each facility in terms of nature of distribution per unit area has been measured using Mathur's method of Mean Spacing which is as follows:

D = 1.0746 A/N

Where, D denotes the theoretical distance between the facilities in a hexagonal pattern of the area, A denotes area of the ward and N denotes the number of the facility at that ward.

DISCUSSIONS AND ANALYSIS

The unequal distribution of development is a common phenomenon in India. Such problem leads to the emergence of regional disparities in socio-economic development. 32 wards are categorized in developed, moderately developed and underdeveloped regions (Table 1). It is very vulnerable to think that 27 wards of Barasat town are marked in underdeveloped regions (C.I.D. values <159.98). Three wards No. 3, 19, 26 are in moderately developed regions (C.I.D. values 159.98-218.61) and only two wards No. 14 and 25 are marked as developed wards (C.I.D. values >218.61).

Table 1
Gradation and Distribution of Developed, Moderately Developed and under Developed Wards of Barasat Town

Mean of C.I.D.	101.35	Gradation		Status of Wards
Standard Deviation of C.I.D	58.63	i.	<159.98 (Underdeveloped Wards)	1,2,4,5,6,7,8,9,10,11,12,13,15,16,17,18,20,21,22,23,24,26,27,28,29,30,31,32
		ii.	159.98-218.61(Moderately developed Wards)	3,19,26
		iii.	>218.61 (Developed Wards)	14,25

Source: Computed by authors

The most two developed wards 25 and 14 having 252.44 and 251.16 C.D.I. Scores are very close to each other. The highest number of bank, hotel and cinema hall are found in ward number 25 on the other hand maximum number of post office and school are found in ward number 14 (Table 2). Maximum accessibility of bank, hotel and cinema hall also can be seen in ward number 25 and maximum accessibility of post office can be found in ward number 14 (Table 3).

The moderately developed wards 3, 26 and 19 having C.D.I. scores 210.78, 195.07, 184.67 respectively. Maximum count of roads and factory are found in ward number 19 and maximum number of petrol pump is in ward number 26 (Table 2). Maximum accessibility of ATM, School, Park and Factory are found in ward number 19. Easy accessibility of Petrol pump is located in ward number 26 (Table 3).

There are 27 wards marked in underdeveloped regions among which ward number 30, 28, 15, 17 and 16 are in extremely backward conditions (Table 1). The most two underdeveloped wards are 30 and 28 having C.D.I. Scores 40.06, 42.57 respectively. These two are located at the periphery portion of Barasat

Table 2
Statistics of Facility-utility Services in Barasat Town

Facilities	*Wards with highest facility value*
ATM/'000 Population (x6)	Ward No. 5 (0.39)
Health centre/'000 Population (x7)	Ward No. 32 (0.76)
Bank/'000 Population (x8)	Ward No. 25 (1.60)
School/'000 Population (x9)	Ward No. 14 (1.22)
Hotel/'000 Population (x10)	Ward No. 25 (0.79)
Park/'000 Population (x11)	Ward No. 11 (0.29)
Road Density (x12)	Ward No. 19 (124.11)
PO/'000 Population (x13)	Ward No. 14 (1.35)
Cinema hall/'000 Population (x14)	Ward No. 25 (0.20)
Factory/'000 Population (x15)	Ward No. 19 (0.46)
Petrol pump/'000 Population (x16)	Ward No. 26 (0.13)
No. of College/'000 Population (x17)	Ward No. 29 (0.11)

Note: Computed by authors

Table 3
Accessibility- Mean Spacing (Per Unit Area) of Facilities, Barasat town, 2015

Facilities	*Wards with most accessible score*	*Wards with most inaccessible score*
ATM/'000 Population (x6)	Ward No. 19 (0.33)	Ward No. 1 (1.45)
Health centre/'000 Population (x7)	Ward No. 15 (0.46)	Ward No. 1 (1.45)
Bank/'000 Population (x8)	Ward No. 25 (0.44)	Ward No. 18 (1.38)
School/'000 Population (x9)	Ward No. 19 (0.23)	Ward No. 21 (1.54)
Hotel/'000 Population (x10)	Ward No. 25 (0.31)	Ward No. 1 (1.45)
Park/'000 Population (x11)	Ward No. 19 (0.33)	Ward No. 21 (2.17)
Road Density (x12)	Ward No. 15 (0.10)	Ward No. 21 (1.46)
PO/'000 Population (x13)	Ward No. 14 (0.28)	Ward No. 9 (1.69)
Cinema hall/'000 Population (x14)	Ward No. 25 (0.62)	Ward No. 3 (0.98)
Factory/'000 Population (x15)	Ward No. 19 (0.18)	Ward No. 21 (2.17)
Petrol pump/'000 Population (x16)	Ward No. 26 (0.75)	Ward No. 1 (1.45)
No. of College/'000 Population (x17)	Ward No. 29 (0.96)	Ward No. 4 (1.05)

Note: Computed by authors.

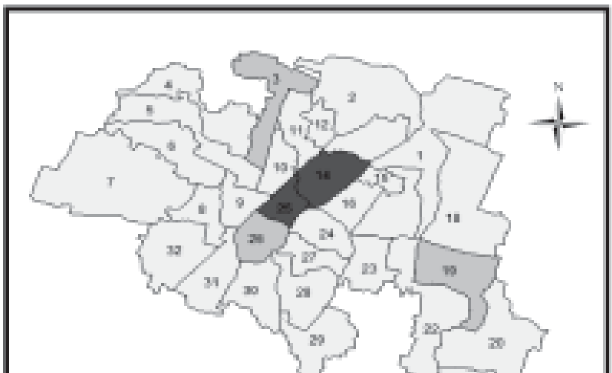

Fig. 1 Developed, Moderately-developed And Under-developed wards of Barasat town, 2015.

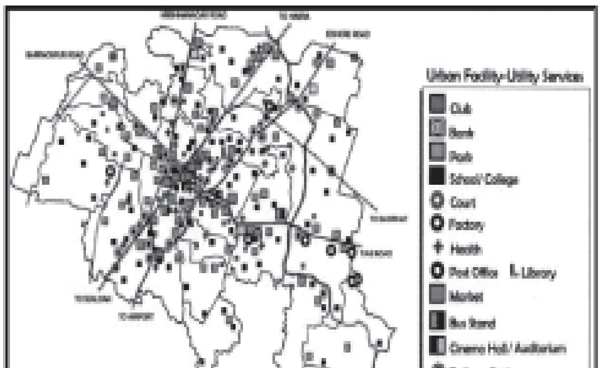

Fig. 2 Distribution of different Facility Services in Barasat town.

town and maximum numbers of facilities are unavailable here (Fig 1).

Using the Principal Component Analysis, six factors coefficients were derived (i.e. Component 1, Component 2, Component 3, Component 4, Component 5 and Component 6) which are Number of banks (0.657), Number of School (0.720), Road density (0.997), Number of Health Center (0.923), Number of Hotel (0.402) and Number of Post Office (0.580). So, these six are the leading factors influencing much the disparities of development in Barasat town (Table 4).

Table 4
Detection of Leading Factors Influencing the Variation of Facility-utility Services in Barasat town by PCA

Facility indicators	*COMPONENTS*					
	1	2	3	4	5	6
ATM/'000 Population (x^6)	-.013	-.032	-.027	.096	-.085	.103
Health centre/'000 Population (x^7)	-.099	.026	-.060	.923	-.065	-.219
Bank/'000 Population (x^8)	.657	-.184	.217	.025	-.906	-1.532
School/'000 Population (x^9)	-.173	.720	.150	-.016	.653	-.908
Hotel/'000 Population (x^{10})	.028	-.220	-.021	-.303	.402	.381
Park/'000 Population (x^{11})	.032	-.006	.016	-.138	-.037	-.020
Road Density (x^{12})	.078	.021	.997	.091	.035	.065
PO/'000 Population (x^{13})	-.014	.229	-.120	.018	-1.461	.580
Cinema hall/'000 Population (x^{14})	.001	-.001	-.001	.001	.005	.006
Factory/'000 Population (x^{15})	.011	.007	.006	-.020	-.046	-.029
Petrol pump/'000 Population (x^{16})	-.004	.000	.001	.000	.032	-.001
No. of College/'000 Population (x^{17})	.001	.001	.001	-.001	-.004	-.006

Note: Extraction method- Principal Component Analysis, Rotation method: Varimax with Kaiser Normalization; Computed by authors

Perceptions on Dweller's Satisfaction on Facility-Utility Services

Finally, a questionnaire based spot, telephonic, mail and through social networking, site survey was organized during March to April of this year with a random and proportionate sample of 194 adults from different parts of Barasat town to estimate the satisfaction level (Fig 3) of each type of facility services and to calculate a '*Composite Satisfaction Index*' (C.S.I.).

Health facility Satisfaction Index was calculated on the basis of the following variables like Access of drinking water, Satisfaction at the time of sickness in health centers, Distance of nearest medical treatment center, Access to modern treatment facilities. The five point answer based scoring was computed and the the overall satisfaction level of health facility showed a status of 63.94%

Education facility Satisfaction Index was calculated on the basis of 5 variables which are Level of Education, Regularity of attending the schooling, Distance of nearest Primary school, Distance of nearest Secondary school, Distance of nearest higher education centers like Colleges and Universities. The five point answer based scoring was computed and the overall satisfaction level about education facility achieved a status of 62.90%.

Financial facility Satisfaction Index was calculated on the basis of 8 variables which are about Income Satisfaction, Job satisfaction, Distance of Nearest Bank, Post Office etc., Distance of nearest ATM counter or E-Corner Center, Regularity of Deposit of Money, Financial Awareness like on 'Jan Dhan Yojna'etc. Getting facility on BPL card etc. or not. Having Life Insurance, Medical Insurance or not etc.The five point answer based scoring was computed and the overall satisfaction level about education facility achieved a status of 54.78%.

Recreational facility Satisfaction Index was calculated on the basis of 3 indicators which are Distance of nearest cinema hall, Distance of nearest hotel and restaurant, Distance of nearest park and playground. The five point answer based scoring was computed and the overall satisfaction level about recreational facility achieved a status of 54.43%.

Other facility Satisfaction Index was calculated on the basis of 7 variables, which are about Condition of roads and bridges of respondents locality, Distance of nearest market, Proximity of telephone and mobile phone, Access to internet facility for communication, Distance of nearest cyber café from respondent household, Status of local transport, If they suffer water logging at the time of rainy season or not. The five point answer based scoring was computed and the overall satisfaction level about others facility achieved a status of 59.68%

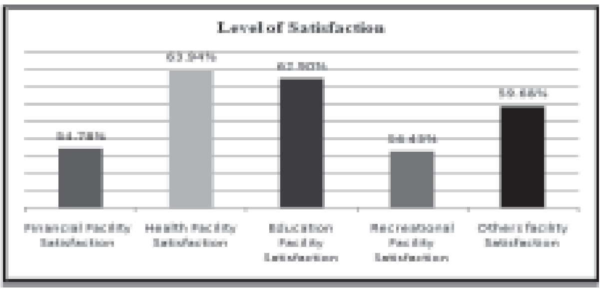

Fig. 3 : Level of Satisfaction in Different Facilities of Barasat Town, 2015.

Composite Satisfaction Index (C.S.I.) of Facility-Utility of Barasat Town

Having summed up all kinds of facility satisfaction level of Barasat town a *'Composite Satisfaction Index' (C.S.I.)* was computed which is just the average value of all five satisfaction indices. The equation is given below:

[(Health Facility Satisfaction Index+ Education Facility Satisfaction Index+ Financial Facility Satisfaction Index+ Recreational Facility Satisfaction Index+ Other Facility Satisfaction Index)/5]

= [(63.94%+62.90%+54.78%+54.43%+59.68%)/5]

= 59.15%

So, the overall satisfaction of dwellers about facility-utility services is achieved a status of 59.15% which indicates a lack of facility infrastructure in various perspectives. What we have found in C.I.D. scores is that maximum numbers of wards (27 wards) are falling in under developed categories and only 5 wards achieved the status of moderate and developed categories. It shows the disparities in development within a single municipality town.

CONCLUSION

The preceding analysis based on secondary data and field survey infers to the inter-ward disparities in socio-economic development consequent upon the irrational as well as unequal distribution of amenities and facilities. Having discussed the findings, we can conclude that the role of basic physical infrastructure is very significant in Barasat town. Despite heterogeneity in socio-economic structures of the wards within the municipality, the need for and the type of infrastructure deficiencies in the wards are more or less same. The very issue of inter and intra-wards disparity of infrastructure seriously have an impact on the overall development of the town.

REFERENCES

1. Bhattacharjee, D (2010); Identification of Disparities in the level of Urbanization of 24 Parganas (N), West Bengal. Indian Journal of Landscape Systems and Ecological Studies, pp 71-82.
2. Dadibhavi, R. V. (1998); *Indian Journal of Regional Science*, 30(2), pp 84-97.
3. Dayley, R. (1996). Infrastructure Adjustment: The Political Economy of Infrastructure Development and Marginalization in Thailand. *An Interdisciplinary Journal of Southeast Asian Studies*, 10(1), pp 77-112.
4. Iqbal, Z. & Suleman, A. (2010). Indonesia: Critical Constraints to Infrastructure Development. Economic Research and Policy Department. Islamic Development bank.
5. Klytchnikova, I. & Michael L. (2011). Measuring Welfare Gains from Better Quality Infrastructure. *Journal of Infrastructure Development*, 1(2), pp 87–109.
6. Kumar, S (2009); *Indian Journal of Regional Science*, 41(1), pp 22-36.
7. Kundu, A., Bagchi, S. & Kundu, D. (1999). *Regional Distribution of Infrastructure and Basic Amenities in Urban India: Issues Concerning Empowerment of Local Bodies*. *Economic and Political Weekly*, 34(28), pp 1893-1906.
8. Kurian, N. J. (2000). Widening Regional Disparities in India: Some Indicators. *Economic and Political Weekly*, 35(7), pp 538-50.
9. Lall, S. V. (1999). The Role of Public Infrastructure Investments in Regional Development- Experience of Indian States. *Economic and Political Weekly*, 34(12), pp 717-25.
10. Mahadevia, D. (2007). Urban Infrastructure Financing and Delivery in China. *Economic and Political Weekly*, 42(11), pp 964-72.
11. Mallikarjun, M (2000).; *Indian Journal of Regional Science*, 32 (2), pp 01-10.
12. Mathur, A.; Regional development and Income Disparities in India – A Sectoral Analysis. Economic
13. Mehta, A. K. (2002). Multidimensional Poverty in India: District Level Estimates. Paper presented at IIPA, New Delhi on 15th and 16th May.
14. NABARD (2004). Infrastructure for Agriculture and Rural Development- An Impact Assessment of Investments in Rural Roads and Bridges under *RIDF*. Mumbai, NABARD.
15. Neogi, D. (2010). Disparity in Socio-Economic Development and Its Implications on Communal Conflicts: A Study on India's North-Eastern Region. *International Journal of Human and Social Sciences*, 5(5), pp 303-10.
16. Paul, S (2012); Factors and Dimensions of Inter-Ward Disparities in Urban Facility-Utility Services in Burdwan City, India. Archives of Applied Science Research.4 (3), pp 1376-1388.

GEO-SPATIAL TECHNOLOGY FOR RISK RESILIENT URBAN PLANNING, CASE STUDY FOR BHUBANESWAR CITY

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ABSTRACT

During the last two decades, India has experienced rapid urbanization, which is being triggered by parallel economic growth. The contribution of the urban sector to India's GDP has increased from 29 percent in 1950-51 to 47 percent in 1980-81 and is currently estimated to be about 62-63 percent. It is estimated that by 2030 there will be 590 million people in 6,000 cities with 5 states more than 50 percent urbanized. The objective of the study is to analyze how effectively risk assessment and climate change impact can be analyzed using geospatial techniques that subsequently help in risk resilient urban planning in Bhubaneswar. This study describes a detailed natural hazard risk assessment for the key natural hazards (cyclone, flood – riverine and urban flood, earthquake) affecting Bhubaneswar city and the impact of climate change on future disaster trends in the city. An index-based approach has been used giving weightage for factors contributing to each hazard and analysis has been performed by overlaying them using GIS. Next, the risk scores have been grouped into five classes using natural breaks to categorize risks into extreme, high, medium, low, and negligible categories. Thus, composite hazard risk-index maps have been generated based on cumulative risk values of all the three hazards to identify the hotspots. GIS based analysis of hazard maps and climate change maps have been prepared along with proposed development zones to understand the risk potentials to suggested development zones. It is observed that the master plan emphasizes heavily on economic growth and has largely overlooked disaster risk and climate change impacts while defining future development zones.

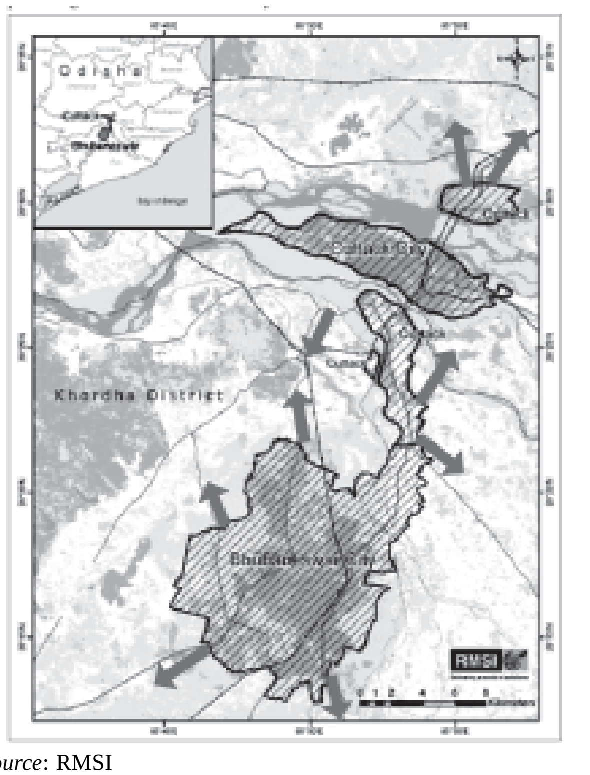
Keyword(s): *Disaster risk management, city planning, risk resilient urban planning*

INTRODUCTION

Understanding the vulnerabilities and associated risks due to natural hazards is important for creating safe and resilient cities, since such cities are likely to attract business investment and thereby promote economic growth. This is highly relevant for India in the context of the smart city initiative in the country. Understanding of vulnerabilities and risks will help in devising the appropriate interventions and measures to adapt/mitigate such risks. On the other hand, understanding climate change impact helps in developing medium and long term development plans, which are risk resilient.

URBANIZATION TRENDS IN BHUBANESWAR MUNICIPALITY AREA

While comparing the rate of urbanization, Odisha is the 24th most urbanized State in the country with about 17 percent of its population residing in urban areas. Bhubaneswar, the capital of Odisha, is located in Khordha district and has 67 administrative wards (2014) covering a total area of about 135 sq. km. The city has grown from an initial built up spread of about 16 sq. km as envisioned during its design phase to the present 135 Sq. km. As per Census 2011, the city has a total population of 8,40,834 with a population density of 6,228 persons/sq. km. The growth recorded in the last decade was about 30 percent. Thus, the growth in population demands parallel growth in service delivery and infrastructure.



Source: RMSI

Fig. 1: Urban Growth Directions Around Bhubaneswar City

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Urban growth of the city has been triggered by several factors. These include temples of the capital city, business and commercial activities of the old capital Cuttack, and the tourism circuit connecting the temple towns of Puri and Konark. In addition to this, Bhubaneswar recently has envisioned urban development initiative through developing the Capital Region by merging adjacent urban areas. Monalisha et al (2011) study shows that the city's built up area has increased from 1 sq. km (1930) to 86 sq. km (2011). The residential area experienced maximum growth of 84 percent in the city during 2000-2011.

Bhubaneswar city's lateral growth is very apparent from fast growing residential areas particularly around Patia, Raghunathpur, Barang, Rudrapur, Pahala, Pandara, and Kesora. The growth trend of Bhubaneswar tends towards the formation of an urban continuum merging Bhubaneswar and Cuttack municipalities (Fig. 1).The increase in urban built up is leading to an increase in rainfall run-off and water logging in many parts of the city and increase in temperature during the summer months due to back radiation. According to the spatial analysis of Pathy and Panda 2012, the city has a high growth trend in the northwest (along the NH towards Khordha) and northeast directions (along Chandrasekharpur-Patia) from 1985 onwards. The urban growth is also along the four major roads radiating from the city's central area i.e. NH5, Khandagiri-Chandaka road, Jayadev Vihar to Nandankanan Road and NH-203 to Puri.

OBJECTIVE

The objective of the study is to analyze how effectively risk assessment and climate change impact can be analyzed using geospatial techniques that could subsequently help in risk resilient urban planning.

DATABASE AND METHODOLOGY

Key Data Types and their Sources

Demographic and socio-economic data from Census 2011 (Census of India);Administrative boundaries and Master Plan (Bhubaneswar Municipal Corporation); Cyclone and rainfall data (Indian Meteorological Department); Earthquake catalogue (United States Geological Survey), River discharge data (Central Water Commission), Digital Elevation Model (United States Geological Survey and RMSI in-house data); Building clusters and transportation network at ward level (Cartosat satellite image); Field survey (RMSI).

A comprehensive methodology has been adopted in this study to estimate the Composite Hazard Risk Index at Municipal Ward Level. The methodology has been divided into two key steps: Hazard risk assessment and preparation of a Composite Risk Index using geospatial techniques.

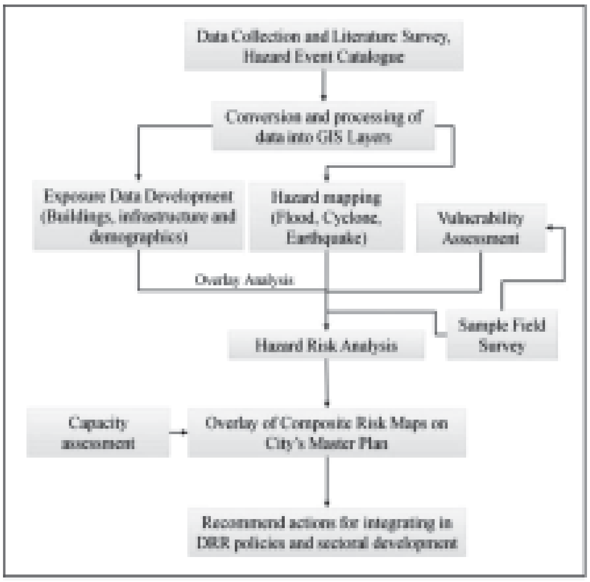


Fig. 2 : Overall Methodology Used for the Study

The hazard risk profiling was carried out using qualitative and quantitative risk assessment methods for the cyclone, flood, and earthquake hazards as shown in above Fig. 3. The quantified risk assessment based on hazard scenarios was used for calculating the Probable Maximum Loss (PML) from each hazard. Sector-specific economic loss assessment was carried out for specific return periods using current unit replacement costs. Composite hazard risk index maps were generated based on cumulative risk values of all the three hazards to identify the hotspots. Finally, the output was overlaid on the existing city master plan to find out the impact of natural hazard risks and impact of climate change on the city's future development.

On the other hand, for qualitative analysis, an index-based approach was used giving weightage to factors contributing to each hazard and analysis was performed by overlaying them using GIS. The risk scores were grouped into five classes using natural breaks to categorize risks into extreme, high, medium, low, and negligible. Composite Hazard Risk Index maps were generated based on cumulative risk values of all the three hazards to identify the hotspots.

In this regard, the hazard risks due to projected climate change for 2040s and 2080s were also assessed for flood and cyclone. Economic losses were calculated for these projected climate change scenarios for each hazard taking into account the growth in various sectors. Replacement costs consider the projected price inflation as well.

DISCUSSION AND ANALYSIS

The city is vulnerable to all the three hazards – cyclone, flood and earthquake in addition to heat waves, epidemics and human induced hazards including traffic accidents and fire. In the present analysis, economic loss analysis for the three hazards was carried out to understand the risk.

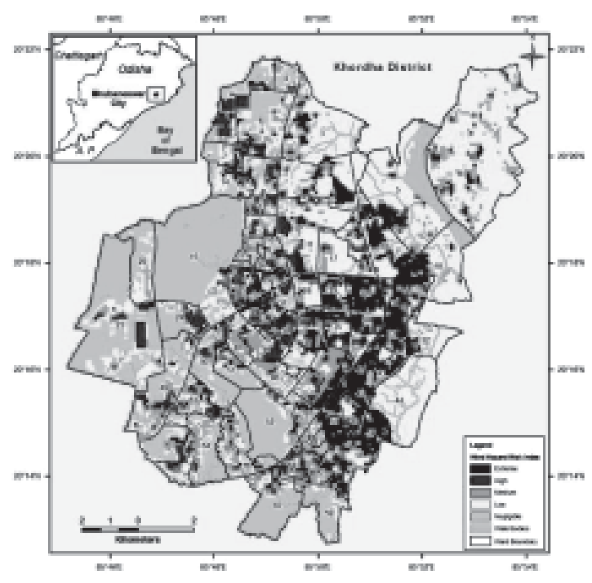


Fig. 3: Cyclone hazard risk index map of Bhubaneswar

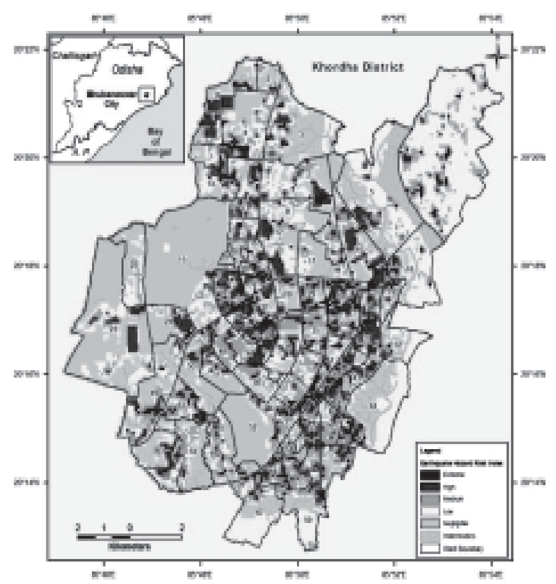


Fig. 4: Earthquake hazard risk index map of Bhubaneswar

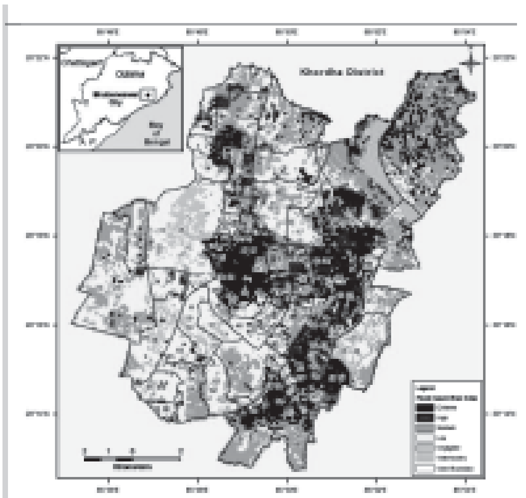


Fig. 5: Flood hazard risk index map of Bhubaneswar

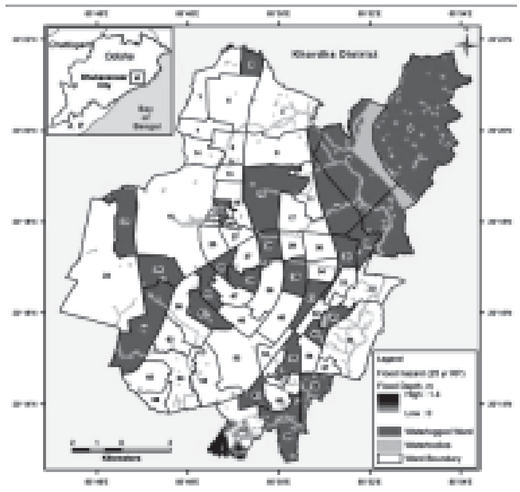


Fig. 6: Flood hazard (25 yr return period) and municipal wards reported to have water logging, Bhubaneswar

Hazard Analysis

The hazard risk index maps for all the three key hazards were prepared (Fig. 3 to Fig. 5). Being on the east coast of India, the city is exposed to cyclone and cyclonic disturbances. The peak frequency is found to be in the months of July, August and September. In the 137-year period between 1877 and 2013, 110 tropical disturbances passed within 150 km of Bhubaneswar city that included 39 cyclonic events, an average of one cyclone in 3.5 years. Earthquake risk index development for the city has two components - assessment of earthquake hazard index based on PGA soil (using ground motion data - PGA rock and Vs30 for soil amplification) and then overlaying the hazard index with various asset layers (buildings, urban infrastructure elements etc.) to get the earthquake risk index. The city is more vulnerable to urban flooding (water logging) than a riverine flood.

Risk Assessment

People and assets of the city are at risk from all the three hazards, but while considering the exposure and vulnerability, the city is more vulnerable to cyclone and urban flooding. The flood risk in the city is basically due to urban flooding, which is due to poor drainage facilities including narrow channel exits, encroachment of floodplain areas, and choking of drains due to the dumping of solid waste. The city is also vulnerable to heat waves and has a moderate risk from earthquakes.

About 61 percent of the city is under extreme to moderate cyclone risk while 59 percent is under extreme to moderate urban flood risk. Almost 50 percent of the city is under extreme to moderate earthquake risk.

Housing, commercial sector, and electrical and telecommunication networks are highly vulnerable to the cyclone hazard. Almost 50 percent of the houses are in the extreme to high cyclone hazard zone with an estimated Probable Maximum Loss (PML) of INR 2,230 million (USD 37 million). The estimated loss to the electrical network is estimated around INR 20 million (USD 0.33 million).

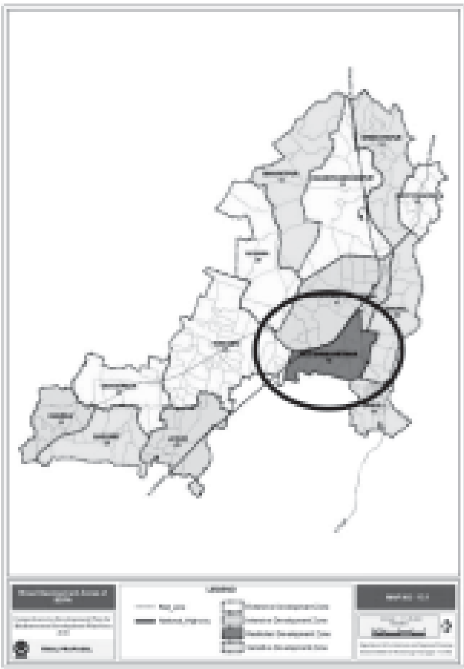
The urban flood hazard in Bhubaneswar poses a higher risk through business interruptions and health problems (vector and water borne diseases) than damage to city assets. However, the hazard does not pose any substantial risk to life. Almost 50 percent of houses and 48 percent of the road network are in the extreme to high hazard zone with an estimated PML of INR 0.68 million (USD 0.01 million). Almost 80 percent of the commercial and industrial establishments in the city are in the extreme to high flood risk area.

The city is located in Seismic Zone-III. About 20 percent of the city comes under the extreme to high earthquake susceptibility zone. The estimated PML for earthquake hazard is estimated around INR 60,090 million (USD 1,001.5 million) for residential buildings, INR 38,920 million (USD 649 million) for commercial buildings, and INR 2,970 million (USD 49.5 million) for industrial buildings.

Considering four days of wage loss for 40 percent of working population in the city in the case of a cyclone event, the estimated loss would be to the order of about INR 110 million (USD 1.9 million). In the case of flood and heavy rainfall events, assuming 10 days of interruption in work, estimated losses in terms of wage-losses would be approximately INR 270 million (USD 4.5 million) for the city.

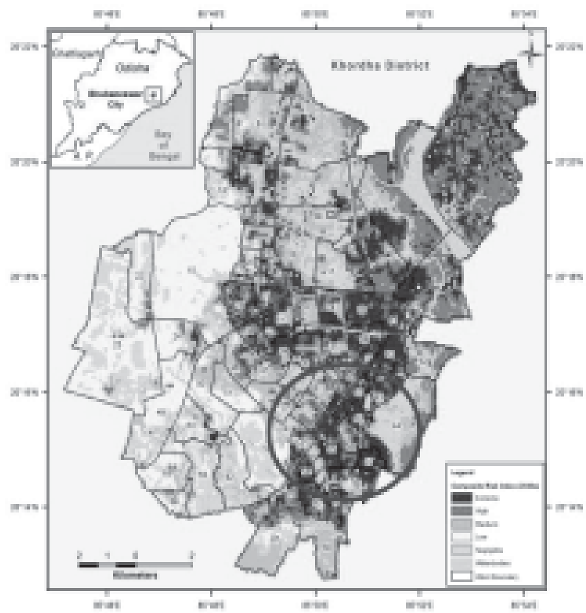
When considering the 2040s scenario, with an increase in population and inflation, the loss number for cyclone hazard would be three times that of the present and for flood/water logging hazard it would be almost double (about INR 500 million (USD 8.33 million).

Urban Resilient Master Plan: The city has prepared a Comprehensive Development Plan for the Bhubaneswar-Cuttack Urban Complex (CDP 2030) in 2011. Fig. 7 showsthe proposed land use plan of Bhubaneswar Development Authority as per Comprehensive City Development Plan (CDP). Fig. 8 shows the composite risk (risk due to all the three hazards based on the analysis) index map of Bhubaneswar city. The circled area in Fig. 7 is marked as an intense development zone as per the CDP, which is part of the high-risk index as per our analysis. This demands local risk resilience planning, including structural intervention measures considering the hazard risks.



Source: Bhubaneswar Municipal corporation

Fig. 7: Broad development zones Bhubaneswar Development Area (including the city) as per CDP



Source: RMSI

Fig. 8: Composite risk index 2040, Bhubaneswar city

CONCLUSION

There are several pockets in the city with high vulnerability and risk and needs appropriate risk reduction interventions.

Urban planning and development of the city master plan should consider hazard risk of the city and appropriate risk based interventions need to be in place for risk resilient city development.

Geospatial technologies can be effectively used for disaster risk assessment and for risk resilient urban planning.

REFERENCES

1. AC Pathy and GK Panda 2012, Modeling Urban Growth in Indian Situation - A Case Study of Bhubaneswar City, International Journal of Scientific & Engineering Research Volume 3, Issue 6, June -2012.
2. BDA (2008), The Orissa Gazette, Bhubaneswar Development Authority (Planning and Building Standards), Regulation 2008.
3. BMTPC, 2006, Hazard maps of India, http://www.bmtpc.org/topics.aspx?mid1=178 &Mid=56
4. CDA (2010), The Orissa Gazette, Cuttack Development Authority (Planning and Building Standards), Regulation 2010.
5. Ministry of Urban Transport 2011, Service level bench marking, urban transport, http://utbenchmark.in/UsersidePages/CityProfile.aspx?City=2
6. Monalisha Mishra, Kamal Kant Mishra, A.P. Subudhi, 2011, Urban Sprawl Mapping and Land Use Change Analysis Using Remote Sensing and GIS, Geospatial World Forum, 2011.
7. UNISDR BBSR 2011, http://www.unisdr-apps.net/confluence/display/THAICITY/Sasakawa+Award+2011+-+Bhubaneswar+Municipality: Mainstreaming institutionalization of Disaster Risk Reduction, Nomination for Sasakawa Award for Disaster Reduction by Local Governance Network.
8. USAID 2006, City Development Plan: Bhubaneswar, Orissa, India Final Report. Government of India, JNNURM, Formation of a City Development Plan.

IMPACT OF HOUSING AMENITIES ON HEALTH CONDITION ACROSS SOCIAL GROUPS AND SLUM-NON-SLUM POPULATION, URBAN JHARKHAND

Sudeshna ROY[1]

ABSTRACT

Housing infrastructure is one of the basic civic amenities, which entitle the population to lead a healthy life. The quality of housing amenities affects the standard of living and degree of human capital formation. Thus, provision of minimum basic housing amenities is not only a human right but, is also a moral liability of an effective democratic governance system. Theoretical requirements for healthy living are safe drinking water and sanitation facilities, access to basic education, health care and secured accommodation and sustainable environment. Housing amenities is a broad term and diverse in its nature and quality. It comprises of a host of utilities like the condition of houses and its structure, associated sewerage and drainage systems, energy consumption, ownership of assets, etc. In this paper, an attempt has been made to analyse the pattern and trend in the level of housing amenities and the degree of variation among the social groups in urban Jharkhand between 2001 and 2011.

Apart from socioeconomic factors like literacy rate, work participation ratio, sex ratio, household size, an account is made of some indicators that represent good quality of living and affect over-all well-being of households. Data from Census of India and Annual Health Survey (2010-11 to 2012-13) has used to correlate between the situation of housing conditions and health status among the population groups in the state. It is hypothesized that occurrence of some acute as well as some chronic diseases such as diarrhoea, tuberculosis, asthma and others can be associated with the condition of housing amenities. Apart from that, the distribution of health-care infrastructure in the state shows a marked spatial concentration and discrimination towards the economically backward and socially vulnerable scheduled population. The intra-urban inequality is quite prominently noticeable at the town level and between the slum and non-slum population categories. Jharkhand being relatively young and an under-developed state, richly endowed with diverse natural resources and dynamic human capital is chosen for the study. In the wake of burgeoning urbanization accompanying rapid economic growth trajectory in the state, presence of decent housing and health-care conditions are fundamental determining factors in the planning for inclusive development of smart cities. Insufficient infrastructural services, unequal access and use of inferior quality resources adversely impact the health, productivity and in turn the gainful participation in the mainstream socio-economic life, particularly of the poor and marginalized population groups such as SCs, STs and slum dwellers.

Keyword(s): *Housing Amenities, Smart City, Health Status, Disease, Marginalized Population*

INTRODUCTION

Availability of better quality housing amenities forms the basic component of healthy productive living. Dilapidated housing structures, use of inferior quality fuel and drinking water, lack of sufficient room space, absence of hygienic sanitation facilities are some of the major constraints in the built-up environment, which adversely affect demographic health profile. This is especially true for the economically disadvantaged scheduled castes and tribal populations who become marginalized even further. The low-income groups and slum dwellers are burdened with various chronic and contagious diseases, which are direct outcomes of the appalling quality of living of their physical surroundings. The poor access to health infrastructure due to their pitiable financial status aggravates the already wide health inequality.

Jharkhand being one of the youngest states remains under-developed. It is home to numerous tribal communities like Munda, Oraon, Ho, who are yet to be fully integrated into the mainstream economy. The poor governance, political instability and lack of political will, makes it all the more complicated for implementation of targeted policies in Jharkhand, making it one of the socio-economically lagging states in India. The newest venture of Smart Cities launched by the current government comes as a boon for the upgradation of decaying urban infrastructure in India. The burgeoning level of urbanization along with over-inflated concentrations of housing-health-transport infrastructure at only a few urban centres makes it mandatory for the introduction of schemes like smart cities, that aim at improving the distributions of civic amenities across the 1 lakh plus and lower tier cities. Thus an analytical knowledge

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of the current housing-health interface in the state would provide a much needed holistic insight for directing future policy interventions at the deprived geo-spatial locations.

OBJECTIVES

- To analyse the pattern and trends in the level of housing amenities across the social groups in urban Jharkhand between 2001 and 2011
- To study the distribution of housing amenities and consequently the quality of living between the slum and non-slum population of Jharkhand towns
- To examine the degree of spatio-temporal variation in the health status of urban population across the districts of Jharkhand during 2010-11 to 2012-13
- To bring out the correlation between housing condition, health status and level of socio-economic development in urban Jharkhand

DATABASE AND METHODOLOGY

The paper is based on Census of India 2001 and 2011 data; PCA, H-Series, and data provided by Annual Health Survey for three consecutive years; 2010-11 to 2012-13. Use of MS Excel and SPSS for data analysis and ARCGIS for thematic representation of the results is done. Pearson's Correlation method and Composite index using Z-Score are used.

DISCUSSION AND ANALYSIS

Housing amenities is a broad term and diverse in its nature and quality. It comprises of a host of utilities like condition and structure of houses, associated sewerage and drainage systems, energy consumption, ownership of assets, etc. In this paper, an attempt has been made to evaluate the pattern and trend in the level of housing amenities and assess the degree of variation among the social groups in urban Jharkhand between 2001 and 2011. Census data computed indicates the spatial inequalities in the availability of better quality of amenities. Mining-Industrial districts sheltering higher proportion of the urban population; Bokaro, Dhanbad, Hazaribagh, Ramgarh and Purbi Singhbhum have larger percentages of households with safe drinking water from tap in 2001 and treated tap water in 2011.(Map.1a, 1b) Non-SC-ST households are in a much better position and there is a less inter-district difference among them, unlike the scheduled ones. The proportion of households drawing water from unsafe sources such as river, pond, etc. is higher in the northern districts.ST and SC households have a bigger share of almost 8.5 to 9% in 2011, while it is a mere 3.2% of the other households.(Map.1c) For the toilet facilities within premises, there has been a marked improvement in the figures over the decade, especially for the SCs, who were poorly positioned in 2001.But the households of Garwah, Palamau, Chatra in the north-west and Sahibganj, Pakur in the north-east yet remain using primitive type of toilets in their homes.(Map.1d) Open defecation remains a big embarrassment in India and Jharkhand is not an exception. The scheduled households still practice defecating in the open especially those located in the northern towns of the state in districts of Garwah, Kodarma, Godda, where even 52% of non-scheduled houses share this unhygienic habit. (Map.1e) Similarly, in drainage methods and connectivity of the waste water outlet, it is mostly open drains for scheduled households.

The economic conditions of the urban population in these poorly performing districts is equally deplorable, more so for the SCs. One can take ownership of durable assets such as telephone, vehicles, computers as a proxy to gauge the financial status of the households.(Map.1f) Ranchi, Dhanbad, Bokaro, Purbi Singhbhum are better off in terms of asset possession and economic security. One paradoxical and baffling situation is that there has been a tremendous jump in households owning mobile telephones even though they may be still going out in the open to relieve themselves. Districts having greater numbers of women headed urban households, are the ones with high proportions of STs like Sahibganj, Pakur, Dumka, Lohardaga, Khunti. Women headed households are economically weaker and vulnerable, but surprisingly the southern and south-eastern districts of Simdega, Khunti, Gumla, Paschimi Singhbhum, show better position in terms of almost all aspects. This can be attributed to the concentration of resources and wealth in these administratively better managed districts with higher levels of literacy and urbanization and lower proportions of child populations.

The health implications of the type of cooking fuel used and the location of the kitchen is vital when analysing the occurrence of air borne diseases like asthma, chronic-obstructive pulmonary disease (COPD) and chronic respiratory disease (CRD). Inferior quality fuels like coal, charcoal, firewood and cow-dung are the major source of indoor air pollution that affect the respiratory system of the household members adversely, resulting in some chronic bronchial disorders. Economically worse off SC and ST households are found to depend more on such cheap energy sources than the general population. In 2011, 85% general households of only urban Latehar reported using inferior fuel. There has been a substantial reduction in the usage of inferior fuel for STs as well since 2001, but the situation for the SCs remain pathetic. Infact there are instances of increased utilization of inferior fuels by the SC households in Simdega and Khunti in 2011.(Map.1g) Simultaneously, the use of cleaner and environment-friendly LPG has seen an escalation, especially among the SC households over the ten years. (Map.1h).

The roof is the most important portion of the house and the material used for its construction gives a rough idea about the type of house and indirectly about the economic stature of the owner. Concrete roof is taken as a representative of durable and better house structure. Data shows a slight increase in the proportion of households with a concrete roof with the non-SC-STs of entire urban Jharkhand (60%) amounting to more than double that of SCs(39%) and STs(30%) in 2011.(Map.1i).Most houses use inferior construction materials like thatch, mud, grass,etc., and the houses are thus temporary in nature. Godda, Sahibganj and surrounding N-E districts in Jharkhand have higher percentages of households occupying temporary abodes.(Map.1j) Household size and room density can be used as an indicator for ascertaining the social and health environment within the household. The proportion of households with no exclusive room or one room is an effective indicator of the shortage of housing space and the dire state of economic condition of the household concerned. It also affects the hygiene and physical and psycho-social health status of the occupying members. Around 27.1% of SC households in Sahibganj and Pakur report having more than nine household members living precariously in 1 roomed houses in 2011.(Map.1k) These districts along with Jamtara, Deoghar, Dumka, Garwah feature among those with extremely worse living standards when mapped taking into account, some negative indicators embodying horrendous quality of living. For the ST households, Saraikela-Kharsawan fares worse as well.

Infirm housing structures, cramped accommodation, poor ventilation, inadequate lighting, the absence of toilet facilities and drainage systems, and pollutant fuel used for cooking are a direct cause of various air and water borne diseases.(Chandramouli,2003). Quality of living can be ascertaine dusing a composite index computed out of 10 negative indicators – no tap water within premises, use of unsafe source of drinking water, absence of toilet within home, open defecation,no electricity, one room households, one room occupancy by more than 9 household size, no bathroom within premises, temporary roof and use of inferior fuel for cooking within house. Each of these indicators has a direct impact on the environment and consequently on health and sustainability of the households. The composite indices are arranged in three classes- fair, bad and worse. SC households of northern nine districts are found to be worse off with higher index values, while four southern better performing districts are averaging fair in values feature invariably across all social groups. (Map.1l, 1m, 1n)

AHS data from 2010-11 to 2012-13 depicts temporal and spatial variation in disease prevalence across the adult and children population. AHS clearly portrays the existing socio-economic-health divide between north-south districts. Health-care facilities and access to the infrastructure in the form of hospitalization, immunization coverage for children less than two years, institutional birth incidences, etc. are much higher in the south-eastern districts, near to the administrative capital of Ranchi. Incidences of chronic and acute diseases like diarrhoea, acute respiratory infection (ARI), reported in greater proportions in northern districts.(Map. 1o).The worrying issue is that respiratory tract syndromes, like asthma, tuberculosis (TB) is on a rise and there lies a strong concurrence of these diseases with the use of inferior cooking fuels.(Figure.2b)Infant mortality rate (IMR) has reduced over the time-period but it is on a higher side in the less-developed northern districts adjoining Bihar. Under five mortality rate has declined marginally in urban Jharkhand from 35 to 29 in the three year span, with peaks visible in Garwah and Sahibganj (Figure.2a).The economically stronger and resource rich southern districts show a uniform better immunization pattern averaging 50% in 2012-13 (Map.1p).The same good coverage is seen in the proportion of institutional deliveries and longer stay duration of mothers and infants in hospitals after births.(Map.1q).These southern district urban households together with the highly urbanized belt of Bokaro, Dhanbad, Ranchi,by virtue of their greater affordability and awareness levels; seek regular treatment facilities for chronic illnesses at public hospitals relative to the northern districts.(Map.1r). The average population pressure per hospital has decreased substantially over the decade, except in small census towns like in Chas, Adityapur, and Giridih.(Table.3a)

About 32 towns in Jharkhand report presence of slum households, mainly agglomerated in the south-eastern region.2011 data compilation brings out the wide gap in the distribution of housing amenities between slum and non-slum households. Especially in the availability of basic sanitation, electricity connection, LPG use, the non-slum population has thrice better access relative to their slum counterparts. But when it comes to the use of technologically superior amenities such as flush latrines, owning mobiles, cars, this slum-no-slum economic segregation narrows down. This can be explained by the mediocre level of economic development of Jharkhand in general. The precarious state of life in the non-slum chunk of urbanites can be estimated from the fact that use of inferior polluting fuels and open drainage is almost double that of the slums. The slum households in Dhanbad, Ranchi, Jamshedpur and Hazaribagh to some extent have a fairer quality of living than the non-slum households in smaller census towns. About 8% of slum dwellers in Dhanbad own a four wheeler, while it is a 5.6% for non-slum habitants there. It is interesting to note that a higher percentage of non-slum households in Ranchi have availability and accessibility of good quality amenities, while slum households in Dhanbad are better off than the ones in the capital city of Ranchi.

Composite index using Z score is again computed to categorize the non-slum, total and slum households of the towns in terms of quality of living.(Table.3b) Jamshedpur ranks first in the former two while it is Ranchi and Dhanbad for the slum households. But in general, the standard of living in Jharkhand is bad, irrespective of household category. Almost all the towns located in northern region; Basukinath, Hussainabad, Latehar, etc. lead a worse living quality. Good quality housing amenities and robust health status shows a strong and significant correlation.(Table.3c) People living in concrete houses generally have fewer diseases whereas households cooking with inferior fuels have a positive and significant correlation with asthmatic disease incidences. Similarly, TB prevalence is strongly correlated with one room tenements occupied by large household size, thus pointing to the nexus between housing environment and health, especially among the scheduled slum dwelling economically weaker population groups. Households with better financial stature conventionally are of better health regime. Poor level of social development manifested in low literacy rate especially of women, a larger proportion of child population and bigger household sizes have a strong and significant correlation with disease occurrence rates and meagre access to institutionalized health care.(Table.3d) In general, women headed and scheduled tribe households are found to be intensely vulnerable and deprived in general health conditions, while the SC households are backward in terms of maternal and reproductive health status. Higher literacy rate represents better educational qualification which in turn ensures engagement in better paying jobs and higher household income. (Table.3e)These households thus have access to better sanitation amenities and asset ownership that is reflected in positive correlation coefficient figures.

CONCLUSION

Both in 2001 and 2011, distribution of households having access to better amenities were more south or Ranchi centric, though a market over-all improvement was observed in 2011. Southern districts namely, Ranchi, Purbiand Pashimi Singhbhum,Gumla, Khunti, are in a better position than the northern districts of Palamau, Chatra, Godda, Pakur, Sahibganj, etc. General households are in a much better position in all indicators and all districts, except Pakurand Sahibganj in the north which are backward in all aspects. In almost all housing indicators ST households perform better than SC households. ST households show a greater level of improvement than SC households in some indicators such as electrification, possessing four-wheeler in the decadal time-span. The level of social development; which is mirrored in the proportion of literates, the mean size of household, the share of children in the population and sex ratio, is deplorable for SC population, clearly making them more marginalized in the state. Towns like Dhanbad(890), Jugsalai(890) have extremely low sex ratio than the state average of 934 females per 1000 males. This can be attributed to the employment related in-migration of the male working population to these mining and industrial towns. The distance factor comes into play in the distribution of high end amenities and health infrastructure. As one moves away from the southern and south-eastern nodes of capital, the governmental-industrial-urbanized seat of power such as Ranchi, Jamshedpur, Dhanbad and two Singhbhum districts, the inequality in the availability of amenities, disparity in health situation and overall socio-economic variation among the social communities keeps on amplifying.

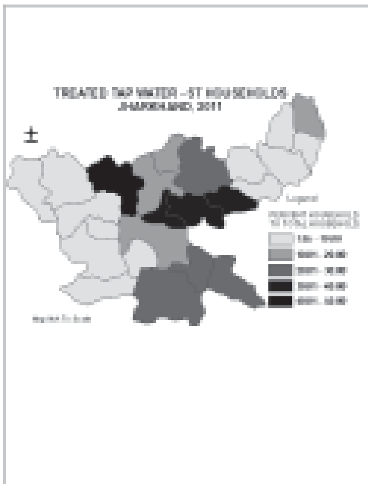
Thus, market economics and space-distance conjunction largely determine location and implementation of infrastructure and governance mechanisms. Here comes in the role of integrative public sector funded projects like smart cities, which aim to bridge this inter-district, inter-city gap. But the use of geospatial technology is a must to explore the most deprived sections, especially in a state like Jharkhand; which is characterized by low level of urbanization, lack of public awareness, widespread poverty and illiteracy, gender bias and skewed distribution of health care facilities including the reproductive, maternal and antenatal health. Findings suggest that to have a durable and sustainable foundation of smart city concept, authorities must direct their policy attention towards establishing sound health and housing policy interventions and service delivery structure in the state.

REFERENCES

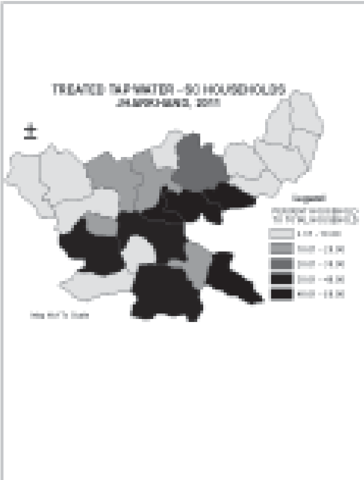
1. Chandramouli, Dr.C (2003):"Quality of Living Index in Chennai: An Approach Paper",*Proceedings of the Third International Conference on Environment and Health*,Chennai, India (Dec. 15-17),pp.75-81.
2. Mukherjee, S, A Chaudhuri, ABarik (2015): "New Health Policy and Chronic Disease. Analysis of data and evidence", *Economic and Political Weekly*, Vol. L. 37, (Sep 12), pp. 21-24.
3. Nayar, K. R. (1997): "Housing Amenities and Health Improvement Some Findings", *Economic and Political Weekly*,(May 31),pp.1275-1279.
4. Rani, S., S. Ghosh, M Sharan (2007): "Maternal Healthcare Seeking among Tribal Adolescent girls in Jharkhand", *Economic and Political Weekly*, (Dec 1), pp. 56-61.
5. Sundari, S (2003): Quality of Life of Migrant Households in Urban Slums", *Proceedings of the Third International Conference on Environment*, Health, Chennai, India, (Dec. 15-17), pp. 537-552.

MAPS

Map.1A



Map.1B



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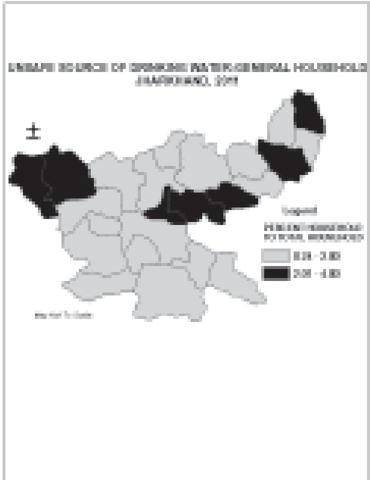

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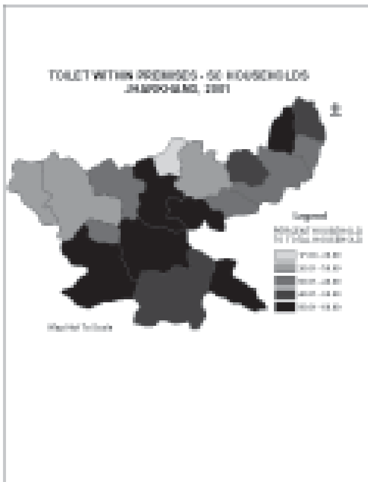

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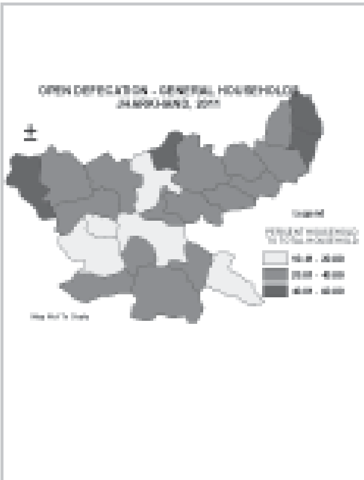

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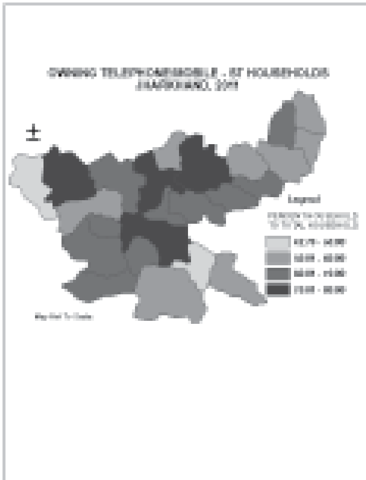

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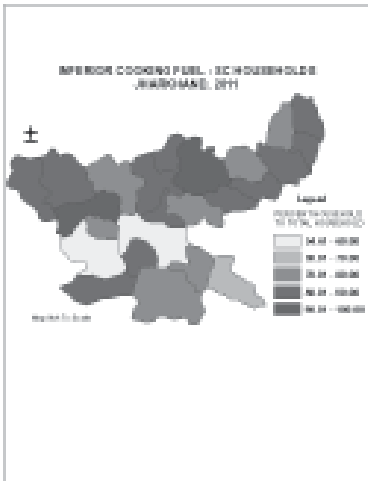

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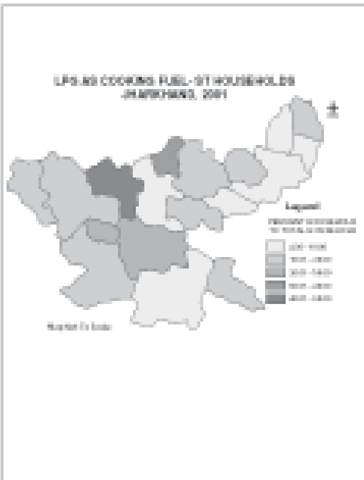
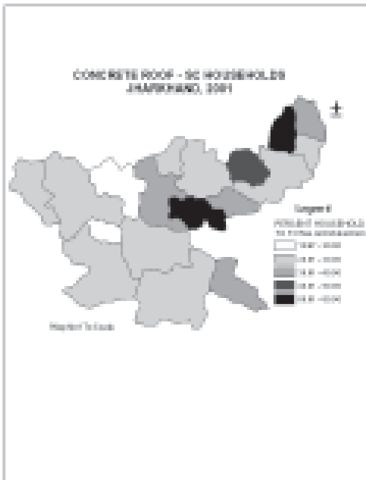


Map.1I



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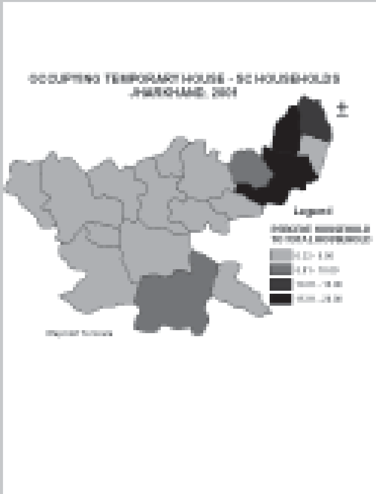

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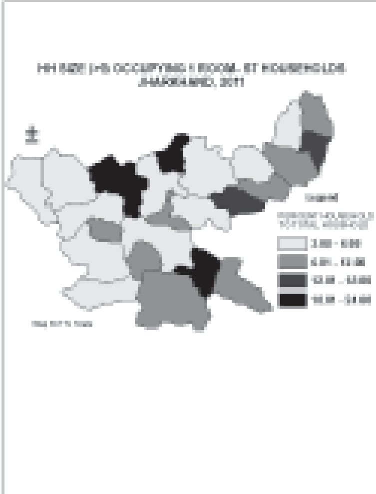

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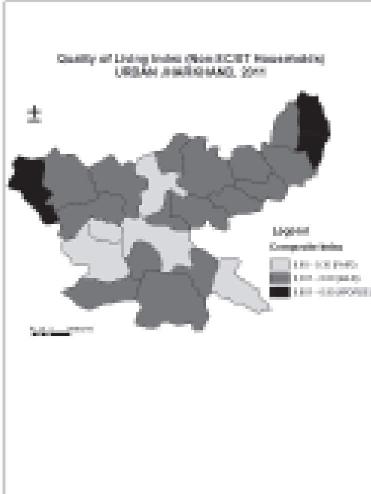

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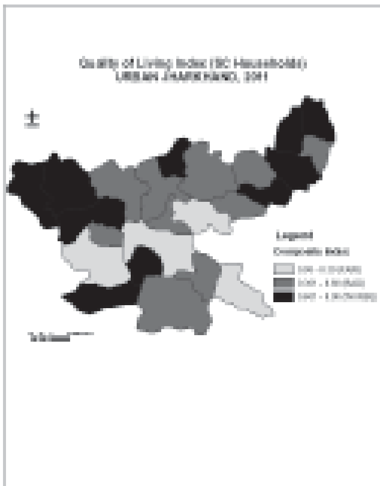

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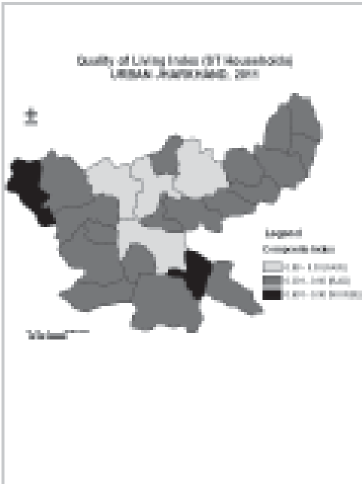

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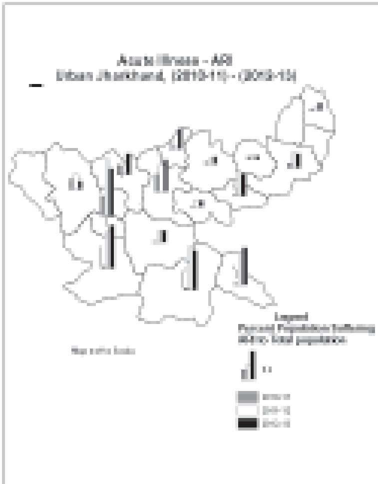

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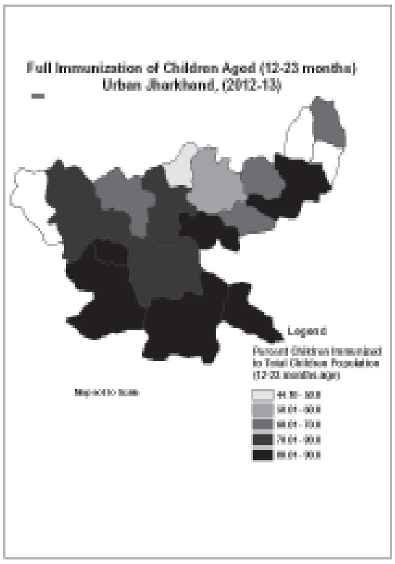

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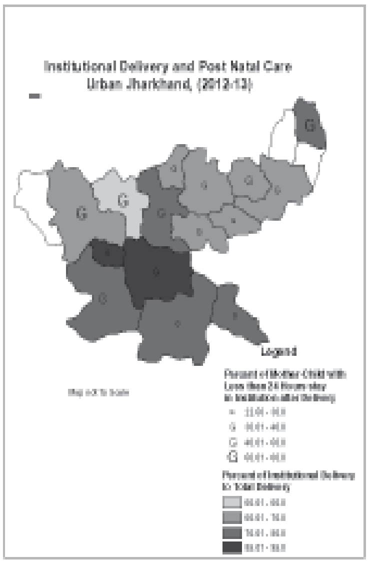

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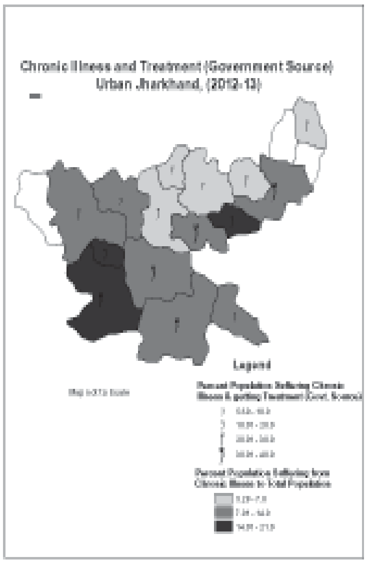


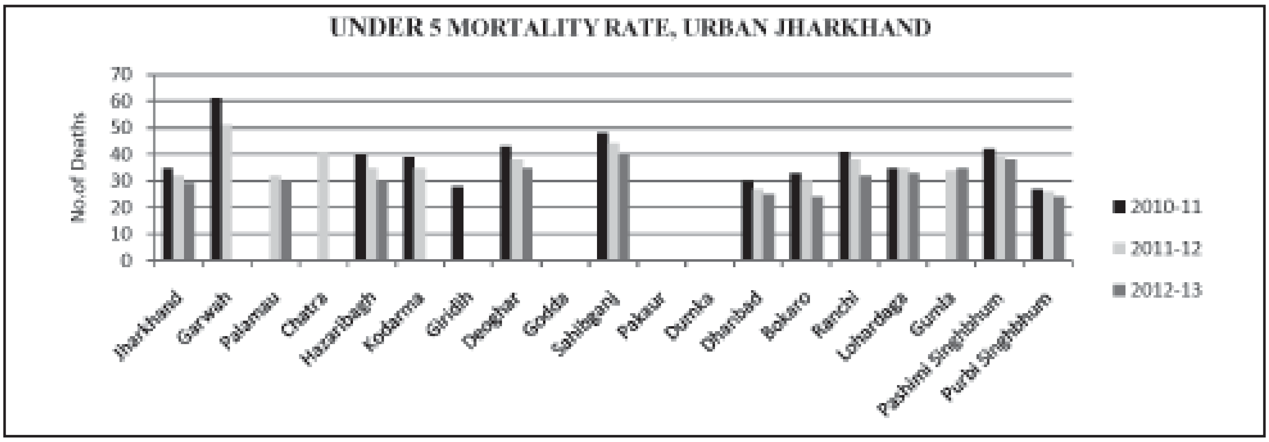
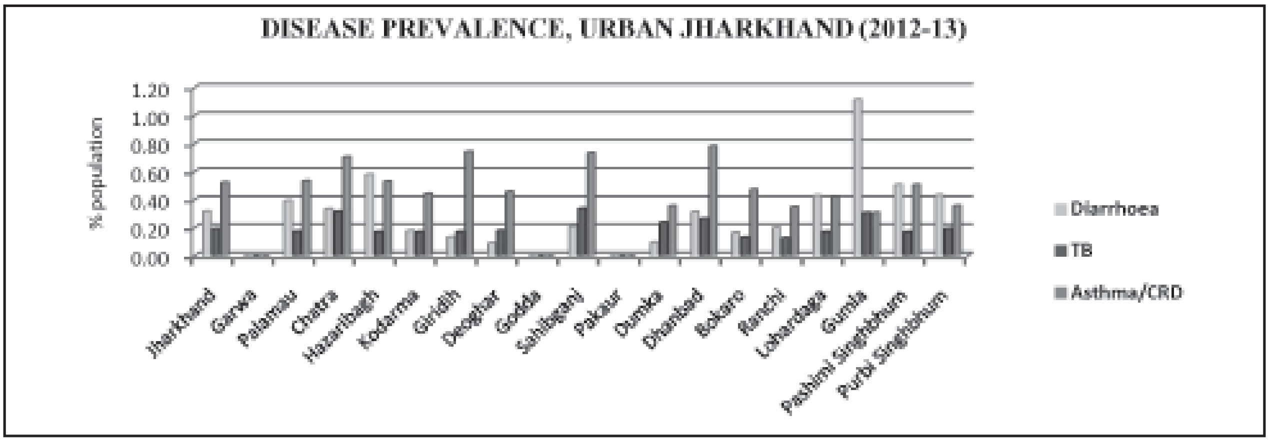


Fig. 2a Distribution Of U5MR Across Districts, Urban Jharkhand, 2010-11 to 2012-13



Source: Generated from Annual Health Survey (2010-11) to (2012-13)

Fig. 2b: Distribution of Selected Diseases Across Districts, Urban Jharkhand (2012-13)

Table.3a
Decadal Average Population Per Hospital/Dispensary, Urban Jharkhand (2001-11)

Population Per Hospital/Dispensary, Jharkhand					
Urban Districts	2001	2011	Urban Districts / Towns	2001	2011
JHARKHAND	**6860**	**1637**	Dumka	18140	1554
Garhwa	24654	820	Jamtara	_	1071
Chatra	20293	1463	Ranchi	5082	1857
Kodarma	6017	1219	Khunti	_	1219
Giridih	20928	1747	Gumla	24940	2062
Deoghar	7519	1634	Simdega	_	1263
Godda	16122	1150	PashchimiSinghbhum	8863	1364
Sahibganj	23789	1812	Saraikela-Kharsawan	_	1957
Pakur	21927	1007	Giridih (Nagar Parishad)	1432	1363
Dhanbad	2663	1640	Deoghar (M Corp.)	2282	1587
Bokaro	3924	2070	Dhanbad (M Corp.)	6838	1730
Lohardaga	8891	1104	Chas (Nagar Parishad)	1591	2053
PurbiSinghbhum	3652	1855	Mango (NAC)	2515	1695
Palamu	17935	1343	Jamshedpur (NAC + OG)	2419	2004
Latehar	_	1706	Hazaribag (Nagar Parishad)	1307	853
Hazaribagh	5780	1093	Ranchi (M Corp.)	2370	1962
Ramgarh	_	1406	Adityapur (Nagar Parishad)	2724	2356

Source: Generated from Census of India (2001-11)

Table 3b
Ranking on Towns based on Quality of Living Index, Jharkhand, 2011

Quality of Living Index of Towns, Jharkhand, 2011						
Total Households	**Composite Index**	**Slum Households**	**Composite Index**	**Non-Slum Households**	**Composite Index**	**Quality of Living Index**
Jamshedpur (NAC + OG)	0.08	Ranchi (M Corp.)	0.17	Jamshedpur (NAC + OG)	0.06	**(0-0.30) FAIR**
Jugsalai (M)	0.10	Dhanbad (M Corp.)	0.18	Jugsalai (M)	0.08	
Ranchi (M Corp.)	0.18	Giridih (Nagar Parishad)	0.19	Ranchi (M Corp.)	0.17	
Hazaribag (Nagar Parishad)	0.23	Hazaribag (Nagar Parishad)	0.21	Hazaribag (Nagar Parishad)	0.21	
Giridih (Nagar Parishad)	0.30	Jamshedpur (NAC + OG)	0.24	Giridih (Nagar Parishad)	0.25	
Mango (NAC)	0.31	Deoghar (M Corp.)	0.24	Chaibasa —(Nagar Parishad)	0.26	
Gumla (NP)	0.34	Mango (NAC)	0.25	Mango (NAC)	0.27	
Dumka (Nagar Parishad)	0.34	Medininagar (Daltonganj) (NP)	0.25	Dumka (Nagar Parishad)	0.30	
Chaibasa (Nagar Parishad)	0.35	Chas (Nagar Parishad)	0.29	Gumla (NP)	0.32	**(0.301-0.60) BAD**
Chakardharpur (Nagar Parishad)	0.36	Seraikela (NP)	0.30	Lohardaga (Nagar Parishad)	0.32	
Deoghar (M Corp.)	0.38	**STATE - JHARKHAND**	**0.30**	Medininagar (Daltonganj) (NP)	0.35	
Lohardaga (Nagar Parishad)	0.40	Dumka (Nagar Parishad)	0.31	Chakardharpur (Nagar Parishad)	0.35	
STATE - JHARKHAND	**0.40**	Chakardharpur (Nagar Parishad)	0.33	Deoghar (M Corp.)	0.37	
Medininagar (Daltonganj) (NP)	0.41	Phusro (Nagar Parishad)	0.34	Seraikela (NP)	0.38	
Chas (Nagar Parishad)	0.41	JhumriTilaiya (Nagar Parishad)	0.35	Jamtara (NP)	0.39	
JhumriTilaiya (Nagar Parishad)	0.45	Gumla (NP)	0.35	**STATE - JHARKHAND**	**0.39**	
Adityapur (Nagar Parishad)	0.45	Jugsalai (M)	0.35	Chas (Nagar Parishad)	0.40	
Jamtara (NP)	0.45	Lohardaga (Nagar Parishad)	0.36	Adityapur (Nagar Parishad)	0.40	
Phusro (Nagar Parishad)	0.46	Adityapur (Nagar Parishad)	0.40	Phusro (Nagar Parishad)	0.44	
Seraikela (NP)	0.47	Sahibganj (Nagar Parishad)	0.45	JhumriTilaiya (Nagar Parishad)	0.45	
Dhanbad (M Corp.)	0.48	Chaibasa (Nagar Parishad)	0.47	Dhanbad (M Corp.)	0.46	
Mihijam (NP)	0.51	Chatra (Nagar Parishad)	0.50	Khunti (NP)	0.49	
Khunti (NP)	0.52	Latehar (NP)	0.52	Mihijam (NP)	0.50	
Sahibganj (Nagar Parishad)	0.53	Rajmahal (NP)	0.58	Sahibganj (Nagar Parishad)	0.51	
Simdega (NP)	0.56	Bundu (NP)	0.59	Simdega (NP)	0.53	
Chatra (Nagar Parishad)	0.56	Jamtara (NP)	0.59	Chatra (Nagar Parishad)	0.56	
Kodarma (NP)	0.59	Mihijam (NP)	0.63	Kodarma (NP)	0.56	
Bundu (NP)	0.74	Basukinath (NP)	0.67	Rajmahal (NP)	0.71	**(0.601-0.90) WORSE**
Rajmahal (NP)	0.75	Kodarma (NP)	0.68	Bundu (NP)	0.72	
Basukinath (NP)	0.77	Khunti (NP)	0.71	Basukinath (NP)	0.73	
Hussainabad (NP)	0.79	Hussainabad (NP)	0.77	Hussainabad (NP)	0.77	
Latehar (NP)	0.79	Simdega (NP)	0.77	Latehar (NP)	0.78	

Source: Generated from Census of India,2011

Table.3c: Pearsons Correlation Matrix Between Housing Amenities And Health Status

Correlation between Housing Amenities & Health Status, Urban Jharkhand, 2011										
	Sufferring from Diarrhoea	**Sufferring from ARI**	**Chronic Illness**	**Suffering from Tuberculosis**	**Suffering from Asthma/ CRD**	**Delivery at Home**	**Institutional Delivery**	**Less than 24 hrs stay in institution after Delivery**	**Children suffering Diarrhoea**	**12-23 Months Children Fully Immunized**
Tap Water	-.147	.171	.225	.074	.110	-.163	.184	**-.701****	.141	.156
Treated Tap Water	-.117	.202	.231	.041	.019	-.209	.232	**-.673****	.126	.244
Unsafe Water	-.127	-.031	.148	.111	.249	.097	-.118	-.228	-.107	.170
Flush Toilet	.198	.386	.237	-.351	-.493	-.492	**.545***	-.388	.101	.457
Concrete Roof	**-.542***	**-.532***	**-.570***	**-.509***	.260	.260	-.246	.117	-.252	-.441
Electricity	-.008	.096	.116	-.382	-.161	-.202	.270	**-.599***	-.016	.077
Good Residential HH	-.063	.320	.103	**-.533***	**-.536***	-.475	**.534***	-.539*	-.263	.488
1 room 9 plus HH	-.042	-.009	-.054	**.572***	**.429**	-.017	-.070	.372	.191	-.043
LPG	.267	.310	.198	-.394	**-.712****	**-.503***	**.554***	-.247	-.037	.426
Inferior Fuel	-.252	-.373	-.212	.405	**.726****	**.547***	-.601*	.329	.114	**-.504***
Banking	.077	.160	.153	-.463	-.429	-.181	.258	-.435	-.040	.365
Telephone	-.009	.023	.014	**-.551***	-.384	-.047	.132	-.380	-.082	.123
4 Wheeler	-.177	.096	-.009	**-.501***	-.540*	-.412	.463	-.379	-.220	.409
With no Asset	.044	-.041	-.039	**.588***	.370	.149	-.231	**.513***	.094	-.128
**. Correlation is significant at the 0.01 level (2-tailed).										
*. Correlation is significant at the 0.05 level (2-tailed).										

Source: Generated from Census of India, 2011

Table.3d: Pearsons Correlation Matrix Between Social Characteristics And Health Status

Correlation between Social Characteristics & Health Status, Urban Jharkhand,2011							
	Average Household Size	Sex Ratio	Child Population	Literacy Rate	Women Headed HH	SC Population	ST Household
Sufferring from Diarrhoea	-.230	.618*	-.173	.435	.655**	-.438	.686**
Sufferring from ARI	-.533*	.693**	-.465	.540*	.769**	-.494	.718**
Chronic Illness	-.495	.525*	-.387	.400	.618*	-.334	.636**
Suffering from Tuberculosis	-.154	.119	.223	-.285	.471	.033	.221
Suffering from Asthma/CRD	.384	-.561*	.450	-.630**	-.372	.736**	-.588*
Delivery at Home	.665**	-.729**	.372	-.328	-.465	.717**	-.583*
Institutional Delivery	-.655**	.747**	-.425	.404	.466	-.729**	.609*
Less than 24 hrs stay in Institution after Delivery	.480	-.361	.513*	-.345	-.193	.158	-.329
Women aware of ARI/Pneumonia signs	-.378	.253	-.129	.166	.211	-.564*	.431
12-23 Months Children Fully Immunized	-.685**	.439	-.709**	.618*	.547*	-.459	.622*
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

Source: Generated from Census of India, 2011

TABLE.3E: PEARSONS CORRELATION MATRIX BETWEEN HOUSING AMENITIES AND SOCIAL CHARACTERISTICS

Correlation Between Housing Amenities & Social Characteristics, Urban Jharkhand, 2011							
	Level of Urbanization	Child Population	Literacy Rate	Female Literacy Rate	Women Headed HH	SC Populati on	ST Populati on
Tap Water	.771**	-.558*	0.198	0.118	-0.051	0.186	0.066
Treated Tap Water	.775**	-.616*	0.268	0.186	0.005	0.099	0.143
Unsafe Water	0.349	-0.154	-0.317	-0.385	-0.095	.532*	-0.167
Flush Toilet	0.4	-.771**	.854**	.868**	0.196	-.522*	0.39
Toilet within Premises	0.301	-.711**	.820**	.853**	0.221	-.532*	0.364
Open Defecation	-0.311	.726**	-.823**	-.856**	-0.243	.534*	-0.381
Concrete Roof	0.245	0.195	-0.182	-0.241	-.844**	0.459	-.781**
Electricity	.619*	-.569*	.547*	0.461	-0.243	0.03	-0.029
Good Residential HH	0.466	-.803**	.747**	.713**	0.102	-0.393	0.241
1room all HH	-0.05	0.277	-.571*	-.520*	0.225	0.021	-0.141
1 room 9 plus HH	-0.136	0.264	-.528*	-0.451	0.288	0.051	-0.039
LPG	0.16	-.542*	.771**	.796**	0.297	-.738**	0.466
Inferior Fuel	-0.21	.628**	-.787**	-.791**	-0.371	.733**	-.530*
Bathroom within Premises	.597*	-.792**	.744**	.724**	-0.016	-0.291	0.195
Closed Drainage	.656**	-.524*	0.366	0.314	-0.284	-0.098	-0.038
Banking	.578*	-.687**	.722**	.619*	-0.149	-0.112	0.179
Telephone	0.436	-0.466	.624**	.537*	-0.339	-0.032	0.008
4 Wheeler	.608*	-.718**	.655**	.605*	-0.093	-0.275	0.164
With no Asset	-.506*	.548*	-.643**	-.562*	0.316	0.061	-0.012
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

Source: Generated from Census of India, 2011

ASSESSMENT OF MEDIUM TOWN CHARACTERISTICS IN KAMBAM, THENI DISTRICT, TAMIL NADU – A GEOSPATIAL ANALYSIS

V. RENGAN[1], M. KIRITHIGA[1] & G. R. PARTHASARATHY[2]

ABSTRACT

Over the past few decades there has been raising concerns from planners and researchers about the need for evolving optimal services for any area particularly in towns and cities. Studies on medium towns are comparatively few not only in India but also at the international level. It is apt to quote a few observations from SMESTO (Small or Medium Sized-Town) project under EPSON (European Spatial Planning Observation Network, May 2006). The recent European Spatial Planning Observation Network, Territorial Development and Cohesion project1 indicates "The Role of Small and Medium Sized Towns" gives one example. The knowledge of the role of small and medium sized towns should be explored to a higher degree in order to formulate policy recommendations at European Union (EU) as well as at national level. The above observations related to the European scenario are also relevant in the Indian context. Keeping this in mind for the present study tries to analyse the characteristics of a medium town of Kambam.

Keywords: *Geospatial, Population, Service, Characteristics and Kambam*

INTRODUCTION

The level and size of urban centres are classified in different ways all over the world. As per census of India, urban centres are classified based on their total population. During 1970 to 1990s the overall population was comparatively less. During this period an urban centre with a population of more than 100000 is called a 'city' as per census. All other urban centres that have less than 100000 population are called "towns". Hence as per Indian Census, Class I urban centre is a city while Class II to Class VI urban centres are called towns. The later is further grouped as Medium towns (Class II & Class III) and Small towns (Class IV, V and VI). However the very high growth of total population in general and urban population in particular resulted in changes in the perception of the so - called 'medium' towns. Since Census 2011 has identified M1 to M7 categories within Class I cities, a few researchers considered even urban centres with 100000 to 300000 as 'medium' towns. However, the present investigation follows the earlier nomenclature of Census of India where medium towns had a population between 20000 and 100000 and small towns had less than 20000 people.

OBJECTIVES

The main aim of this paper is to highlight the characteristics of medium town in Theni district. To fulfill the aim, the following objectives are set as the main goal.

- To study the spatial pattern of population characters in Kambam town
- To identify the landuse types, health and educational facilities in the town

DATABASES AND METHODOLOGY

The following data sources are used for the present study

- Primary Census Abstract-2001and 2011
- SOI Topographic sheets 1:50,000 scale
- Quick bird imagery 4th January 2012
- Relevant literatures
- Arc GIS v 10.1

STUDY AREA

Kambam town is located at the foothill of the Western Ghats in the Kambam Valley region. The town is very popular in coconut and cardamom cultivation and export. The town extends between 9° 42′ 58″ to 9° 45′ 11″ North latitudes and from 77° 16′ 17″ to 77° 17′ 57″ East longitudes. It is located in the southwestern part of Theni district. Kambam town was first notified in 1958 as a third grade Municipality, with part of Uthamapuram and part of Kambam village, which was later upgraded as a second grade Municipality in 1975. Further elevation as first grade Municipality came to the town in 1991 and is continuing till date. It is the block headquarters for Kambam block. The area of the town is about 6.6 sq km as per 2011 census. A total of 68090 persons live in the town as per 2011 census. The town is sub divided into 33 Wards for administrative reasons.

The physiography of the town mostly has rolling topography. The elevation ranges from 400 m to 430

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m above mean sea level. The climate of the town is pleasant because it is situated on the foothill of Western Ghats. Kambam Mettu is located in the western part of the town. Suruli River flows from southwest to northeast in the eastern part of the town. The town is completely surrounded by agricultural fields in the Kambam Valley region. Within the town there are no any hillocks and water bodies. This town is not connected by railways. However, National Highway 220 passes through the town in a southwest - northeast direction (Fig 1).

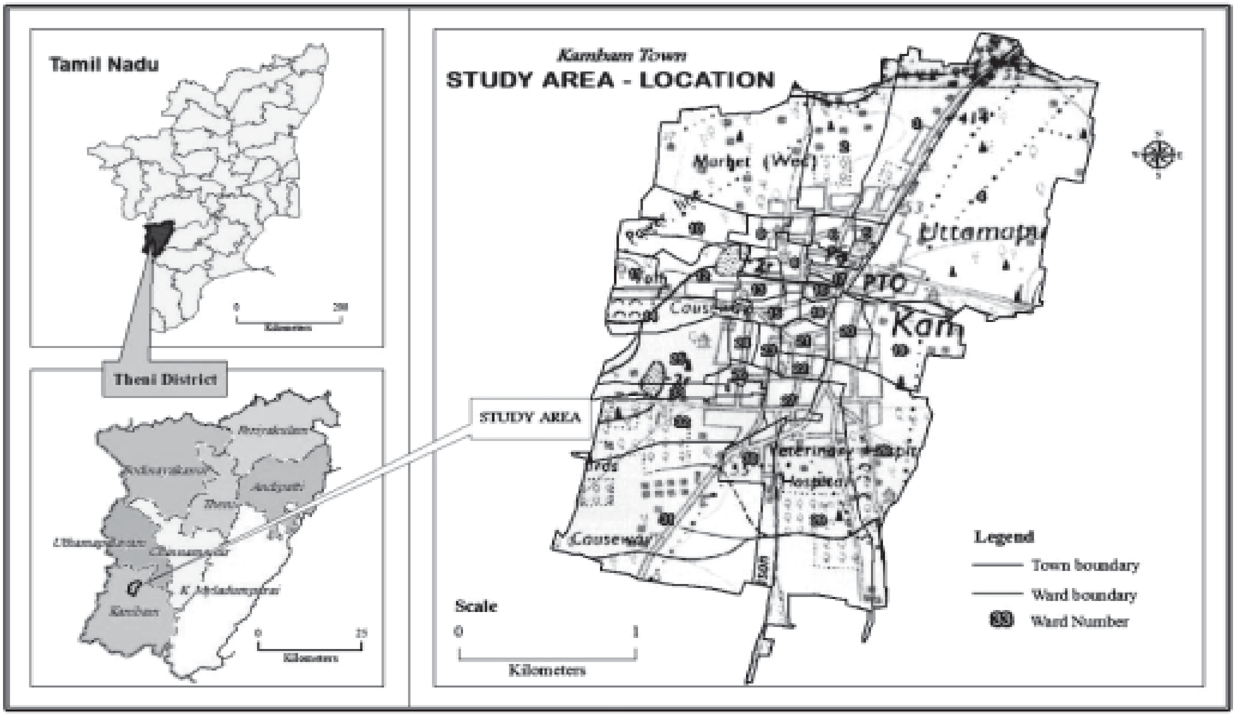

Fig .1 : Location of the Study Area

DISCUSSIONS AND ANALYSIS

Growth of Population

In the year 1951, the total population was only 26908. At present, the population is about 68090 persons as per 2011 census. Thus the population has increased nearly threefold in the last 60 years. However, the decadal growth rate of population has shown much variation during the study period. Between 1951 and 1961 the growth rate stood around 20.8 percent. In the subsequent decade, the maximum growth rate of 25.5 percent is registered. There was a slight decrease in the growth rate during 1971 - 1981. However, the town witnessed the lowest growth rate of 4.2 percent in the 1981 - 1991 decade. After creation of new Theni district, the population growth of the Kambam town is slightly increased during the year 1991 - 2001. The subsequent decade also noticed a slight growth of 15.6 percent in the year 2001 - 2011. This indicates that Kambam town still remains as a town with low ‘attractions’ or ‘pull force’ (Table 1).

Table 1
Kambam Town – Growth of Population
(1951 – 2011)

S. No	*Year*	*Total Population*	*Decadal Growth Rate (in percent)*
1.	1951	26908	—-
2.	1961	32517	20.8
3.	1971	40796	25.5
4.	1981	50340	23.4
5.	1991	52435	4.2
6.	2001	58891	12.3
7	2011	68090	15.6

Source: Census of India 2011.

Population Density

The population density of Kambam town is about 10363 persons per sq km. and it varies from 2696 persons to 62285 persons/sq km in the town. The high density areas of above 30000 persons/sq km spread out in the central part Wards of the town. The moderate density of population of 15000 - 30000 persons/sq km is mostly noticed in some central part Wards of 14, 19 20, 21, 22, 23, 24, 27 and 33 as an east - west stretch in the town. Low density of below 15000 populations is noticed in the remaining Wards of in the northern, western and southern parts of the town (Fig. 2).

Sex Ratio

Kambam town has an average sex ratio of 1012 females per 1000 males as per 2011 census. It is comparatively high or positive sex ratio. The highest sex ratio of 1121 females/1000 males is noticed in Ward 17 in the central part and it is followed by Ward 24 which also has a sex ratio of 1111 females / 1000 males. On the other hand, low sex ratio of 871 is found in Ward 2. It is interesting to note that these two Wards are nearest Wards but the sex ratio is very different. A moderate sex ratio of above 1000 is noticed in the central and south eastern parts of Kambam town. A Lower sex ratio of less than 1000 is observed in the Wards of 1, 2, 3, 4, 5, 6, and 10 in the

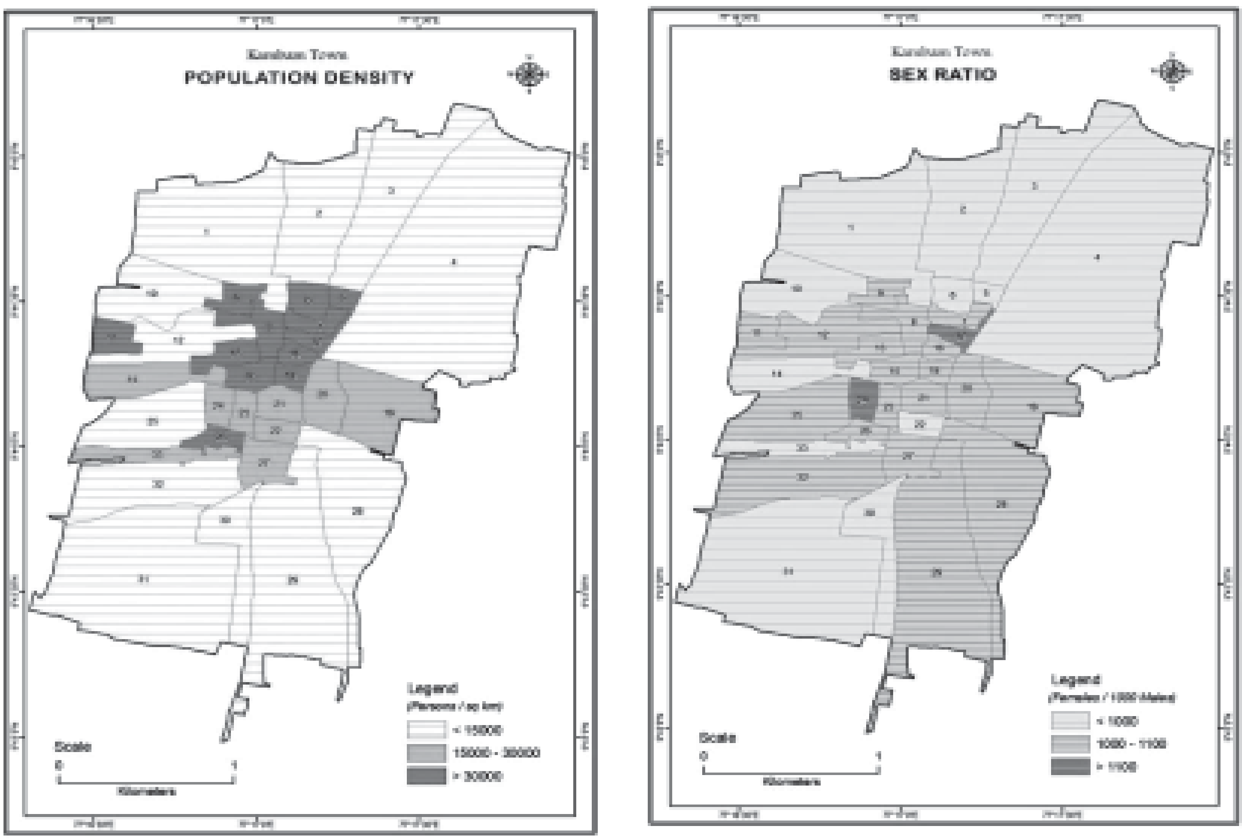

Fig .2 : Population Density and Sex Ratio

northern part, Wards 30 and 31 in the southwest and Wards 14, 22 and 33 in the western part of the town (Fig. 2).

Literacy

In the year 2011, the total literacy rate (Excluding 0-6 Population) in Kambam town was 76.6percent. A very high literacy rate of 89.4 percent is noticed in the central part Ward 23. On the other hand, the lowest level of 63.6 percent is also noticed in the central part Ward 17. Among the Wards high level of above 80 percent is noticed in the central part Wards and western part Wards in the town. Lowest level of below 70 percent is concentrated in Ward 1, 2, 10 and 11 in the northwest and western part Ward like of 25. Moderate literacy level is observed in the southern part and north eastern part Wards (Fig. 3).

SC/ST Population

The percentage share of SC/ST population in Kambam town is about 7.8 percent. It is comparatively very lower than the District average (20.9percent). Among the Wards, Ward 17 has a very high share of 74.2percent in the year 2011. However, the nearest Wards of 15, 13, 12, 8, 6, 2 and 1 have no SC/ST population during the study period. High concentration of above 30 percent of SC/ST population is noticed in the Wards of 17 and 4 in the north eastern part and Ward 30 in the southern part of the town. On the other hand moderate share of SC/ST population is also noticed in southern part Wards of 27, 29 and 31 and western part Ward 11 and Ward 16 in the central part of the town. Other Wards in central and northern part have less concentration of SC/ST population (Fig. 3).

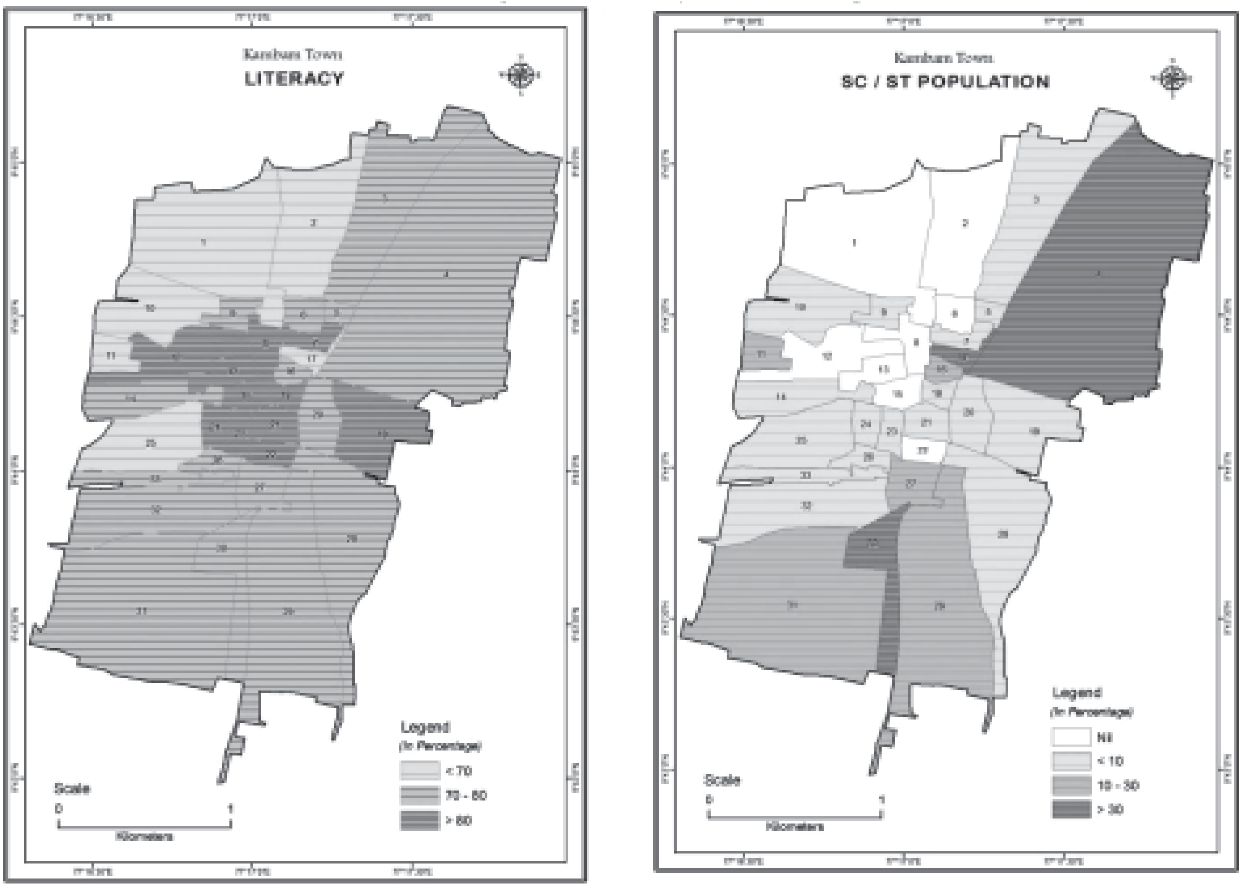

Fig .3 : Literacy and SC/ST Population

Occupational Structure

Census of India 2011 categorizes the main workers into cultivators, agricultural labourers, household industrial workers and other workers.

1. Cultivators

During the year 2011 Kambam town has only 2.7 percent of the total workers as cultivators. It has very minimum share in the total workers share because the study area is basically a town. However, the share of cultivators varies from a minimum of 0.1 percent in Ward 9 to a maximum of 11.4 percent in Ward 7. Ward 10 and 17 does not have this type of workers category. On the other hand, a high concentration of above 4 percent is noticed in south western part Wards of 33, 32 and 31. Central part Wards of 7, 8, 18, 21 and 24 and west of 14, north of 3 also have a high share. Least share of below 2 percent has eastern part Wards and central part Wards in the town. The remaining Wards have a moderate share in cultivator category of workers (Fig. 4).

2. Agricultural Labourers

Of the total, 46.7percent of people are engaged as labourers in various kinds of agricultural related activities in the town. However, for Theni district as a whole, the agricultural labourer category has a share of 51.9 percent. This indicates that in the town agricultural based activities are nearly the same, and half of the total workers are engaged in agricultural activities. Ward 1 in the north western part has the highest concentration of agricultural workers which had a share of 79.4 percent to the total main workers in the Ward.

On the other hand, Ward 16 has a low share of 2.8 percent agricultural workers in the central part. Fig. 4 shows that the northern part Wards in Kambam town have more than 50 percent share of agricultural labourers. Southern and western part Wards have less than 25 percent share in this category. The remaining Wards of 7, 8, 13, 15, 16 and 17 in the central part have the least share in the agricultural labourer's category of workers.

3. Household Industrial Workers

In Kambam town the household industrial workers have the least share of only 2.6 percent in the worker's category. It is nearly equal to the district average (2.4 percent). Ward 24 in the central part there does not have this type of workers. Among the 33 Wards a higher share of the household industrial workers of more than 8.1 percent is noticed in Ward 30 in the

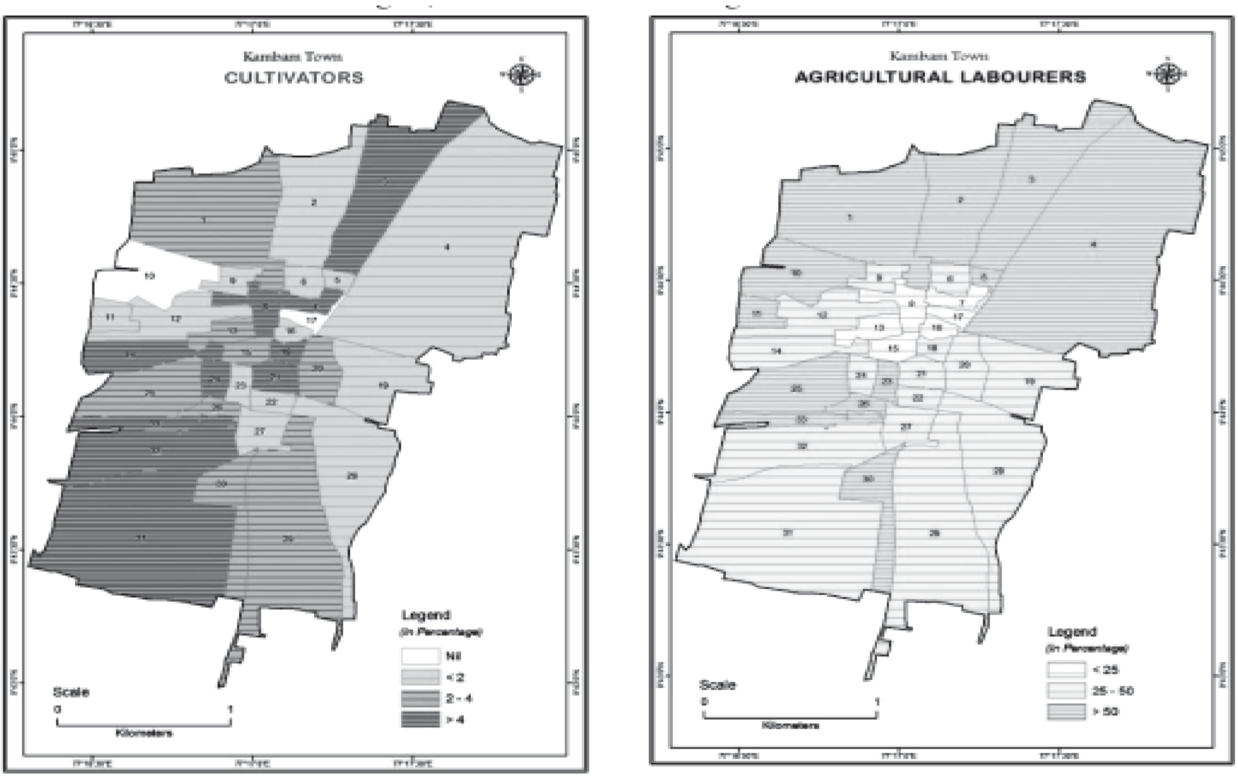

Fig .4: Cultivators and Agricultural Labourers

south. On the other hand, northern part, Ward 5 has the least share of 0.5 percent in this category. Of the total household industrial workers above 4 percent concentration is noticed in the south western part and some central part Wards of the town. The central part Wards have least share of below 2 percent workers noticed. However, the moderate concentration is also noticed in the north western and south eastern part Wards of the town (Fig. 5).

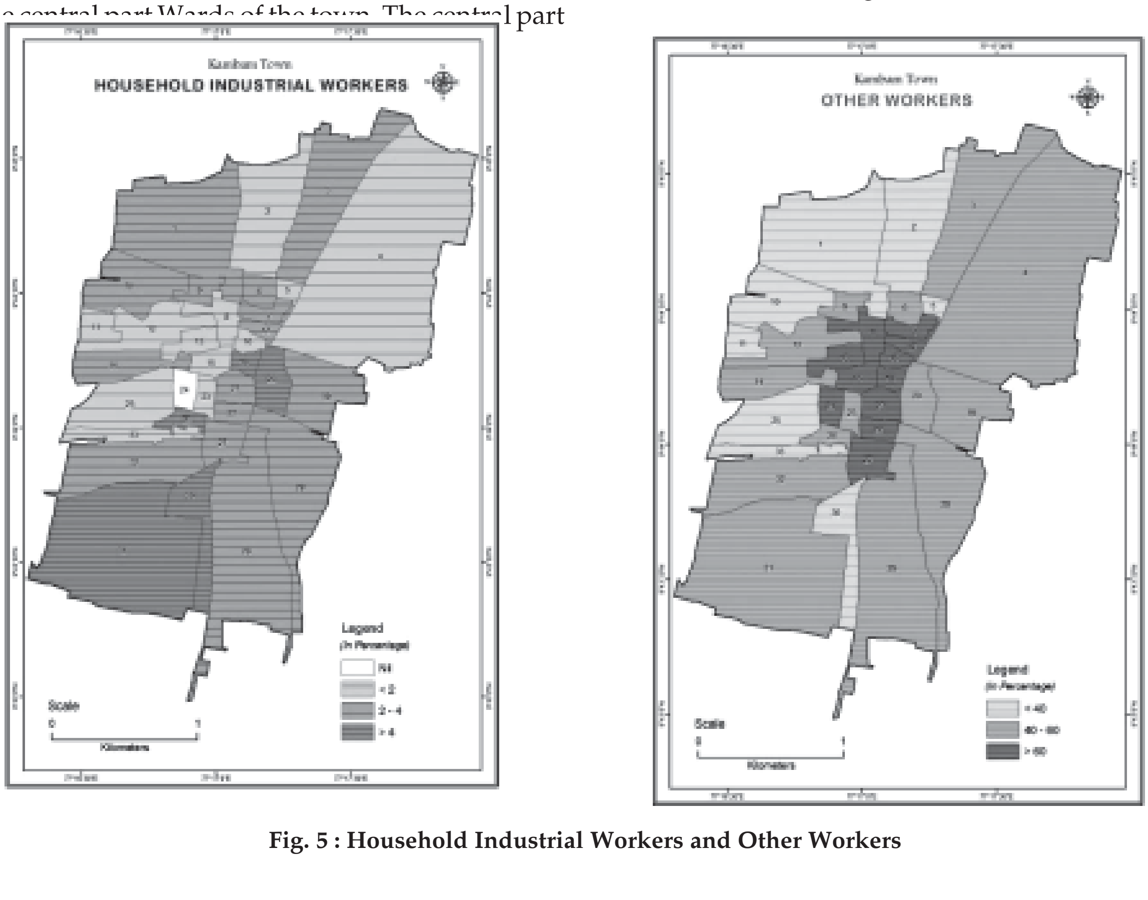

Fig. 5 : Household Industrial Workers and Other Workers

4. Other Workers

The average share of Other workers category in the town is about 48 percent, which is higher than the district average (38.8percent). Among the Wards the concentration of Other workers group is high (95.3 percent) in Ward 16, while it is low (14.4 percent) in the Ward 1.

A total of 11 Wards have a high concentration of above 60 percent workers which can be observed in the central part of the town. On the other hand, the northwestern part of the town has a low concentration of below 40 percent coming under Other workers category. Eastern and southern part Wards also have a moderate concentration in Other workers category (Fig. 5).

Spatial Pattern of Land Use in Kambam Town

Quickbird imagery acquired on 04th January 2012 and Town and Country Planning map 2011 have been used for land use classification. The image and Town Planning maps were overlaid on a common platform. The results are given below.

Generally, urban areas have more area under residential land use. In Kambam town this residential land use has a share of above one-third (36.8 percent) of the total area. This residential land use covers in the entire central part of the town. Kambam town has a large undeveloped area in the form of plantation and other agricultural land which is the most dominant type of land use covered in the north and southern part of the town (Fig. 6). Plantation gets second rank and has a share of 24.7 percent in the total area. Fallow lands ranked third place in terms of area with a share of 12.1 percent. Agricultural lands have a share of 7.1 percent. Commercial and scrub land accounts for a share of above 5 percent each in terms of total area. Public and semi-public land use

Fig. 6: Land Use Pattern

has a share of 4.1percent. It is interesting to note that the industrial and educational types of land use have the lowest share of less than 3 percent each. Water bodies have a very low share in the town.

Functional Characteristics of Kambam town

Generally, the size of an urban centre also has a major say in the number of functions. Smaller urban centres provide a limited number of services. Further, the level of the services is also low. On the other hand, large Metropolitan cities perform a variety of urban functions. These functions decide the role of the urban centre in the regional setting. Each function has a certain service area in terms of distance. In Kambam town health and educational function is taken to identify the service area analysis with the help of buffer zone.

1. Buffer Zone based Service Area

Buffer analysis is one of the tools in GIS used for spatial analysis of geographical phenomena. Buffer commonly denotes the creation of a zone of a specified width around a point or a line or a polygon (area). It is also means as a zone of specified distance around the coverage features. Buffers can be used in queries to determine which entities occur either within or outside the defined buffer zone.

2. Health Function in Kambam Town

Kambam town is the block headquarters. Kambam town has a big Government-Hospital with modern facilities. This is located in the southern part of the town. The medical services are mostly found in the southern part of the town, particularly along National Highway 220 from Kambam to Kumuli. Out of 33 Wards, only 8 Wards have medical facilities in the town. Compared to the other Class II towns in the district, Kambam is better served with regard to health facilities. A 100, 200 and 500 m buffer zone is used to identify the service area of the health facilities in the town. Central part Wards have better service

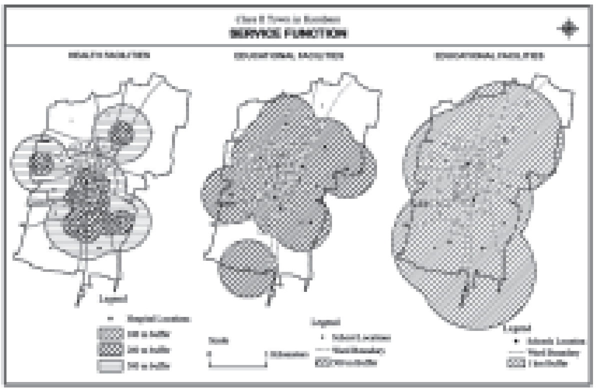

Fig .7 : Health and Educational Facilities

facilities in the town. On the other hand, northern and southern part peripheral Wards are not served better. On the whole, more than 50 percent of the total area of the town has better services with regard to health care.

3. Educational Function in Kambam Town

Educational facilities include Primary, Middle, High and Higher Secondary schools. For the present study, only school educational service has been taken for detailed analysis. Educational functions grouped into two broad category- primary education and higher secondary education.

4. Primary Educational Function

In Kambam town there are 15 schools at primary level. Fig 7 shows the distribution of primary educational facilities in the town. It may be seen that these schools are distributed throughout the town and hence the town is served better. On the other hand, a small area in the northwest and another area in the south have a comparatively poor service with regard to primary education.

5. Higher Secondary Educational Functions

Altogether 6 higher secondary educational institutions serve all the 33 Wards in Kambam town. One km buffer zone clearly displays the service area of the town. Almost the entire town is better served in this higher secondary educational function. Only a small part in the northwest is comparatively poor in the higher secondary educational facility. To conclude it may be noted that with regard to the educational services as well as health services in Kambam town is better in these service facilities.

CONCLUSION

From the detailed analysis of the medium town characteristics in Kambam town the following broad inferences are drawn.

- i. Kambam town has low urban pull power
- ii. Agriculture and related activities dominate the entire town.
- iii. No major industries are located and most of the manufacturing sector is under small scale category
- iv. The available characteristics of towns indicate that urban growth will be minimum in the near future.
- v. Kambam town has good transport facilities, but this did not help to further urban growth, mainly because of heavy its dependence on agricultural activities
- vi. Improvement of recreation facilities such as tourism attractions may help to accelerate the urban pull power character of Kambam town
- vii. The study area as a whole does not exhibit 'true' urban character in the towns and dominance of agricultural based activities makes the towns to have only retarded growth in the near future. As suggested above, development of agro based / forest based product based industries and tourism may infuse better urban characters to the towns.

REFERENCES

1. Adsul, R. S. (1994): "Urban Perspective of Class I Cities in Maharastra," Unpublished Ph.D. Thesis, Department of Geography, Shivaji University, Kolhapur.
2. Alexander, J. W. (1954): "The Basic-Non basic Concept of the Urban Economic Functions", *Economic Geography, Clark University* Vol. 30, No.3, pp. 246 – 261
3. Bose, Ashish (1984): Studies in India's Urbanization 1901-1971, Tata McGraw-Hill, New Delhi.
4. Cherunilum, F. (1984): Urbanization in Developing Countries *(A Socio–Economic and Demographic Analysis)*, Himalaya Publishing House, Bombay.
5. ESPON 1.4.1 (2006): "European Spatial Planning Observation Network 1.4.1", Project Report.
6. Jayamala Didee (1997): Indian Medium Towns, Rawat Publication, Jaipur and New Delhi.
7. Kavitha, D. (2002): "A Spatio Temporal Analysis of Urbanization in South Tamil Nadu With Special Reference to Class II Towns," Unpublished M.Phil Dissertation, Department Geography, Madurai Kamaraj University, Madurai
8. Nelson, H.J. (1955): A Service Classification of American Cities, *Economic Geography, JSTOR*, Vol 31, No 3, pp. 189-210
9. Rengan, V. (2007): A Geographical Analysis of Land Use and Urban Functions of a Class II Town – A Case Study of Karur, Tamil Nadu, Unpublished M.Phil Dissertation, Department Geography, Madurai Kamaraj University, Madurai
10. Swaminathan, E. (1977): The Occupational Structure of Small towns in Coimbatore District, Tamilnadu A Factorial Approach, *The Indian Geographical Journal,* Vol. 52, No. 1&2, pp. 68 – 78
11. United Nations (2015): "World Urbanization Prospects: 2014 Revision", Economic and Social Affairs, New Yark
12. Vasantha, Viswanath (1981): Growth and Development of Towns in Tamil Nadu. 1901– 1981, *The Indian Geographical Journal,* Volume 56, Number 1, pp. 43 – 53.

URBAN GROWTH AND INEQUALITY OVER DIFFERENT SIZE CLASS CITIES: UNFOLDING A CASE OF MAHARASHTRA

Veronica GOMES[1] & Pallabi GUHA[1]

ABSTRACT

Urbanisation is an inherent part of regional development. Maharashtra has experienced highest urban growth since 1961. Besides it contains Mumbai, the largest city and the financial capital of India with a population of 41 million. Rapid urbanisation has hardly kept pace with the growth in services and infrastructure to provide basic amenities in cities across the state. It resulted in an increase of inequalities and exclusion of the urban poor. Government policies favouring privatisation fuels the present process. In this context, the study would seek to map the spatial variation in the disparities among the different city size classes in terms of access to basic amenities and to explain the variations in such.

***Keywords**: Urbanisation, Growth Rate, Basic Amenities, Social Exclusion.*

INTRODUCTION

Urbanisation in India has grown at a very rapid pace. It is the inevitable result of regional development and economic growth. Maharashtra has the highest level of urbanisation and is the second most urbanised state in India, in terms of absolute numbers. In last three decades, the state has witnessed a spurt in urban growth. The pace of urbanisation has not been able to keep up with the coverage of amenities. Urban amenities are provided by the state through urban local bodies. These local bodies are mostly under financial constraint to provide the amenities. Funding for the amenities mostly comes from the state government which is more biased towards large cities, therefore, creating inequality. The provision of the amenities also varies spatially as the core cities receiving better services as compared to the satellite towns, outgrowths and smaller towns and cities.

Urbanisation in Maharashtra was accelerated by migration, natural growth and economic and educational opportunities and distress in agriculture. Cities grow in their peripheries to accommodate the huge incoming population. This puts pressure on the resources and services of the city. In the age of globalisation, cities are becoming more exclusive in nature; they are favouring the rich while the poor remain deprived. Government policies of sanitisation and development have pushed the poor away from the central cities to the suburbs. Privatisation of the provision of basic amenities, in aiming at decentralisation of the process has made the cost prohibitive, beyond the reach of poor. Social exclusion is manifested in deprivation and polarisation of resources.

OBJECTIVES

The objectives of the paper are the follows:

- To trace the population growth dynamics over the Class Size Cities of Maharashtra in the year 2011.
- To assess the levels deprivation in terms of basic amenities over different size class cities of Maharashtra.
- Examine the changes in the level of deprivation in the year 2001 and 2011.
- To bring about an association of urban growth with that of the change of the level of deprivation.

DATABASE AND METHODOLOGY

The analysis of the urban growth and deprivation in terms of basic amenities entailed the computation of data for the population in numbers and the selected four basic amenities. Data for the study was procured from the following sources:

- Census of India, 2001, Maharashtra, Tables on Houses, Household Amenities and Assets
- Census of India, 2011, Maharashtra, Tables on Houses, Household Amenities and Assets

METHODOLOGY

The dynamics of the urban growth in India is insulated, the biased nature of the urban growth favours the Class I cities, making the lower class cities impoverished or making them all, the more dependent on the metropolitan cities. This phenomenon has found manifestation in almost every state in the country, which reflects the history of the development of the place and the futile government policy initiatives to bring about uniformity in the development of the regions. A qualitative and quantitative analysis of the study was opted for the proper examination of the patterns of urban growth and the biasness in the development

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of regions. The level of inequality was examined in particular, which ought to prevail among the Class size cities. The association of population growth patterns and deprivation of the households in terms of selected attributes of basic amenities was further carried out.

DISCUSSION AND ANALYSIS

Decadal Growth Rate

Size class cities

The state of Maharashtra has the highest level of urbanisation and the highest level of income, in scale, pace and degree. It is artificially embedded as people left agriculture under distress. The level of urbanisation presently is 31.2 % in 2011. Tracing urban growth from 1951-71, Census towns had increased by 9%.Large scale rural to urban migration has taken place. Therefore small towns have grown at an accelerated rate. Bhagat (2011) and Kundu attributed natural increase, rural to urban migration and reclassification and change of boundaries of towns as factors responsible for unprecedented urban growth. Maharashtra, in particular, has a high level of disparities in development between urban and rural areas. This unequal pattern of development causes differences in migration patterns as migrants not only come from within the state but also from other states as Bihar and Uttar Pradesh.

Kundu mentions that urban growth has taken place in such a way that it discourages migration to the cities leading to the deceleration in urban growth. Formalisation and sanitisation of the cities have meant the exclusion of the poor. However, a dramatic increase in Urban Agglomerations was in noted census 2011. In 2001 the class I cities consisted about 11% of the settlements and had about 80% of the population. Declassification of the towns and adding of the new ones are making the distribution of population more precarious.

Table 1
Number of Cities in Different Size Classes

Class Size Cities	*2001*	*2011*
I	40	44
II	44	54
III	135	167
IV	101	134
V	50	109
VII	8	26
Total	378	534

Source: Compiled from the Census of India 2001 & 2011.

The state had 378 towns in 2001 which has risen to 534 in the present census. In 2001 Maharashtra had 40 Class I cities, four more cities were added on in 2011 census. Class II cities had 44 cities in 2001 which rose to 54 in 2011. Class III and IV cities had experienced a growth of 32 and 33 cities respectively during the inter-census period. The highest growth was observed in Class V cities which added 59 more cities from 50 in 2001 to 109 in 2011. The smallest size class VI too grew from 8 in 2001 to 26 in 2011.This has been tabulated in Table1.

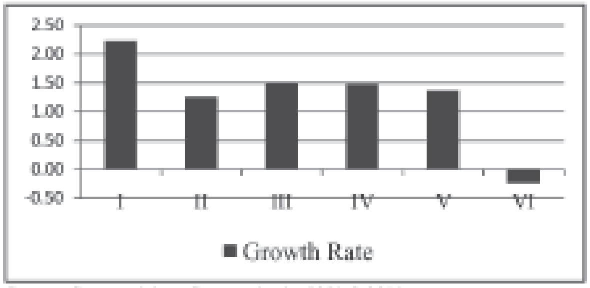
Table 2
Growth Rate of Different Size-Class Cities

Class Size Cities	*Exponential Growth Rate*
I	2.23
II	1.25
III	1.51
IV	1.47
V	1.36
VI	-0.24

Source: Computed from Census of India 2001 & 2011.

From Table 2 it is observed that class I cities in Maharashtra has experienced a growth of 2.23%, between decades 2001-2011, which is highest among all the six size classes of cities. The second highest growth rate is reflected among the Class III size cities with a value of 1.51%. The third highest growth rate of 1.47 was noted in class IV cities. A growth rate of 1.36 was observed in the case of class V cities, and a negative rate was displayed by class VI cities. A notable aspect here is the insufficient growth of Class II cities, which might otherwise be ideal cities to ease the population pressure of the Class I cities. Inconsistencies exist in the growth of the cities through the different Class orders, being highest for the Class I cities and plummeting to negative for the Class VI.

Cities in Maharashtra have witnessed vertical growth in population. Large cities in class I category have higher growth rate due a natural rise in population. In addition to this investment naturally, pours into these cities due to industrial inertia and economic motives resulting in population growth. Agrarian crisis forces people out of agriculture in search of jobs in urban areas with a promise of better life. The population at first stage migrates from rural to small towns resulting in an increase of class III and Class IV towns. At the second stage, population migrates in search of better employment from small towns to large cities such as Class I and Class II causing the decline of population in Class VI cities. Growth rate across different size class cities is depicted in bar graphs in Figure 1.



Source: Computed from Census of India 2001 & 2011.

Fig. 1. Exponential Growth Rate 2001-2011

Large metropolitan cities exhibit strong tendencies for primacy. Rank-size rule value for top fifty cities in Maharashtra was computed to measure the value of norms which is decreasing from the degree of 1.26 in 2001 to 1.10 in 2011. The decline in the index by 0.16 reflects marginal evenness or lessening of inequality in the distribution of towns and urban population of different cities. Analysis of Rank-size rule clearly indicates Mumbai as a primate city in Maharashtra. Pune the second largest city is far less in size as compared to Mumbai.

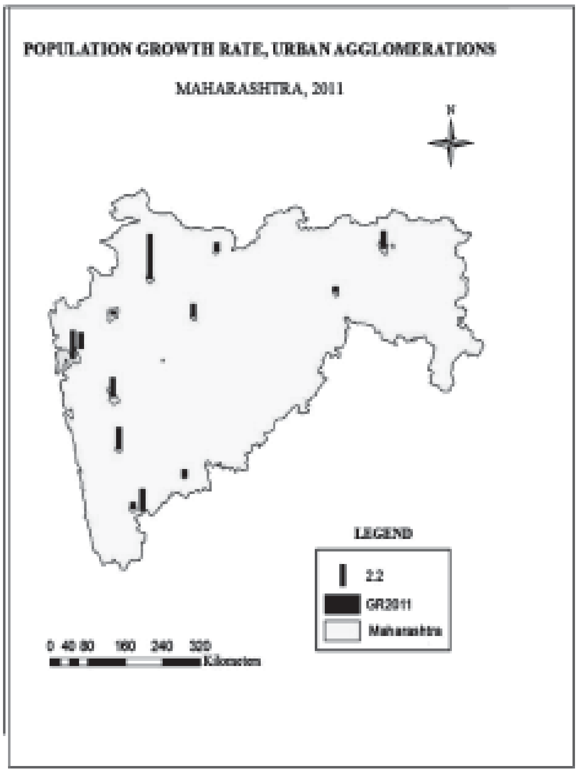
Demographically fixed threshold of the cities definition creates fallacy and gives an image of an urban explosion. By UN projections Mumbai is set to have 26 million in 2015. Incoming and outgoing category create differences.

Growth rate of Agglomeration

Urbanisation is oriented towards the large cities, resulting in the formation of urban agglomerations to accommodate expansion of the cities. The concentration of class I cities increased over the decades, indicating top heaviness of urban structures. The state has fifteen urban agglomerations Mumbai being the largest followed by Pune, Nagpur, Nashik,etc., although in terms of growth rate it is low as Malegaonh as the highest population growth rate of 0.42 and Nashik has the lowest growth rate of 0.032.

Biasness of the concentration of population exists spatially. The growth of the Mumbai Agglomeration has been stark as compared to the fringes of Mumbai metropolitan area occupying nearly 60% of the geographical area but only 6% population. The concentration of Mumbai and much of its urban problems has been due, to the time lag in development and distance decay and unilateral decision making. Mumbai has grown linearly and extended to accommodate the expanding population. However, in this process, it had become more exclusive in terms of population distribution. For example land from derelict, cotton industries were transferred to the private developers to be used as prime real Estate instead of making it available for a public purposes such as urban low-cost housing and education or public infrastructure purpose. This as a result has created spatial segregation, gated communities and more inequality in urban life.

The impetus for the development of Mumbai came with the opening of railways connecting the hinterland. The Recent scenario shows a decline in blue-collar industries in the city core which led to a decline in population. Slow gentrification has taken place along with a change in Social and economic structures of the cities. The following Map 1 displays the Growth Rate among the Urban Agglomerations in the state.



Source: Computed from Census of India 2001 & 2011.

Map 1.

Mumbai has the second highest growth rate among urban agglomeration, preceded by Aurangabad with a growth rate of 1.12.Three Urban agglomerations have shown a negative growth rate or decline in urban population, Ahmadnagar being the highest with a rate of -0.09, followed by Yavatmal -0.03 and the lowest Kamptee -0.02.

The agglomeration of Nagpur has grown to a lesser degree, and a slight decline was observed due to its merger with Vidarbha. The growth rate of cities in terms of their selected agglomerations bears testimony to the primacy of the state in favour of the Mumbai agglomeration. Urban Development is selective and concentrated in pockets leading to the dearth of proper infrastructure in the urban centres.

II. Deprivation Index among the Size class cities

Access to basic amenities is an important indicator of the quality of urbanisation. In urban areas, electricity is better and more easily accessible than sanitation. It is not necessary that more urbanised state would have better amenities, or bigger city would be better off than smaller towns. Class I town in Maharashtra is in better position in terms of electricity and drinking water. Drinking water availability is at a medium level between 33.95 to 55.04 percent. Even electricity and latrine and kitchen were at a moderate level between 62.63 to 86.93% and 38.32%-65.64% respectively. Bathroom facility is above 51.46%. In the case of water much of the coverage was in terms of hand pumped wells. Toilets are mostly located outside the premise in urban areas but had a positive correlation with literacy rate. Drainage of waste water is needed as it is important to hygiene (Khan 2013).

Concentration and growth of population are indirect measures of Deprivation as it indicates over-crowding. The core has better access to basic amenities in spite of having high density but low growth rate. Deprivation is often beyond the slums in terms of infrastructure, housing and basic amenities which has severe shortages.

A striking feature of the access to basic amenities is the inequality which is prevalent in the urban areas. Differentials exist not only in rural-urban level but are also prominent among social groups in the urban centres. Poverty variations occur due to personal heterogeneity, environmental diversities, various social climate and difference in relative Deprivation. Backward states and small towns are deprived; large gaps exist in the levels of access between rural and urban areas. The culmination of which leads to the adoption of Government policies such as Bharat Nirman, PMGSY, IAY, RGGVY, rural development, drinking water and sanitation and PURA were developed by the government to meet the deficits. These Policies, however, were implemented in the urban centres of the higher order which abridged the rural and urban areas further more. For instance, JNNURM was launched in 2005 for 65 cities but hardly covered beyond the metropolitan centres.

Another problem faced by the cities is the creation of slums due to a shortage of proper housing. These slum dwellers are in the majority of the cases deprived of adequate toilet facilities and therefore depend on public toilets which are unhygienic in nature. Open defecation is also a common feature. They also lack access to water for drinking purposes causing the spread of water-borne diseases. Right to safe drinking water, housing, and food are related to the right to health.

Table 3
Deprivation Index, Maharashtra

Class Size cities	*2001*	*2011*	*Change in Points*
I	2.42	2.74	0.32
II	2.87	3.61	0.74
III	3.74	4.40	0.66
IV	3.12	3.95	0.83
V	3.14	3.21	0.07
VI	3.41	3.80	0.39

Source: Computed with the data procured from the Census of India, 2001 and 2011.

The deprivation index of basic amenities including drinking water, electricity, latrine and polluting fuel for Maharashtra showed a very different trend over a decade. The values of the Deprivation Index have shown an increase in the year 2011 for all class cities. The increase in deprivation has been more for the cities in the Class IV and Class II order followed by the Class III cities. These are the cities which are witnessing a larger influx of population in the recent decade due to the overcrowding of the Class I cities. The lowest deprivation index is 2.74 in 2011 which has moderately increased by 0.32 since 2001. Large cities get more funds from the government which has enabled it to provide basic infrastructure to huge masses. Urban governing bodies are also able to attract more investment in the form of projects and aid from external agencies. Their revenue base is also higher which puts them in an advantageous position in comparison to other cities. Class II cities displayed a higher index of 3.61, which is more by 0.74 as of 2001. Class size cities III has the highest deprivation index of 4.40 in 2011, enhanced from 3.74 in 2001 and marginally less by 0.66 compared to the previous size class. Second highest deprivation in 2011 was observed among Class IV cities with an index value of 3.95 up by 0.83 from 3.12 since 2001. The change in the deprivation index points was least on order of 0.07 points for the Class V cities over the decade. Moderate level of deprivation index was found in Class IV cities with deprivation index of 3.80 in 2011and change by 0.39 from 3.41 since 2001. Lower class cities are more deprived as they lack funds and management capacity to provide for infrastructure. They also accommodate the huge migrant population, therefore, making it difficult to pursue a decent living. This is depicted in Table-3.

Apart from the inequality among the Class size cities in their access to basic amenities, inequality within the cities is rampant. Water supply is unequally distributed within the city favouring the rich. Non-notified slum areas are not served by Government facilities of water and sanitation. 6 million out of 12 million live in slums, and 1 million on the pavements and 2 million as tenants on the *chawls*. Discrimination based on gender often finds manifestation in the inequality of access to basic amenities. Women, in particular, face a lot of hardships in collecting water. Sanitation especially open defecation stands as a common problem. They are often harassed and molested. Taps are often crowded and have long queue. The quality of basic amenities also differs in different regions for e.g. Pune which has an abundant supply of water suffered from the problem of unequal distribution among the masses.

Complete coverage of amenities has not been accomplished in spite of rapid urban growth. The causes are various, such as gaps in demand and supply, financial deficit and political motives. The approach taken by the government is exclusionary in nature as it ignores a large part of the population. The definition of smart cities renders vague and unspecified, and it tends to overlook the major problem of lack of democracy, informality, enclaves and incomplete citizenship.

Agglomeration

Greater Mumbai Urban agglomeration has low deprivation Index in comparison to other agglomerations in 2011 value of 2.12 with a change of 0.07 from 2.19 in 2001. Pune has a low deprivation Index of 1.52 with no change in two decades. Sangli has a similar condition as Mumbai with the marginal difference between the two decades of 0.52.Ahmadnagar has low levels of depreciation Index in 2011 with the value being 1.95 and previous decade being 1.57 the change over decades is around 0.38.Bhusawal had the similar change in depreciation Index in 2011. Yavatmal has a slight higher deprivation Index than Mumbai of 2.90 in 2011, higher by 0.49 since the preceding year. The following table reflects the picture of deprivation in Urban Agglomerations of Maharashtra.

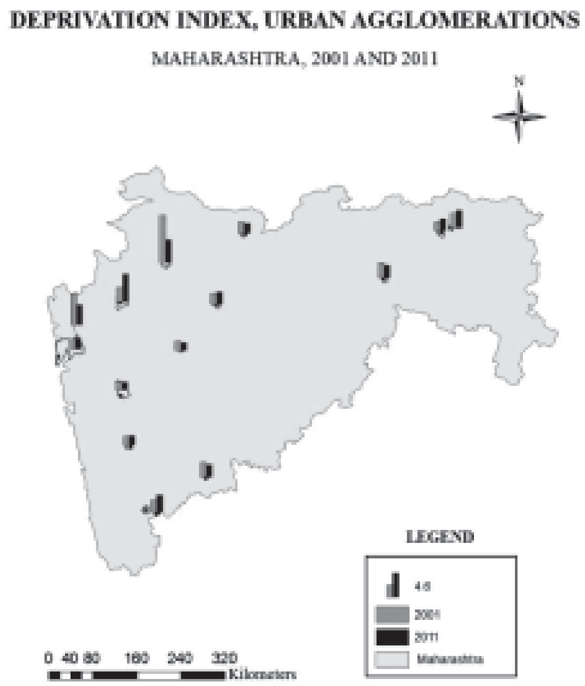
Table-4
Deprivation Index, Urban Agglomerations of Maharashtra

Urban Agglomeration	*2001*	*2011*
Greater Mumbai	2.19	2.12
Pune	1.52	1.52
Nagpur	2.15	1.49
Nashik	5.30	2.68
Aurangabad	2.35	2.09
Bhiwandi	3.81	6.01
Malegaon	4.52	9.21
Sangli	2.36	2.87
Ahmadnagar	1.57	1.95
Ichalkaranji	3.28	2.29
Bhusawal	1.87	2.24
Satara	1.91	1.80
Kolhapur	-	1.37
Yavatmal	2.41	2.90
Kamptee	3.45	2.96

Source: Compiled from the data of Census of India.

Bhiwandi has the highest deprivation Index in 2011 and second highest in the former decade, with second highest change across the decade of 2.19. In 2001 Kamptee had the third highest deprivation Index of 3.81in 2001 which reduced to 2.96 in 2011 this is a positive sign since the urban growth has declined which made the amenities more accessible for the residents thereby reducing deprivation. Malegaon has the highest deprivation Index of 9.21 in 2011 and the highest rate of change 4.69 since 2001. It had the second highest deprivation index in 2001 of 4.52. This high level of deprivation could be explained, high rate of population growth of 4.33%. The pace of its growth has been unable to keep up with the development and provision of basic amenities. The following map depicts the aforesaid situation.

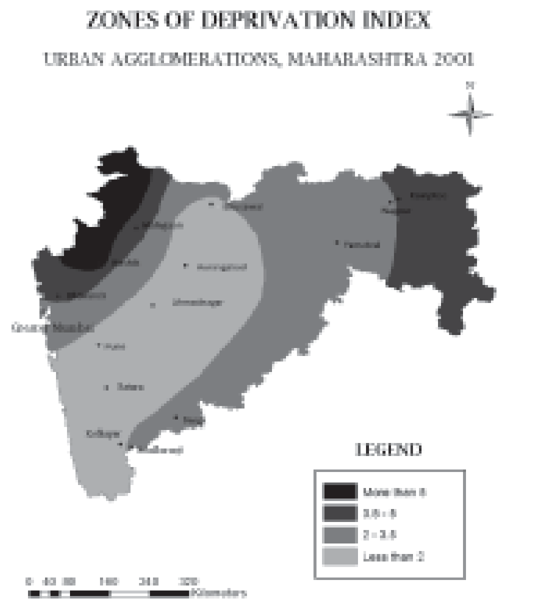
Cities such as Nagpur, Nashik, Aurangabad, Ichalkaranji, Satara and Kamptee has improved on

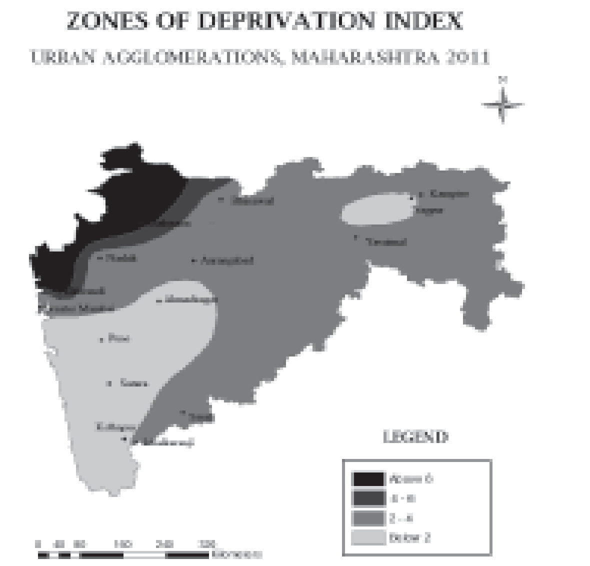


Source: Compiled from the data of Census of India 2001 & 2011.

their deprivation Index as they have displayed a considerable amount of change over a decade from 2001 to 2011.The highest change was seen in Nashik by 2.61 from 5.30 in 2001 to 2.68 in the present decade. Second, comes Ichalkaranji which portrays has a change of 0.99 from 2.29 to 3.28, followed by Kamptee which has nearly 0.50 change over the two decades. Nagpur too had a decline by 0.66. The least decline was observed in Aurangabad and Satara with a decline in 0.26 and 0.11 respectively.

The analysis of the DI spatially, drawing the isolines indicates the concentration of higher level of deprivation in the north western and north eastern part of Maharashtra in the year 2011. However, the northeastern part has shown improvement in the access to basic amenities as depicted by the Nagpur agglomeration, which has taken great strides in ameliorating DI. Greater Mumbai has been observed to have entailed the similar deprivation index over the decade. The improvements towards making the basic amenities accessible have been negligible. DI concentrates in the north-western part of Maharashtra in both the decades and improvement of Deprivation has been subtle if not marked. Malegaon continues to suffer from extreme deprivation, due to a population shift from other class size cities or rural areas. In spite of being located in the north-western part, Nashik has shown improvement in the quality and accessibility of basic amenities in the year 2011. The region having the least deprivation Index covers the agglomerations located in the central and south-western part of the state which is also maintained in the recent decade 2011. The central part of Maharashtra has remained more or less stagnant in Deprivation Index which is due to its low concentration of population and low level of urbanisation which hasn't changed since the last decade.





Source: Compiled from the data of Census of India 2001 & 2011.

Mumbai has always been thought of in binary terms. Upper and middle class have their access to water through developers who convince officials to ensure proper supply of water. The dearth of the legality of settlers in informal settlements keeps them deprived of municipal services. The city is very much vulnerable in physical as well as social terms. The physical vulnerability is due to its terrain which makes water transport difficult. Social vulnerability is in the form of over-crowded slum which lacks civic amenities leading to a proliferation of tuberculosis and malaria. Industrial pollution too poses vulnerability.

According to Bhide (2015), city level politics exclude the migrants from basic amenities. For them the city is a battle ground where they have to struggle to survive. The gap in services exists between a core and peripheral areas. The congestion in the city compels the poor masses to move out to the peripheries for housing as the cost is prohibitive in the city. Economic growth which is determined by the amount of funds available to the urban local bodies in Mumbai is often affected by the lack of infrastructure, the dearth of capital and human resources. Policies are aimed to benefit the corporate not the poor. Poor displaced due to development projects do not receive any rehabilitation.

Massive changes in the structure of the city have brought about the shift in the land use patterns which in turn have increased the gap between the rich and the poor. Inequality between the masses has intensified due to government policy initiatives. For instance, the implementation of the JNNURM brought about major changes in the city. Both private a public sector have poured in their capital to formulate and execute their policy which further displaced the poor. Slum removal programmes launched under the JNNURM aims to the eradication of slums, yet the State is more accommodative to the private developers, act together to marginalise the poor.

III. Variability and Correlation

A better measure to trace the variability and disparity of the households in access to the basic amenities would be to look into a value for the coefficient of variation of the deprivation Index. The value as computed for the two different decades shows that the disparity in terms of deprivation index has increased between 2001 and 2011. The year 2001 shows the lesser consistency of the values of the deprivation index among the cities. This means that deprivation prevailing among the cities was unequally distributed across space. The coefficient value dips down to 53.75% from its initial value of 55.38% which means that the level of deprivation has become less stark. This hints the better utilisation of government resources towards the amelioration of the deprivation in the lower class cities.

Table 5
Coefficient of Variation, Deprivation Index

Class Size Cities	*2001*	*2011*
I	37.60	48.18
II	35.19	40.44
III	40.91	45.23
IV	50.64	65.82
V	105.73	58.88
VI	64.22	75.53

Source: Computed with the data procured from the Census of India 2001 and 2011.

The Inequality prevails not only among the different class cities, but it is also evident within the class cities individually. Higher inconsistencies in the deprivation index have been well noted with the higher order cities. However, lower values of coefficient of variation have been noted for Class I and II cities. This means that the lower order cities are not only inflicted with poor basic amenities but is also variable in terms of its accessibility. All the class size cities have witnessed an increase in the variability of the deprivation over the time. This is evident in Table.5. Among the Class I cities in 2001 the coefficient of variation has been 37.60% which has increased to 48.18% indicating a rise in inequality in the access to basic amenities. Class II cities also display the same trend with a coefficient of variation values being lower (35.19%) in 2001, while 40.44% in the next decade. Size class III and IV cities have the similar increasing trend in the variability.

The exception to this trend is with the class V cities which show a decline in the coefficient of variation values. The higher value of 105.73% in 2001 shows the spurt of class V cities which led to the strain in the accessibility of the amenities. The improvement of the variability value in the following year, however, indicates the efforts of the planning and state intervention to improve the situation.

CONCLUSION

The population dynamics shows a higher growth rate for the Class I cities are driven basically due to distress and agrarian crises. The step wise migration of people from the rural areas to the urban centres bears testimony to the high exponential growth rate of class III cities in 2011. Apart from this, the class I cities are attractive for investment, which leads to the greater population being diverted towards these cities.

The status of deprivation of basic amenities in Mumbai Metropolitan Region is moderate and has better coverage in comparison to other cities. The poor and the marginalised have to bear the brunt of deprivation. Spatial variation in the distribution of basic services exists within the city, leading to polarisation and emergence of exclusive spaces such as gated communities. Large cities across the state are better off as they face less deprivation, small and upcoming cities face more deprivation in comparison to them. Irrespective of their size some cities such as Nagpur, Nashik,etc. have been successful in reducing deprivation over a decade. The level of deprivation is higher in 2001 in comparison to 2011 which emphasises and highlights the exclusionary nature of urbanisation.

Accessibility to basic amenities has been unequal not only among the different class cities but also within communities in the class I cities. A new system of governance, however, calls for the reduction in public sector intervention and subsidies. Agencies ought to be made accountable to the users through their collective action through legal measures to reduce inequality. Also, policies of an inclusive and comprehensive nature are the need of the hour. Group specific and target approach ought to be implemented to better arrest the problem of inequality within urban spaces.

REFERENCES

1. Anand. Nikhil and Rademacher, Anne, (2011), *"Housing in the Urban Age: Inequality and Aspiration in Mumbai"*, Antipode Vol. 43 No. 5 pp 1748–1772.
2. Bagchi. Soumen and Chattopadhyay. Soumyadeep, (2004), *"Decentralised Urban Governance in India: Implications or Financing o Urban Infrastructure"*, Economic and Political Weekly, Vol. 39, No. 49, pp. 5253-520.
3. Bhagat, (2011), *Urbanisation and Access to Basic*

Amenities in India.' URBAN INDIA, VOL. 31 NO.1, pp. 1-14.

4. Bhonsle, (2010), '*A study of urbanization in Nagpur district*', Institute of Town Planners, India Journal 7 - 3, 88 – 95.
5. Chakravorty. S (1996), *"Too Little, in the Wrong Places? Mega City Programme and Efficiency and Equity in Indian Urbanisation"*, Economic and Political Weekly, Vol. 31, No. 35/37, Special Number, pp. 2565 2567+2569-2572 .
6. Deore, (2014), '*Analysis of Population Growth and City Expansion using Census, Topographical and Remote Sensing Data: A Case Study of Nashik City of Maharashtra (India)*', Online International Interdisciplinary Research Journal, {Bi-Monthly}, Volume-IV, Issue-1, pp 126-132.
7. Doifode Kanhu Rajendra, (2004) '*Levels and trends of urbanisation in Maharashtra (1981-2001)*', unpublished M.A. Dissertation; International Institute for Population Sciences.
8. Kundu. A, et.al (1999), *"Regional Distribution of Infrastructure and Basic Amenities in Urban India: Issues concerning Empowerment of Local Bodies"*, Economic and Political Weekly, Vol. 34, No. 2, pp. 1903-1906 .
9. Kundu, (2001), '*Institutional Innovations for Urban Infrastructural Development: The Indian Scenari'o*; Development in Practice, Vol. 11, No. 2/3, pp. 174-189.
10. Phadke. A (2012), *"Mumbai Metropolitan Region: Impact of Recent Urban Change on the Peri-urban Areas of Mumbai"*, Urban Studies, Vol. 51(11), pp. 2466–2483.
11. Poyil and Mishra, (2015), '*Urban agglomeration impact analysis using remote sensing and GIS techniques in Malegaon city, India*.' International Journal of Sustainable Built Environment. Volume 4, pp. 126-134.
12. Sharma. R.N., (2010), *"Mega Transformation of Mumbai: Deepening Enclave Urbanism"*, Sociological Bulletin, Vol. 59, No. 1, pp. 69-91.
13. Shaw (2007), "*Basic Amenities in Urban India: Analysis at State and Town Level*", Indian Institute of Management Calcutta Working Paper Series Working Paper WPS 616.
14. Susan Raju, (2009), '*Changing Economies: Urban restructuring of the city of Mumbai in the context of changing economic conditions*.' Graduation Project Report, Faculty of Architecture; TU Delft.

Geo-spatial Technologies for Planning Smart Cities

SUBALTERN URBAN SPACES AND SUBALTERN URBANIZATION IN INDIA

Anupreet Singh TIWANA[1]

ABSTRACT

The process of urbanisation has experienced considerable changes in the post-reform period in India. 'Subaltern Urbanisation' is an endeavour made by the people on their own and without the help of the elite to become part of urbanity (Mukhopadhyay, 2012). It denotes to the growth of human settlements that may or may not be classified and treated as urban by any government agency and are autonomous in their interactions with other local and global urban settlements; moreover, independent of the nearby metropolis, planned city and traditionally important urban centre. Similarly, Subaltern Urbanisation engulfs the census towns as well as unacknowledged spaces also (Denis et al, 2012). This concept primarily undertakes the theorization of the subaltern spaces vis-a-vis the ordinary population of such spaces. The concept of 'subaltern urbanisation' stimulates the researchers to think beyond the existing epistemological and methodological compartments of their disciplines (Schindler, 2014). There is dire need to analyse this recent concept about its origin, relevance and frequency of usage in research on urban studies. The historical lineage of the concept is deep rooted in the Marxist literature on Gramsci and his ideas of hegemony and subalternity. But the concept is silent on questions like material articulation of what Michael Mann calls (1984) 'infrastructural power' of the state and more specifically urbanization and city spaces.

Revolving around modernisation thesis of development and urbanisation, the dominant discourses on urban development in India has endorsed with a thrust towards building huge infrastructure in metropolitans, state capitals, industrial centres, along national highways and places enjoying political patronage. The small and non-metropolitan urban centres have grown without any properly laid down policy either at centre or at the state level (Banerjee-Guha, 2013). The present paper is divided into three parts-: emerging patterns and trends of urbanisation in the context of subaltern spaces along with the contemporary urban theory; critical appraisal of literature on subaltern urbanisation; and observations from small urban agglomerations and census towns. Subaltern Urbanisation is clearly different from Subaltern Urbanism, Peri-Urbanisation, Suburbanisation, Postcolonial Urbanisation, Exclusionary urbanisation and Rurbanisation. The paper will highlight relations and clear divides between various contemporary concepts of urbanity and subaltern urbanisation to show how these are intermingled and criss-crosses through each other.

Keyword(s): *Subaltern Urbanisation, Metropolis, Public Policy,Urbanity, Agglomerations.*

INTRODUCTION

Small cities and towns have emerged as one of the key catalytic agent of the urban scenario in both the developed and developing realm. The study of contemporary economic-political processes and their impacts are germane and relevant to Indian society which has also adopted the neoliberal paradigm of growth. No doubt, neoliberal restructuring is engendering considerable changes in the life of a common man as an individual and spatio-cultural on the society as a whole.Theories on urbanisation crisscross through space, urbanism, cities, politics, industrialisation and globalisation. Karl Marx was of the view that at the heart of urbanisation lay the motive of accumulation of capital and the transformation of non-capitalist resources of production into capitalist means (Bhattacharya and Sanyal, 2011). Similarly, Marxists view the city as being central to the reproduction of capitalism and class inequality and thus subjected the idea of urbanisation that lay at the nucleus of conventional urban studies to emphasise to observe and critically appraise for the welfare of masses. Urbanisation is not only driven by population growth and migration, but rather by the actions of social actors and agents which produces and reproduces space in urban areas (Lefebvre, 1991). David Harvey expressed these social actors, such as real estate agents, colonizers and bankers who exploit the value of urban space for capital accumulation (Harvey, 1988; 1989;2009).

There has been a paradigm shift at the international level in the political geographies of governance from a welfare outlook to a neoliberal orientation that is purely rooted in the soils of economic competitiveness and urban entrepreneurism. Whereas, contemporary capitalism is radically restructuring and cartographically presenting urban space into a new economic geography[1] of urbanisation and as a political system based on the perspective of a pseudo welfare state. The neo-laissez-

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faire and economic doctrines do not view welfare state to be extenuating and mitigating the conflicts of a market society. Under capitalism, urban processes are framed by the intersecting concrete abstractions of money, space and time and shaped directly by circulation of capital in time and space (Harvey, 1989). The scholars working in the field of urban studies documented in their research studies that the process of urbanisation has become exclusionary, deinstitutionalized and marginalized in nature (Kundu, 2003; Bayat, 2000; Roy, 2011). Cities have become 'workshops for the production of relative surplus value (Harvey, 1985). The study of capital formation in urban space cannot be attempted from one disciplinary gaze rather it requires comparative perspective for urban studies. Hence, there is rapidly growing interest among social scientists to critically discuss, debate, and deliberate on urban discourses through an interdisciplinary approach.

The present paper is broadly divided into three parts:

- emerging patterns and trends of urbanisation in the context of subaltern spaces along with the contemporary urban theory;
- critical appraisal of literature on subaltern urbanisation
- present scenario of small urban agglomerations and census towns.

The present paper is also highlighting relations and clear divides between various contemporary concepts of urbanity and subaltern urbanisation to show how these are intermingled and criss-crosses through each other.

'Subaltern Urbanisation' is an endeavour made by the people on their own and without the help of the elite to become part of urbanity (Mukhopadhyay, 2012).Subaltern urbanisation refers to the growth of human settlements that may or may not be classified and treated as urban by any government agency and are autonomous in their interactions with other local and global urban settlements, moreover, independent of the nearby metropolis, planned city and traditionally important urban centre (Denis et al, 2012). Such urbanisation is often regulated by the historical and economic-geographical forces.It is worth mentioning here that though the concept of subaltern urbanisation is very much near to autonomy yet the role of state and corporate sectors directly or indirectly important. Subaltern Urbanisation engulfs the census towns as well as unacknowledged spaces also.Partha Mukhopadhyay (2012) correlated urbanisation with the process of migration and summarized the concept in the form of a slogan: *'Movement of People - Transformation of Place'*. The most important process that has been active in urban India over the past decade is an increase in the number of census towns. These are the towns that are not recognised as urban areas in a statutory sense but fulfil the criteria laid down by the census (Swain, 2013).Hence, it has become a herculean task for the planners and policy experts.

Urbanisation in India has started altering with new urban growth coming up in areas away from metropolitan dominance and this emerging trend can be scrutinized under heads such as 'Urban Territories, Rural Governance' and more relevantly and broadly as subaltern urbanisation (Samanta, 2013).Interestingly, the concept of 'subaltern urbanisation' stimulates the researchers to think beyond the existing epistemological and methodological compartments of their disciplines and this recent concept also acts as a conduit for existing knowledge to flow from global south to global north and vice versa (Schindler, 2014). This concept is quite helpful because it draws attention to the doldrums situation and complexities of multi-dimensional space that is hard to decipher to contemporary urban theory especially in developing countries like India.On the other hand, there is dire need to analyse this recent concept about its origin, relevance and frequency of usage in research on urban studies.

The historical lineage of the concept is deep rooted in the Marxist literature on Gramsci and his ideas of hegemony and subalternity. Antonio Gramsci coined the term subaltern in his Prison Notebooks (1973), but he never clearly defined the term himself (Hoare and Smith, 1999). Gramsci broadly referred the oppressed as subaltern and that may be an individual or group of inferior rank and station due to race, class, caste, gender, religion or ethnicity. However, in Gramsci's literature, the term 'subaltern' has never been detached from the perspective of a struggle for social transformation (Gohain, 2012).The Subaltern Studies Group[6] arose in the eighties under the influence of scholarly writings of Ranajit Guha. Interestingly, subaltern has been used in post-colonial studies in different ways even by the SSG scholars. In the words of Cherniavsky "subalternity is inevitably, a terrain of representational manoeuvre in the production of elite knowledge. It advocates for a form of global South discovery that would recognize as an effect of the neoliberal globalization in which it seems to intervene, the irreducible limits on thinking the South from within the institutions of the North and the discursive practices they sustain" Cherniavsky (2007). But the concept is silent on questions like the material articulation of what Michael Mann calls 'infrastructure power' of the state and more specifically urbanisation and city spaces.

Michael Mann is of the views that there are two meanings of State Power; firstly, 'despotic power' that refers to the state elite (the actions taken without considering the civil society groups) and secondly, 'infrastructural power' through which the state actually penetrates civil society to implement logistically political decisions. He further elaborates that states in the capitalist democracies are 'despotically weak' but 'infrastructurally strong' as power infrastructure leaped with the Industrial Revolution. Therefore, Industrial capitalism destroyed 'territorially federal' societies replacing them with nation states. Autonomous state power is the product of the usefulness of enhanced territorial-centralization to social life in general. Hence, greater the infrastructural power, the greater is the territorializing of social life (Mann,1984).Similarly, David Harvey is also of the views that the reproduction of capital requires a wide range of 'physical infrastructure' and 'social infrastructure' and these two hang together as a spatially specific resource complex of culturally created assets to support both production and reproduction (Harvey, 1989). Where states are strong, societies are relatively territorialized and centralized (Mann, 1984).

Subaltern Urbanisation primarily undertakes the theorization of the subaltern spaces vis-a-vis the ordinary population of such so called urban spaces. Oppressive spaces can also create potential geographies of resistance, enablement and spatial justice and it is need of the hour to recognise and study subaltern spaces of hope hinges on the development of spatial consciousness as a motivating force for seeking spatial justice (Soja, 2010). Historically, while studying the subalternism in the context of Indian urbanisation, the researchers mainly followed the path of the epistemology of Western social sciences, therefore, several studies focused on the textuality of post colonialism and culture-class-caste differences are available but on the other hand, literature on complexity of urban system that is indifferent to the oppressed is buried under the development discourses (Teltumbde, 2008).Subaltern urbanisation is an endeavour to seek spatial justice by exploring 'how people resist to hegemony and dominance in urban areas. 'It opens the avenues to theorise about the urbanisation resulting due to the historical geography of space and class struggle and capital accumulation in the neo-liberal regime.

Emerging Patterns and Trends of Urbanisation and Public Policy in the Context of Subaltern Spaces

Geographically speaking, the mean latitude of the global urban populace has been steadily shifting towards the south. In India, there is an unexpected increase in urban population in the recent years. According to 2011 Census 31.16 percent of the total population of India resides in 7,935 towns/cities. The level of urbanisation increased from 27.81 percent in 2001 to 31.16 percent in 2011. The number of towns has significantly increased from 5,161 in 2001 to 7,935 in 2011. On the other hand, during the same decade, the proportion of rural population declined from 72.19 per cent to 68.84 per cent. During the decades of the fifties and sixties, India experienced speedy growth in the number of urban residents. But the Indian population exhibited a slowing down of the rate of urbanisation and urban growth in the past decades of 1981-1991 and 1991-2001. But there has been again an urban turn in the present years (Das, 2013). Interestingly, Bhagat (2011) highlighted an important fact that natural increase in urban growth has declined in terms of proportions but its share in absolute numbers (more than 40 million) continues to be huge due to a large base of urban population. Whereas, Kundu noticed the phenomenal increase of 2,552 new census towns which is greater than the number of such new towns identified in all of the twentieth century (Kundu, 2011).

Urbanisation can be defined as a process of change and its consequences when a society is transformed from an agrarian economy to an industrial one and from a small homogeneous society to a larger heterogeneous mass resulted in a change in the pattern of population distribution (Chandna, 1992; Hauser & Duncan, 1954). Urbanisation cannot be measured only through demographic attributes but is also directly connected to economic development, migration, employment, infrastructure development, cultural institutions and society. Likewise, the process of urbanisation also created severe problems of congestion, crime, housing, education, pollution, lack of civic amenities and public services and unemployment (Patel & Deb, 2011; Button, 1976; Mohanty, 1993). The comprehensive view of urbanisation process links the search for 'right to the city.' Lefebvre, an urban spatial theorist and philosopher, developed this idea (Harvey, 2009). Ashish Bose, the doyen of urban studies in Indian subcontinent rightly said 'God made the city in heaven, while the devil made the town' (Bose, 1973).

Working Groups and Committees were set up by the Planning Commission and Ministry of Urban Development to suggest measures for improving civic amenities and infrastructure, to overcome the inequalities and to provide work opportunities to people in their own place of residence. The post-reform period continued with two inherited policy directions with regard to small cities and towns i.e. the recommendations of the National Commission of Urbanisation, 1988 and the scheme of IDSMT (Integrated Development of Small and Medium Towns). IDSMT was discontinued after the year 2005. The Central government scrapped the Urban Land

(Ceiling and Regulations) Act, 1974 as a Central Act. Likewise, most of the states have replaced the Act after the economic reforms of 1991. The 73rd and 74th Constitution Amendment Acts aiming to empower rural and urban local bodies were passed by the Parliament in1992.After the long wait of more than twelve years after the advent of economic reforms, the government launched 'urban reforms' aimed at increasing the efficiency of urban local bodies, to create infrastructure and for improvement of civic amenities. The first initiative by the government came in the year 2003 in the form of Urban Reforms Incentive Fund. Since the year 2005, JNNURM (Jawaharlal Nehru Urban Renewal Mission) has been proved as a milestone through which the government provided 5,00,000 million rupees for the over hauling of urban system in the form of infrastructure development and improvement in the effective functioning of urban governance.

Cities and towns that are not among the selected 65 are covered by two other schemes under the umbrella of JNNURM. The first is UIDSSMT[3] (Urban Infrastructure Development Scheme for Small and Medium Towns) and the second one is IHSDP[4] (Integrated Housing and Slum Development Programme). The total financial allocation for both the programmes was 1,08,500 million. Sivaramakrishnan opined that the better-off states (more urbanised and developed) are taking the major chunk during the process of fund allocation due to biased approval of projects and as a consequence, inter-state imbalances are on the rising trend (Sivaramakrishnan, 2011). That is why the large and more urbanised states have benefitted enough. However, Shaw (2011) is of the view that the approach of the government is scheme oriented rather than an outcome of well thought out policy. The government has taken a backward step by removing the holistic focus of IDSMT by replacing it with the narrow focus of UIDSSMT, as more number of towns are being covered for a shorter period of time. Once a particular amenity such as sewerage treatment plant has been installed, its future is uncertain and depends on the economic dynamism of that particular town. No doubt, the programme is somehow promoting 'Ad-hocism' in urban planning. Likely, not even a single small town got its place in the tallies of 329 National Priority Cities and State Priority Cities. High Power Expert Committee (2011) on 'Urban Infrastructure and Services' also highlighted that small towns have languished for want of an economic base.

Revolving around modernisation thesis of development and urbanisation, the dominant discourses on urban development in India has endorsed with thrust towards building huge infrastructure in metropolitans, state capitals, industrial centres, along national highways and places enjoying political patronage. The small and non-metropolitan urban centres have grown without any properly laid down policy either at centre or at the state level (Banerjee-Guha, 2013). The scholars of both the schools of Western and Indian thought unanimously argued that acute opaqueness characterises the Indian planning process. As a result of such planning process, cities are becoming hyper-active sites of 'creative destruction' to dismantle the old at the command of capitalism and to give birth to the new (Banerjee-Guha, 2010).Today, Indian Welfare State too is caught in the debate of growth or development first. Though the Constitution of India guarantees equality to all citizens, and a socialist framework, the idea of 'Growth First' is being promoted as the schema of Indian Welfare State in the Globalised free market economy. Observations put forward by the existing urban literature highlight that the public policies are clearly oriented towards metropolitan areas. Presently, the corporate funded research is re-orienting the public policy debate towards the need of developing high-tech 'smart cities'. Surely, the urban poor will constitute a significant percentage of upcoming smart city's population. But the blue prints of the utopian concept of smart cities and research studies so far focused on Lavasa[1] revealed the fact that the smart cities have not created space for subalterns at all (Trivedi, 2014).

The recent research studies on subaltern urbanisation explore the relationship between the relevance of public-private partnership in the field of urban infrastructure and contemporary politics of minimizing the role of the state in the era of over privatisation. One of the main objectives of subaltern urbanisation research is to challenge the usual approach that tends to regard the urban globe only through the prism of big cities, even though nearly half of the urban dwellers do not reside there. Cities are not investment destinations, they are places to live in and they must provide equal access to all (Gopal, 2014).The Urban theory is heavily subjective and prejudiced towards large cities, offering almost insignificant description about the life of small towns (Gill, 2013). The large city focus of neo-liberal urban policy, the insufficient funding and programmes to develop small cities and towns led to a widespread opinion that smaller urban settlements are officially neglected and disadvantaged areas.

EMERGENCE OF RESEARCH ON SUBALTERN URBANISATION

The pioneering research work on this concept was initiated by the team of a research programme SUBURBIN[5] under the guidance of Marie-Hélène Zérah, Partha Mukhopadhyay and Eric Denis. It seeks to counter a mental map of urbanisation as reduced to a process of agglomeration and a competition between global cities. The project team comprised of scholars from diverse disciplinary backgrounds and institutions collaborated to work on the hypotheses that there exists a diversity of trajectories of urbanisation, which it seeks to understand with a focus on India's small towns and unacknowledged cities or 'grey spaces'. However, present day urban research is highly inclined and focused towards megalopolises and global cities which are religiously considered as 'growth engines' and are highly regarded as the privileged locations for the production and agglomeration of national wealth, innovative human resource, podiums for political activism, the axis of social movements and eco-developmental problems.

Subaltern Urbanisation is clearly different from Subaltern Urbanism, Peri-Urbanisation, Suburbanisation, Postcolonial Urbanisation, Exclusionary Urbanisation and Rurbanisation. Brief introductory words about the above mentioned are of paramount importance in order to differentiate, to realize the complexity of the processes of urbanisation and to understand the logic to discuss the subaltern urbanisation, as Macionis and Parrillo also wrote that "The City may well be the most complex of all human creations" (Macionis and Parrillo, 2011) .

Ananya Roy in her article "Slumdog Cities: Rethinking Subaltern Urbanism" undertakes the theorization of the mega city and its subaltern classes and spaces (Roy, 2011).Much of the concern revolves around questions of survival of the poor in an urban environment, social differences, emerging forms of sociality and much emphasis is directly on slums. Though there is a similarity of approach in studying the urban population which may be ignored by policy experts and elite class yet subaltern urbanisation do not interrogate their subalternity.

'Peri-Urbanisation' describes to such processes of urban growth that generate spaces of fragmented urban and rural characteristics. It can be described as the landscape interface between city and village. The peri-urban is where the urban structure transits into the rural landscape. These urban transitions take place in a new kind of area located outside the urban core and characterize the chaotic urbanisation leading to sprawl in most of the developing world (Ravetz et al., 2013). These peripheries are mostly dependent on the core city for their economic needs, whereas, the scrutiny of peri-urban through the lens of subaltern urbanisation does not satisfy the condition of autonomy.

'Suburbanisation' is the outward urban growth on fringes of cities. Indeed, suburbs are common landscapes in the United States and Canada which are the outlying areas of a city and are well connected to the city centre. Suburbanisation is not only limited to housing, as industries have also suburbanised in the continent of North America and in the post-communist cities of Europe. David Harvey is of the opinion that suburbanisation is 'space covering' style of urban expansion in post-war capitalist countries (Harvey, 1989). Suburbanisation has many philosophical commonalities with subaltern urbanisation, even then the main difference is that subaltern urbanisation looks at locations beyond the suburbs (Denis et al., 2012).

'Postcolonial Urbanisation' refers to patterns of urbanisation among the former colonial societies. It studies the spatial organisation, economy, society, culture, hegemonic control and architecture of the urban centres developed during the phase of colonialism and post-colonialism. It is not justified to study urbanisation of postcolonial spaces without considering the subordination and intrusive political organisation of space (Soja, 2010). The terms *'imperialism'* and *'colonialism'* are often used interchangeably. Imperialism refers to the imposition of power by one state over another (King, 2009). The literature on postcolonial urbanisation comes mainly from Africa and from countries of CIS of former USSR and it is in the form of case studies and sort of historical account. Subaltern urbanisation differs on the point that it deals simultaneously with history, present and future also.

'Exclusionary Urbanisation' directly deals with the spatial-economic dimension of poverty. The pioneer of this concept, Prof. Amitabh Kundu highlighted that poor population is relegated to the degenerated peripheries of urban spaces (Kundu, 2011). This process of exclusion is much stronger in metropolitans where bourgeois provide world class infrastructure to attract middle class to invest in commercial and residential property resulting in the exclusion of the poor from the basic needs required in an urban environment (Kundu, 2012). Another major feature of the exclusionary urbanisation is the elite predominance in a city.This concept differs from the subaltern notion as exclusion is mainly in economic aspect and planning process, while subaltern urbanisation is comprehensive in its nature and scope.

'Rurbanisation' proposes to develop such villages which have a rural soul but an urban feel because of the availability of urban amenities and services for the residents. It also being seen as a tool to invoke reverse trends of migration from urban to rural and thus easing the pressure on over-crowded and polluted urban agglomerations. Further, it is generally assumed that the revival of rurban economies induces the people to return and start

economic activities and capital investment at the places of their origin (GOG, 2013).Rurbanisation is based on the assumptions that this process will reduce and remove the rural-urban divide and revolves around the creation of 'global villages'. This concept has similarities with the subaltern urbanisation because both the concepts are not exploitive rather regenerative and revitalizing positive solutions towards sustainable urban development. Nonetheless, rurbanisation is to think the question through urban design but lacks in addressing the questions of economic and social transformation and as well as with the governance of such global villages (Denis et al., 2012).

There are relations and clear divides between various contemporary concepts and subaltern urbanisation. Moreover, these are intermingled and criss-crosses through each other.

Present Scenario of Small Urban Agglomerations and Census Towns

For balanced urban development that may be able to absorb a near doubling of urban population by 2030, it is a paramount requirement to have a broader view of thousands of small cities and towns (more so the bazaar towns) especially their 'urbanity' and their age old contributions to vast agrarian societies of India. Census data clearly indicates that population in large cities is growing speedily but the small cities and towns are losing their population. Urban areas of less than one lakh population accounted for 55.37 percent of the total urban population in the year 1951. Further, this has fallen to 31.38 percent in 2001. Whereas, towns with a population of less than 20,000 had accounted for 29.69 percent of the total urban population in 1951, contained only 9.36 percent of the total urban population in 2001 (Shaw, 2013). The 2011 census exhibits an increase of2,774 new census towns or non-statutory towns and these accounts for 49 per cent of total urban settlements in India, upward trend from 36 per cent in the census of 2001. Several Marxist scholars are of the view that urbanisation is the natural outcome of the development of the productive forces as well as the launching pad for the future development also. This 'Tsunami' of census towns indicates a bottom-up dynamism which was pathetic in the postcolonial urbanisation of India; pointing towards a number of avenues for economic development.

CONCLUSION

Subaltern urbanisation is a contribution made by the people and for the people. The process of urbanisation has experienced considerable changes in the post-reform period in India. Edward W. Soja (2010) visualises the urban areas as the wellspring for thinking about democracy, equality, liberty, human rights, social and spatial justice. The concept of subaltern urbanisation advocates for the expanding universe of 'small towns and large villages' which are unknown, badly documented, supposed to be economically unhealthy, and totally ignored. It is a step towards the attainment of the 'Humanitarian Right to Enjoy the City' and surely counters the claims of hegemonic narratives of space and identity. Right to the city is much more than the access to the resources for the urban population. According to David Harvey, it is also the right to change the city to the needs and desires of the larger section of the society (Banerjee-Guha, 2010). It puts a question mark on the divided reality of 'right to city' in urbanised India. It is the need of the hour to consider small cities and towns in public policy. Dialogue of a TV advertisement for a two wheeler company is worth mentioning here. "The same road that leads from the small town to the big city also leads from big city to the small town." This dialogue is indicating the importance of both large and small cities for the comprehensive development of India. Subaltern urbanisation refers to such pattern of transformation of rural population to urban that is economically self-sustained, autonomous, widespread, extensive and spatially viable.

Notes

1. *New Economic Geography:* it provides an integral and micro-founded approach to spatial economics. It emphasis the role of agglomeration forces in generating and uneven spatial distribution of economic activities and capital. This approach has been applied in urban economics, to understand regional differences and resulting global inequalities. NEG (New Economic Geography) propounded by Venables (2005) an approach dealing with questions like: why are economic activities distributed unevenly across space? and How does the spatial organisation of economic activity respond to changing policy scenario?
2. *Subaltern Studies Group:* the subaltern studies group or Subaltern Studies Collective is a group of South Asian scholars with their anti-essentialist approach are interested in postcolonial societies. The pioneer scholars especially Ranajit Guha and Eric Strokes formulated a new narrative of the history of South Asia and India in particular. Subaltern is

the social group who are socially, politically and geographically outside the hegemonic power. The associated scholars, who mainly interpreted the subaltern and subalternity in the context of the present paper are Stokes Eric; Chakrabarty, Dipesh; Arnold, David; Chatterjee, Partha; Pandey, Gyanendra; Said, Edward; Spivak and Gayatri Chakravorty. Some scholars are of the view that the concept of subaltern is problematic because it remained a European model of historical enquiry and that is why it is irrelevant to study Indian society.

3. *UIDSSMT:* Urban Infrastructure Development Scheme for Small and Medium Towns provide Central assistance for components such as urban renewal, water supply, sanitation, solid waste management, roads, parking spaces, drainage, and heritage sites. This scheme also provides funds for disaster mitigation for soil erosion and landslides.

4. *IHSDP:* Integrated Housing and Slum Development Programme is to strive for holistic slum development with a liveable urban environment by providing adequate shelter and basic infrastructure facilities to the slum dwellers of the identified urban areas. The scheme seeks to enhance public and private investments in housing and infrastructural development in urban areas.

5. *SUBURBIN:* it is a collaborative project with researchers at the Centre for Policy Research, Centre de Sciences Humaines, Centre for the Study of Regional Development (JNU), the InstitutFrancais de Pondichery, the University of Burdwan, the Department of Regional Planning (SAP) and the Indira Gandhi Institute of Development Research. The project is mainly funded by French National Research Agency. SUBURBIN focuses on a vision of global urbanisation reduced to metropolitan station and competition between global cities. The project discusses the need of change in perspectives on urban transition by focusing on small towns from multiplicity of disciplines, linking macro and micro analysis, survey and secondary data.

REFERENCES

1. Banerjee-Guha, Swapna (2010): “Introduction: Transformative Cities in the New Global Order”, *Accumulation by Dispossession: Transformative Cities in the New Global Order,* Sage Publications, Los Angles, pp.1-16.
2. Banerjee-Guha, Swapna (2013): “Small Cities and Towns in Contemporary Urban Theory and Policy”, Small *Cities and Towns in Global Era: Emerging Changes and Perspectives*, edited by Sharma, R. N. &Sandhu, R. S., Rawat Publications, Jaipur, pp. 17-35.
3. Bayat, Asef (2000): “From ‘Dangerous Classes to ‘Quiet Rebels’: Politics of Urban Subaltern in the Global South”, *International Sociology,* downloaded from: http://iss.sagepub.com/contents/15/3/533 accessed on July 30, 2014.
4. Bhagat, R B (2011): “Emerging Patterns of Urbanisation in India”, *Economic and Political Weekly,* August 20, vol. XLVI No 34, Mumbai, pp. 10-12.
5. Bhattacharya, Rajesh and Sanyal, Kalyan (2011): “Bypassing the Squalor: New Towns, Immaterial Labour and Exclusion in Post-colonial Urbanisation”, *Economic and Political Weekly,* Mumbai, July 30, Vol XLVI NO 31.
6. Bose, Ashish (1973): “Studies on India’s Urbanisation, 1901-1971", *Tata-McGraw Hill,* New Delhi.
7. Button, K. J. (1976): “Urban Economics: Theory and Policy”, The Macmillan Press Ltd., London, pp. 13-29.
8. Chandna, R.C. (1992): “A Geography of Population”, 2nd edition, Kalyani Publishers, New Delhi, pp. 132-252.
9. Cherniavsky, Eva (2007): “The Romance of the Subaltern in the Twilight of Citizenship”, *The Global South,* Vol. 1 (Winter), Indiana University Press, pp. 75-83.
10. Das, Kailash C. (2013): “The Growing Number and Size of Towns/Cities in India: Emerging Issues from 2011 Census Data”, Downloaded from www.iussp.org/—/urban%transition %20India_iussp%202013.pdf, accessed on August 3, 2013.
11. Denis, Eric; Mukhopadhyay, Partha and Marie-Hélène Zérah (2012): “Subaltern Urbanisation in India”, *Economic and Political Weekly,* July 28, vol. XLVII No. 30, Mumbai, 52-62.
12. Gill, Rajesh (2013): “The Academic Bias against Towns: A Cultural Audit”, *Small Cities and Towns in Global Era: Emerging Changes and Perspectives*, edited by Sharma, R. N. &Sandhu, R. S., Rawat Publications, Jaipur, pp. 84-97.
13. Gohain, Hiren (2012): “Subaltern Studies: Turning around the Perspective”, *Economic and Political Weekly,* September 29, Mumbai, pp. 74-76.
14. Gopal, P Venu (2014): “Image of a City”, *Economic*

& Political Weekly, July 19, vol. XLIX NO 29, Mumbai, pp. 8-9.

15. Government of Gujarat (2013): "Rurbanisation: A Transformative Process to Foster Sustainable, Equitable and Inclusive Growth", downloaded from: http://www.vibrantgujarat.com/Portal/Event_Images/Attachment/79/3_1_Panel-Discussion-Rurbanization.pdf, accessed on September 22, 2014.
16. Harvey, David (1989): "The Urbanization of Capitalism", *The Urban Experience,* The John Hopkins University Press, Baltimore, pp. 17-58.
17. Harvey, David (2009): "Social Justice and the City (Geographies of Justice and Social Transformation)", Oxford, UK (revised in 2009).
18. Hauser, Philip M and Duncan, Otis Dudley (1954): "The Study of Population: An Inventory and Appraisal", The University of Chicago Press, pp. 32-36.
19. High Power Expert Committee (2011): "Report on Indian Urban Infrastructure and Services", *National Institute of Urban Affairs,* New Delhi.
20. Hoare, Quention and Smith, Geoffrey Nowell: "Selections from the Prison Notebooks of Antonio Gramsci", *ElecBook,* London, Transcribed from the edition published by Lawrence and Wishart, downloaded from: http://www.walkingbutterfly.com/wp-content/uploads/2010/12/gramsci-prison-notebooks-vol1.pdf, accessed on July 20, 2014.
21. Jessop, Bob (1997): "A neo-Gramscian approach to the regulation of urban regimes", in Lauria, M (ed.), *Reconstructing Urban Theory, Sage, London, pp. 51-73.*
22. King, A. D. (2009): "Postcolonial Cities" downloaded from: http://booksite.elsevier.com/brochures/hugy/SampleContent/Postcolonial-Cities.pdf, accessed on September 19, 2014.
23. Kundu, Amitabh (2003): "Urbanisation and Urban Governance: Search for a Perspective Beyond Neo-Liberalism", *Economic and Political Weekly*, July 19, Mumbai, pp. 3079-3087.
24. Kundu, Amitabh (2011): "Methods in Madness: Urban Data from 2011 Census", *Economic & Political Weekly,* October 1, VOL XLVI NO 40, Mumbai, pp. 13-16.
25. Kundu, Amitabh (2012): "Migration and Exclusionary Urbanisation in India", *Economic & Political Weekly,* June 30, VOL XLVII NOS 26 & 27, Mumbai, pp. 219-227.
26. Lefebvre, Henri (1991): "The Production of Space", Translated by Donald Nicholson-Smith, Blackwell, Oxford.
27. Macionis, John J. and Parrillo, Vincent N. (2011): "Cities And Urban Life", *PHI Learning Private Limited,* New Delhi.
28. Mann, Michael (1984): "The Autonomous Power of the State: Its Origin, Mechanism and Results". *Archives Europeans de Sociologie,* vol. 25, pp. 185-213.
29. Mohanty, L. N. P (1993): "Problems of Basic Amenities in Urban Areas and Community Participation: New Dimensions- A Case Study of Bhubaneswar", *Urbanisation in Developing Countries*, edited by Mohanty, Bidyut, Institute of Social Sciences &Cocept Publishing Company, New Delhi, pp. 345-360.
30. Mukhopadhyay, Partha (2012): "Subaltern Urbanization in India?" Presentation presented at India China Institute on September 12, 2012, downloaded from http://indiachinainstitute.org/wp-content/uploads/2012/10/ICI-presentation-Partha-Mukhopadhyay-Sep-12-2012.pdf accessed on July 11, 2014.
31. Patel, Sujata and Deb, Kushal (2011): "Urban Studies", *Oxford in India Readings in Sociology and Social Anthropology*, Oxford University Press, New Delhi, pp. 20-81.
32. Ravetz, Joe; Fertner, Christian and Nielsen, Thomas Sick (2013): "The Dynamics of Per-Urbanization", *Peri-urban futures: Scenarios and models for land use change in Europe,* edited by Nilsson, K; Pauleit, S; Bell, S; Aalbers, C. And Sick Nielsen, downloaded from: http://www.spinger.com/978-3-642-30528-3, accessed on September 6, 2014.
33. Roy, Ananya (2011): "Slumdog Cities: Rethinking Subaltern Urbanism", *International Journal of Urban and Regional Research,* Vol. 35.2, March, Oxford, pp. 223-38.
34. Samanta, Gopa (2013): "Urban Territories, rural governance", *Agenda,* Infochange News & Features, August, 2013, downloaded from: http://infochangeindia.org/urban-india/analysis/urban-territories-rural-governance.html, accessed on August 9, 2014.
35. Schindler, Seth (2013): "Understanding Urban Processes in Flint, Michigan: Approaching 'Subaltern Urbanism' Inductively", *International Journal of Urban and Regional Research,* Vol. 38.3, May 2014, Oxford, pp. 791-804.
36. Shaw, Annapurna (2013): "Emerging Perspectives on Small Cities and Towns", *Small Cities and Towns*

in Global Era: Emerging Changes and Perspectives, edited by Sharma, R. N. &Sandhu, R. S., Rawat Publications, Jaipur, pp. 36-53.

37. Sivaramakrishnan, K. C. (2011): "Re-visioning Indian Cities: The Urban Renewal Mission", *Sage Publications,* New Delhi.

38. Soja, Edward W. (2010): "On the Production of Unjust Geographies", *Seeking Spatial Justice,* University of Minnesota Press, Minneapolis, pp. 31-66.

39. Swain, Biraj (2013): "Small Towns, their Limited Resourcing Options and Equity Deficits", *Small Cities and Towns in Global Era: Emerging Changes and Perspectives*, edited by Sharma, R. N. & Sandhu, R. S., Rawat Publications, Jaipur, pp.98-101.

40. Teltumbde, Anand (2008): "Subalternismvs Dalitism", *Economic and Political Weekly,* December 27, 2008, Mumbai, pp. 22-24.

41. Trivedi, Divya (2014): "Not so smart idea", *Frontline,* downloaded from: http://www.frontline.in/the-nation/not-so-smart-idea/article6275328.ece, accessed on August 26, The Hindu, Chennai.

42. Venables, Anthony J (2005): "New Economic Geography", written for Durlauf, Steven N and Lawrence E (ed.) *The New Palgrave Dictionary of Economics,* Palgrave: Macmillian.

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CONCEPTUAL MODEL FOR DEVELOPMENT OF URBAN GREEN SPACE IN PROPOSED SMART CITY BHUBANESWAR, ODISHA, INDIA

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ABSTRACT

Urban green spaces play an important role in the urban ecosystem and provide diverse environmental and social services to improve the quality of life in cities. In this study, based on the high resolution remote sensing images and other auxiliary data, we conducted a suitability analysis for green space planning in Bhubaneswar city.

The study identifies the availability of urban green spaces, changes in green spaces, and suitability analysis for green space development. In the methodology, attention was given to the urban planning such as location, physical characteristics and secondly it needs to propose the desirable environmental quality from two aspects,i.e., existing situation and greening indices. After the stakeholder analysis for suitability, five suitability factors were selected to carry out the GIS-based suitability analysis by taking advantage of the method of weighted score. As such, five suitability scenarios will come out according to different sets of scores and certainty factors. Here, it uses statistical integration to calculate the weights for 'suitability scenario. The suitability scenario is based on the improved traditional suitability analysis model.(Yang Manlun, 2003).

The analysis result revealed that highly suitability class with an area of 6415 ha. (26%) of the total area and moderately suitable area of 2683 ha (10%) of the total area has the potential for development of Plantation, considering the environmental condition of the city. For the low suitability area (35%), attention should be given to arbour coverage rate.

***Keywords**: Land use, Green Space, Environmental Quality, Suitability*

INTRODUCTION

Urban green spaces play a vital role in improving the quality of urban community's life and contribute to public health as well as the urban environment of the city. Green space is an important part of complex urban ecosystems that give environmental, esthetic, recreational and economic benefits to the urban dwellers (Li et al., 2005). Meanwhile, urban green spaces can be defined in many ways depending on their demands and specific requirements. According to Jim and Chen (2003), urban green spaces can be defined as outdoor places with varied vegetation species and existing mainly as a semi-natural area which is accessible for public. Urban green space connectivity offers habitats and corridors which mainly led to the contribution of nature conservation. However, the urbanization has increasingly threatened biodiversity and consequently loss and isolation of habitats (Kong et al., 2010). Since the early 1960s, numerous planning models have been developed using information and application of GIS. The integration of Remote sensing and GIS application in monitoring and managing land uses has been widely used in India. Thus, methods of modelling urban green space and its planning have broadly changed from time to time and GIS application has taken a good place in the development of a model for green space identification.

The identification of suitable land for urban green space is one of the critical issues of planning.The suitability of the land for green space is not only based on a set of physical parameters but also very much on the economic factors. The cumulative effect of these factors determines the degree of suitability and also helps in further categorizing of the land into different orders of development. The assessment of the physical parameters of the land is possible by analysing the land use, terrain parameters, ground water prospects, physiography, distance from the waterbodies. The assessment of physical parameters gives an indication to the limitation of the land for urban green space development.

In response to the study, a literature review was selected based on keywords of urban green space planning, urban planning,and modelling system through landscape metrics, GISapplication, remote sensing, Suitability model. Initially, the study on modelling urban green space can be seen as a new paradigm and have yet to be implemented in urban planning and development in Bhubaneswar. Given this,current methodologies were reviewed to assess changes in landscape and associated approach that suit to the related study of modelling urban green

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space. Besides, greater emphasis was placed on literature that addressed research concern and trend in modelling green space planning in the urban area.The aspects taken into consideration in this study were based on the most effective modelling approach that benefits the identification of urban green space.

STUDY AREA

The capital city of Odisha- Bhubaneswar, is located between $20^{0}12'$N and $20^{0}25'$N latitudes and $85^{0}44'$E to $85^{0}55'$E longitude on the western fringe of coastal plain across the main axis of Eastern Ghats in Khurda district of Odisha. The shape of the city is almost dumble shape. The city is divided into 60 wards under the Bhubaneswar Municipal Corporation control. There are 204 more villages along the rural periphery, which are also coming under the direct sphere of influence of the city. As a result, there is tremendous pressure on resources like groundwater. Although the city lies on the western side of the Mahanadi Delta on the bank of river Kuakhai, a distributory of Mahanadi along with River Daya, branching off from Kathajodi that flows along the southeastern part of the city, 35% of water supply depends heavily on dug wells and bore wells. The basement rock of Bhubaneswar and its surrounding lies on the lateritic upland fringed by the alluvial plains to the east and small sandstone ridges to the north-west. About 65% of the land consists of laterites peneplain, 25% of alluvial and only 10% of the land is composed of sandstone ridges. Bhubaneswar lies on the western fringe of the mid-coastal plain of Odisha with an average elevation of 45m above the main sea level. It lies on the low lateritic plateau, and the erosion has made its topography a valley-and-ridge one. Fig.1. Shows the location map of Bhubaneswar City.

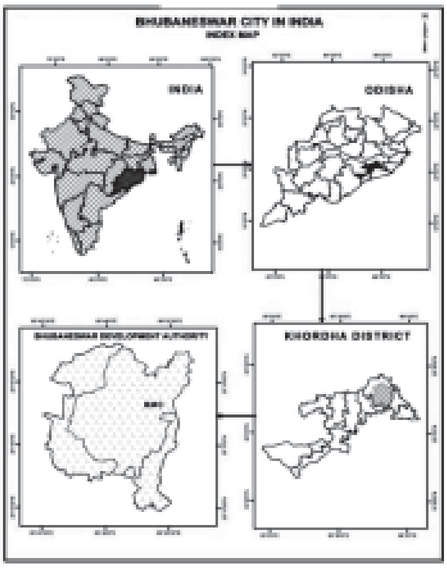

Fig. 1

RESEARCH OBJECTIVE

1. To study the current status of land use and specifically green space in the city.
2. To derive land suitability classification and assessment for identification of green space.
3. To generate suitability model for identification of green space in the city.

Existing Situation Of The Green Space Status Inside Bhubaneswar Development Area (Bda) Area

The built up area in BDA is 7223 hectare (2011)**.**The greening coverage rate in the city is 4629 hectare which is about 18% of the area (excluding agricultural Land)and Green space per capita is 52 meter square (excluding agricultural land), as devised by Remote Sensing and GIS method.

Table 1
Green Space per Population and Coverage Rate during 1974-2011

Year	*Population*	*Green space in (ha)*	*Green space per capita*	*Green space /1000 person (ha)*	*Greening coverage rate (Percentage)*
1974	145000	11589	792	79.2	46
1990	392000	8773	223	22.3	35
2011	881988	4629	52	5.2	18

By looking into the density of Green space in Bhubaneswar city, there are huge differences between green spaces proportion from the year 1974-2011. In 1974 there were green space per capita about 799 m2 which reduces to 223 m2 and 52 m2 in the year 1990 and 2011 respectively. When focussing on green space per 1000 persons, in 2011, the ratio is only 5.2 ha per 1000 persons.

The Greening coverage rate of Bhubaneswar city during 1974-2011, indicates there was a loss of 11% and 17% of green space in the two time periods, i.e., 46% in 1974 which comes down to 35% in 1990. In the year 2011, the greening coverage rate is confined to only 18% (Table 6.2). As per the standards suggested by UDPFI guidelines of ITPI, New Delhi, the greening coverage rate should be more than 30% in the city for the good environmental condition. Bhubaneswar city is far behind the standards of UDPFI/ITPI.

From the green space land, use distribution of the city indicates that the tree cover areas consist of only two percent of the total BDA area. The major permanent green spaces are Dense scrubs/ bushlands (5%) and Seasonal green spaces are grasslands (8%) and agricultural lands (21%). The Parks are only confined to 1% of the total BDA area.

Fig.2

CONCEPTUAL FRAMEWORK

In the research methodology, first, it pays attention to the factors such as location, physical characteristics and social-economic characteristics of the study area. Secondly, it needs to propose the desirable environmental quality from two aspects: existing situation and greening indices. And after the stakeholder analysis for suitability, five suitability factors including existing land use, Groundwater, Slope, land ownership, water system influence, are selected to carry out the GIS-based suitability analysis of the urban green space system, using the method of weighted score.

As such, five suitability scenarios emerge out according to different sets of scores and certainty factors. Here, it uses statistic integration to calculate the weights for 'suitability scenario. The suitability scenario is based on the improved traditional suitability analysis model (ITSAM). The methodology flow chart is presented in (Fig. 3).

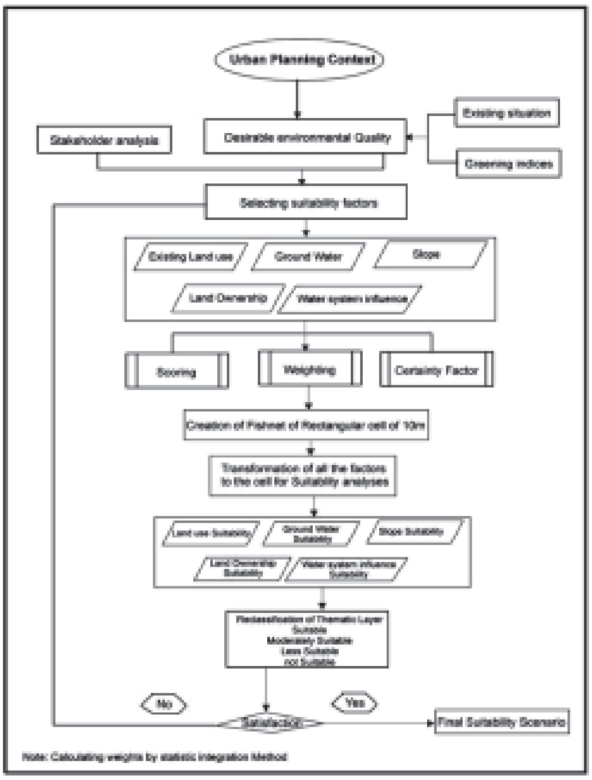

Fig. 3.

DATA COLLECTION, INTEGRATION AND METHODOLOGY

In order to develop site suitability map for urban green space development Cartosat II panchromatic stereoscopic satellite data at a resolution of 0.8 m were used. With the help of stereoscopic satellite data, a Digital Terrain Model(DTM) was created which was further used for preparing scope map. A High resolution Cartosat-II Satellite data was also used for generating land use and land cover and proximity drainage map. Groundwater prospects map was obtained from ORSAC, Bhubaneswar and Land Ownership data was obtained from BDA, Bhubaneswar. All these information layers were integrated and analysed under ArcGIS environment.

A. Scoring/Ranking of Criteria

For Suitability analysis, it is necessary to use some score to each of the criteria as per their suitability for Green space development. The certainty factor is used to improve the GIS-based traditional suitability analysis model. The factor used in the analysis are nomenocultured as Luse (existing land use), Wsystem (water system influence), Gwater (Ground Water), Slope (Slope), Ownership (Land Ownership).These data, which can get the certainty factor arranging from '0.1' to '0.9' score. For example, as to the ecological green space Dense bush/ scrub cover and Park/Garden/Zoo belong to High suitability class and get the score of '0.9'. But the cuneal ecological green space Dense bush/ scrub cover is more suitable for the green space development than the Park/ Garden/Zoo, then we can give a certainty factor of '0.9' to the cuneal ecological green space and '0.8' to the Park, in order to identify the difference between them. Thus the certainty factors for Existing Land use are coming out. The certainty factors for Grund water, Slope, Land Ownership, are determined in the same way. Wsystem is quantitative data, and its certainty factors can be determined by the distance from the Water Bodies.

B. Derivation of Weightages

Weighting in suitability analysis refers to assigning a weight to each factor in order to recognize its relative importance (Pease, Coughlin et al. 1996). Just like the scores, weights also have a major effect on the final results (composite scores). This research makes use of statistic integration methods to calculate the weights for suitability analysis.

C. Calculating Weights By Statistic Integration

The method of statistic integration is a kind of special 'expert-assess' method. Here the 'expert-assess' is based on the stakeholder analysis. Stakeholder analysis is an important element to select the suitability factors. Also, it is the foundation for calculating the weights of the suitability factors. In order to use the method of statistic integration to calculate the factors weights, twenty-four stakeholders including six urban planners, five environmentalists, ten local residents and three local government officials were invited to determine the importance order among the five suitability factors. As such, twenty-four.

Table 2
Investigating Table of Importance Order

Importance order	Existing Land use	Ground Water	Slope	Land Ownership	Water System Influence
First	√				
Second		√			
Third				√	
Forth			√		
Last					√

Table 3
Investigating Information by Statistic Integration

Factor	*First Impor-tance*	*Second Impor-tance*	*Third Impor-tance*	*Fourth Impor-tance*	*Last Impor-tance*
Existing Land use	65%	13%	5%	8%	9%
Slope	13%	8%	9%	65%	5%
Water System Influence	5%	65%	13%	9%	8%
Ground Water	8%	9%	65%	5%	13%
Land Ownership	9%	5%	8%	13%	65%

From Table 1 and Table 2, it is observed that, as to the Existing Landuse, six stakeholders acknowledged that it was the first importance for the suitability analysis of the urban green space system, namely 65% of the twenty-four stakeholders showed this opinion. Second importance with 13%, fourth importance with 8%, fifth importance with 16.7%, sixth importance also with 16.7%, last importance with 8.3%, Likewise, other factors importance has been aggregated in Table 3 in the same way. Then according to the following formula, the preliminary weights of the above five suitability factors are presented below:

$$\overline{W} = [(D*C^T)]^T = \left(\begin{pmatrix} 0.65 & 0.13 & 0.05 & 0.08 & 0.09 \\ 0.13 & 0.08 & 0.09 & 0.65 & 0.05 \\ 0.05 & 0.65 & 0.13 & 0.09 & 0.08 \\ 0.08 & 0.09 & 0.65 & 0.05 & 0.13 \\ 0.09 & 0.05 & 0.08 & 0.13 & 0.65 \end{pmatrix} \cdot \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} \right)^T$$
$$= 4.17, 2.59, 3.5, 2, 94, 1.8$$

Formula 1 Statistic integration

After the normalization, the original weighting factor, W = (4.17, 2.59, 3.5, 2, 94, 1.8), is converted into the final weighting factor, W = (.278, .172,.23,.196,.12). As such, each factor weight is showed in Table 4.

Table 4
Factors Weight by Statistic Integration

Factor	*Existing Land use*	*Slope*	*Water System Influence*	*Ground Water*	*Land Ownership*
Weight	0.278	0.172	0.23	0.196	0.12

Suitability Scenario

According to the ratio values (scores) for all suitability classes, a total of Five GIS data coverage are created, one for each of the suitability factors identified above (Map 3). These coverage based on the individual suitability values for each factor. In addition, weights for the five factors and certainty factors have been determined, so these five single factor maps can be combined into a composite suitability map by the addition of the suitability scores with a weighting system. That means we can use a GIS overlay procedure to get a suitability evaluation of all the five factors. The detailed calculation formulas are

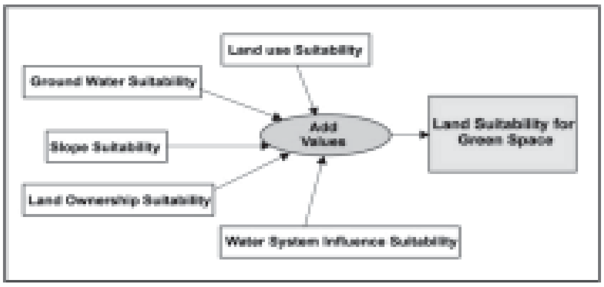

Fig: 4 Composite Suitability Model

presented below (Wa1 represents the weight calculated by statistic integration)

Final Suitability Scenario = Luse*Wa1 + Wsystem* Wa2 + Gwater*Wa3 + Slope*Wa4 + Lownership*Wa5

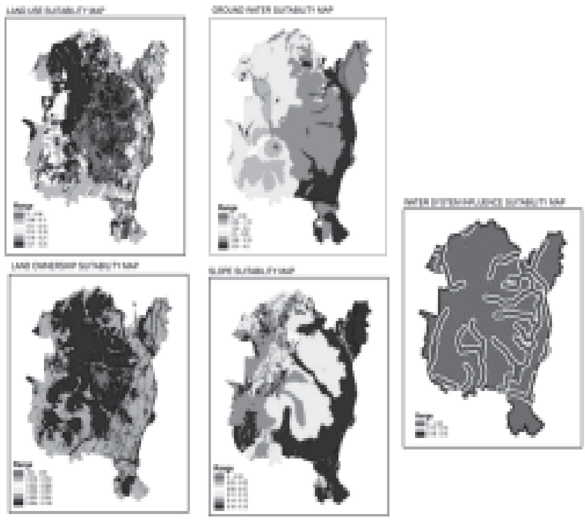

Fig 5 .

Single Factor Suitability Model

As such, the composite suitability score for each scenario can be derived based on the above formulas. Ideally, this composite suitability score ranges from '1' to '4' It is recommended the composite suitability score should be grouped in classes to help clarify the data and to make the resulting scenarios more decipherable and easier to interpret. Thus the final suitability scenario (Figure 6) can be grouped into four levels according to the following suitability intervals (Vs represents the composite suitability score), by using the histogram of the Composite Suitability Score In Arc Gis 10:

Table 5
Suitability Class Based On Histogram

Suitability	*Group*
High suitability	0.67d" Vs d" 0.87
Moderate suitability	0.57 d" Vs < 0.67
Moderate-Less suitability	0.36 d" Vs < 0.57
Less suitability	0.20 d" Vs < 0.36

RESULTS

The results from this study provided the First comprehensive and integrated land suitability assessment of all the five factors for Green space development in Bhubaneswar City. It is estimated that Bhubaneswar was mostly assessed as the less suitable class with an area of 8644 hectares or 35% of the total area (Table 5). The Land suitability map provided the most satisfactory means of conveying the result of assessment to the user in summary form (Fig.6) It is also observed that highly suitable class with an area of 6415 hectares or 26% of the total area and moderately suitable area of 2683 hectare or 10% of the total area has huge potential for green space development considering the environmental condition of the city. The highly suitable areas were mainly identified in the Northwest part of the city. The areas are Bharatpur Reserved forest area, Jagannath Prasad, and Sundarpur area, preventing the development of the area and allowing wildlife to return and be established and considered as the Green belt of the city. Furthermore the highly suitable was identified in Malipada, Nuagaon, Bidyadharpur, Pandara, Naharkantia and in the middle of the city.e., inside the Institutional, Industrial, Heritage or conservation area, Residential, Road and Railside corridor, Drainage corridor, etc.

Table 6
Land Suitability for Green Space

Suitable Zones	*The area in Hac.*	*Percentage of Total*	*Suitability Score*
Less Suitability	7015	29	1
Moderate -Less Suitability	8644	35	2
Moderate Suitable	2683	10	3
Highly Suitable	6415	26	4
Total	24757	100	

Moderately suitable areas were identified in Raghunathpur, Koradakanta, Haridaspur, Patharagadia, and Dumdum area. The central part of the study site has mainly been classified as Less suitable area with an area of 7015 hectare, which is 29% of the total area because this region is mostly under built up area and other land use where there is no scope for any green space development according to the suitability analysis.

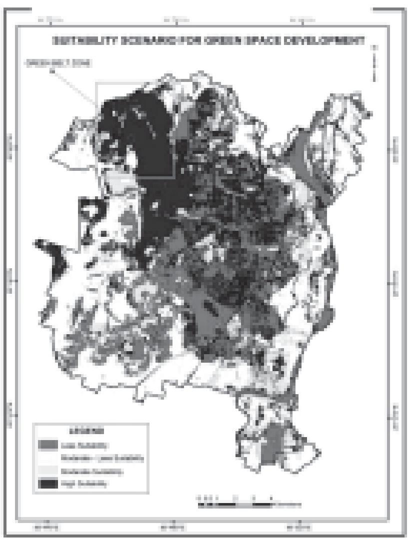

Fig: 6 Final Suitability Scenario

From the analysis of the Land suitability, it is observed that, the Bharatpur Reserve Forest area covering approximately 25 Sq Km of the area under High Suitability land and considered as the Greenbelt of the city.

CONCLUSION

Suitability analysis can be used to help direct the future growth of the green spaces and protect the other important land uses at the same time. The result of implementing the proposed approach is a map that categorizes and illustrates the different levels of green space suitability throughout the study area. As can be seen from the suitability scenario (proposed plan), large portions of the study area are found not to be suitable (less suitable) for the green space system development. This is a direct result of the growing conflict between the ecological environment and development restriction. Areas that receive high and moderate suitability levels are revealed to be the predominant areas of the existing green spaces, vacant areas, and government reserved areas. This is suitable for the future growth of the green spaces.

In order to advance the art of land suitability analysis, it is important that not only the result is replicable within a study area, but also the approach is transferable, or at least adaptable in other places. By applying the proposed approach in Bhubaneswar capital region, this research provides an example of such transferability. The suitability results of the urban green space system are mathematically achieved, so they can be applied as valid factors into the generation of other approaches to achieve alternative land use or design strategies. Reevaluation of initial conceptions or updated information also can easily regenerate land use or design strategies. The evaluation process is so explicit that alternative scenarios can be modelled without reconstructing the entire procedure. From the view of the technical level, this GIS-based suitability analysis approach is quite able to integrate ecological and social geographic data with human knowledge in an objective and manageable nature. It allows for all kinds of information from experts and general public to be used in the weighting process. From the view of the organizational level, the use of GIS technology brings people together, including the urban planners, environmentalists, local residents and local government officials. The high level of cooperation and involvement generates a broad-based approach to multi-objective suitability analysis for the green space system. From this work we are able to suggest that, the approach applied in this study area can be adapted to other urban areas of the state of Odisha.

In summary, the suitability results can provide helpful knowledge on the factors interactions and their relation to the urban environment within the study area. It can be used to help people make better, more informed decisions, thus providing a more healthy quality of life for the community and the surrounding ecological environment. Suitability analysis is a powerful tool for green space system planning. Continued development and refinement of suitability analysis, particularly with GIS technology, can enable urban planners to help local government officials and local residents to create a suitable green space system in the urban environment.

REFERENCES

1. Kumagai Kichiro (2010). Distributional Analysis of Green Tracts and Vegetation covered Areas of Kansai districts of Japan. *PhD theses*, Dept. of Civil Engineering, SetsunaUniversity, Japan
2. Leventa Tüzin Baycan, et al. (2004). Multidimensional Evaluation of Urban Green Spaces: A Comparative Study on European Cities. Paper in the 5^{th} *framework programme of European Union, Istanbul.*
3. Livengood, Avery, & Kunte Keya (2012). Enabling Participatory Planning with GIS. A case study of Settlement Mapping in Cuttack, India. *Environment & Urbanization, 24*(1), 77-97.
4. Luis A. Bojo (2001). GIS-based Approach for Participatory Decision Making and Land Suitability Assessment. *International Journal forGeographical information science.*
5. Luo Lingjun, He Zong, Hu yan (2008). Study on Land use Suitability Assessment of Urban-Rural Planning based on Remote Sensing. A case Liangping in Chongqing. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 37*(Part-II).
6. Miller, Robert, W. (1997). *Urban Forestry:* Planning and Managing Urban Greenspaces 2^{nd}Red Upper Saddle River, N. J. Prentice Hall.
7. Pathan S.K, Jothimani (1992). Urban land use suitability analysis on Kolkata metropolitan area, *Journal of the Indian Society of Remote sensing. 20*(2&3), 1992.
8. Pham Duc Uy. (2008). Application of Land Suitability Analysis and Landscape ecology to urban green space planning in Honoi, Vietnam. *Urban Forestry & Urban Greening7* (2008), 25–40.
9. Yang Manlun. (2003). Suitability analysis of Urban Green space system based on GIS. Masters in Geoinformation Science thesis submitted to the International Institute for *Geo-information Science and Earth Observation, Netherland.*
10. Zhou Xiaolu, Wang Yi–Chen. (2001). Spatial-temporal dynamics of urban green space in response to rapid Urbanization and greening policies, *Landscape and Urban Planning Elsevier,100* (2011), 268–277.

GEOSPATIAL APPLICATIONS TO ASSESS SUSTAINABLE AND INCLUSIVE URBAN GROWTH: A CASE STUDY OF PROPOSED SMART JAIPUR CITY

Laxman SINGH[1]

ABSTRACT

Urban India with almost one third (31.16 percent) of urban population is growing at a faster pace. The result of 2011 census shows that for the first time since Independence, the absolute increase in population is more in urban areas as compared to the rural areas. This growth is again, large city oriented as 42.6 percent of the urban population lives in 53Million Plus UAs/Cities. Jaipur, one of India's million-plus cities and the capital city of Rajasthan had surpassed the 3 million criteria with a 3.04 million population in 2011. Its annual average exponential population growth rate of 2.72 percent in last decade represents a further high growth and expansion in forthcoming future. This phenomenon, especially in developing country like India, requires a scientific understanding of complex urban growth processes and its spatial patterns. The monitoring of this growth is necessary to develop a haphazard and disorganized city into a smart city. Only a planned and an organized city can meet the demands of the market and its citizens. Census data has been used to capture the population aspect of urban growth while further to capture the physical aspect remote sensing and GIS techniques have been used in this study. Built up area is considered as a proxy for the urban growth and built-up density is computed in order to quantify the form and spatial patterns of urban growth. Temporal changes in spatial patterns of urban growth i.e. in built up are easily captured by using sequential satellite images over a period of time from 1975 to 2011 but it is hard to calculate the population growth at ward level as there is a continuous change in ward boundaries for the electoral purpose. This study tries to address this problem up to some extent by using the areal Interpolation of census data, an issue that is applicable to dasymetric mapping. The binary form of dasymetric mapping i.e. "built up/ populated" or "nonbuilt up/unpopulated" is being used and per pixel population of old ward is considered as adjustment weight to interpolate the population of affected zone in new ward boundary. The result of study reflects two different forms of urban growth in relation to both physical and population aspects. Geospatial assessment through built up density reflects that city had grown in a dispersed form till 2000 and thereafter it had shifted to a compact form of urban growth. The results of dasymetric mapping also reflect the two different patterns of population growth in last decade. De-urbanisation or negative growth in the interior, congested and older areas while high urban growth and spatial expansion in the exterior areas. These results are further confirmed by another method i.e. common boundary formation for spatial units in last decade time series ward map by using the geospatial technique.

Keyword(s): *Urban Growth, GIS and RS techniques, Built-up density, Dasymetric mapping*

INTRODUCTION

India during last 30 years had witnessed a radical transformation of the urban scene. In particular, the million plus cities had experienced a rapid growth and expansion. This rapid rate of growth of cities could not entirely accommodate the population within the limits of the existing cities. In order to create a sustainable city Allen, A. (2009) argued that the Physical sustainability i.e. the built up dimension of a city needs a proper monitoring and planning along with population. In recent past, scholars started using remote sensing and GIS techniques on a wider scale for monitoring and mapping of urban growth (Epstein et al.2002).

Scholars have used several methods such as Post Classification Comparison, Spatio-Temporal Classification (Hardin et al. 2007), Built-Up Density (Jat et al. 2008), Shannon's Entropy(Joshi et al. 2006), Agent Based and Cellular Automata Models (Sudhira et al. 2005) to estimate the present status and future simulation of urban growth. Scholars (Jat et al. 2008) have used built up and population as the most important variables in the simulation of urban growth. Temporal changes in spatial patterns of urban growth i.e. in built up are easily captured by using sequential satellite images over a period of time but it is hard to calculate the population growth at ward level as there is a continuous change in ward boundaries of metro cities for the electoral purpose. Scholars had tried to address this problem up to some extent by using the Areal Interpolation of census data, an issue that is applicable to dasymetric mapping (Sleeter et al. 2007). This simplest form of dasymetric mapping is also called as Binary "Populated" or "unpopulated" approach where population totals are uniformly reassigned to populated areas (Holt et al. 2004).

Jaipur is one of India's million-plus cities and is the

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capital city of Rajasthan State. Jaipur with 3.04 million population, the 11th largest metro city of India also reflects an incessant high urban growth rate along with built up expansion and change in ward boundaries. It is one of the fastest growing mega cities of the country with an annual average growth rate of 4.5 percent in 2001 whereas the national urban growth rate was only 2%. In last decade it has increased with a rate of 2.72 percent. With its current growth trend, it is likely to supersede many other cities. Punia et al. (2012) advocate a continuous increase of built up in Jaipur city both in the core and peripheral wards in the form of densification and expansion.

OBJECTIVES

1. To quantify the ward wise patterns of urban growth on the basis of built-up density during 2001 and 2011.
2. To derive dasymetric population densities for areally interpolating, using census ward level population data from 2001 to a common set of census ward boundaries. The areal interpolation was necessary in order to examine temporal trends in ward wise population growth.

DATABASE

1. Spatial data
   a. The satellite data of the year 2000 (Landsat ETM+ dated 13.09.2000) and for the year 2011 (IRS—P6—LISS III dated 12.01.2011).
   b. Ward wise map of Jaipur city (JMC) from Jaipur Development Authority (JDA) for 2001 & 2011.
2. Socio –Economic data
   a. Census of India, District Census Handbook, Town and Village Directory of Jaipur for various census years (1981, 1991, 2001, 2011).

METHODOLOGY

1. Supervised classification had been used for the built-up change detection especially in the landuse and landcover over the period of time.
2. Built up density has been used to quantify the urban growth.

$$\text{BUD} = \frac{\textit{Number of Pixels Belongs to BUILT-UP in a Ward}}{\textit{Total Number of Pixels in that Ward}} \times \textit{Area of Each Pixel} \times 100$$

3. Binary Dasymetric Mapping

This simplest form of dasymetric mapping is called as binary “Populated” or “Unpopulated” approach where population totals are uniformly reassigned to populated areas are used in this study (Holt et al. 2004). The binary dasymetric procedure utilizes ancillary land-use/land-cover data to differentiate populated and unpopulated areas. The ancillary land-use/landcover data was derived from a computer-assisted, manual, pixel-based classification of remotely sensed satellite data. The raster format land-use/land-cover map in binary form (populated versus unpopulated) was overlaid with a ward boundary file. Then the number of residential land-use pixels per Census Ward was calculated using the geospatial techniques. The population per residentially occupied pixel was derived by dividing the population of a ward by the number of residential pixel. Now every pixel had a population value, number of pixels in new ward got multiplied by their population values. Thus the population of new ward got calculated by this method. The assumption and limitation of this simple binary dasymetric mapping is that the population is uniformly distributed in a ward among all residential pixels.

RESULTS AND DISCUSSION

The built-up area had increased 73.92 sq. km in 1989 to 199.83 sq. km in 2011 within the municipal boundary of Jaipur city and the population had increased from 1.4 million to 3.04 million. The percentage increase in built-up in 2000-2011 had outstripped it as compared to 1989-2000. The picture of urban growth becomes clearer by the statistics in the following table

Results in table-1 reveal that the rate of land development in Jaipur has outstripped the rate of

Table 1
Urban Growth Statistics for Jaipur City, 1989-2011

Year	*Built Up Area (Sq. Km.)*	*Increase In Built-Up Area (Sq. Km.)*	*Percentage Increase In Built-Up Area (%)*	*Population*	*Absolute Increase In Population*	*Percentage Growth In Population*
1989	73.92			1400806		
2000	124.91	40.99	55.45	2225905	825099	58.90
2011	199.83	74.92	59.98	3046163	820258	36.85
1989-2011		125.91	170.34		1645357	117.46

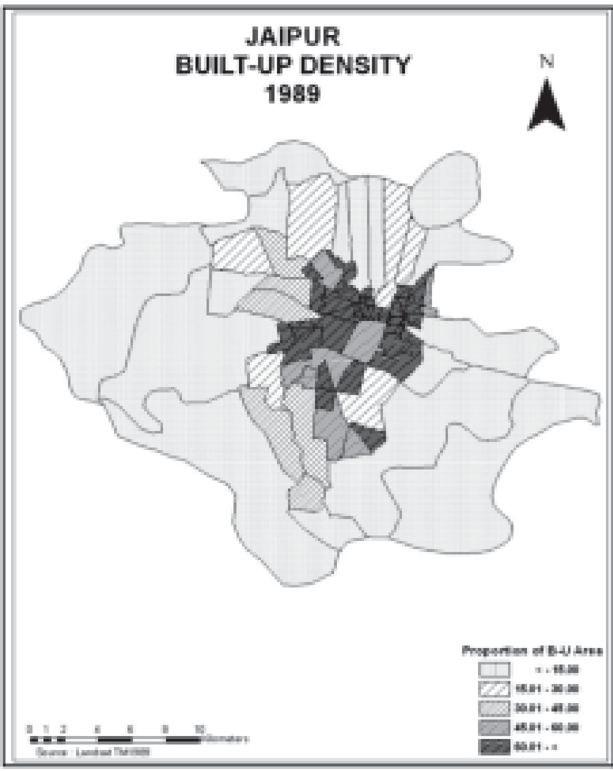
Source: Satellite and Census Data for Various Years population growth. From the years 1989 to 2011, the population in the region increased by 117.46 %, while the amount of developed land grew by about 170.34 %, i.e. more than the rate of population growth. This implies that the land is being used for urbanization at a faster rate, which indicates that per capita consumption of land has increased rapidly over the last three decades. The per capita land consumption refers to the utilization of all lands for development initiatives, like commercial, industrial, educational, recreational and residential establishments per person.

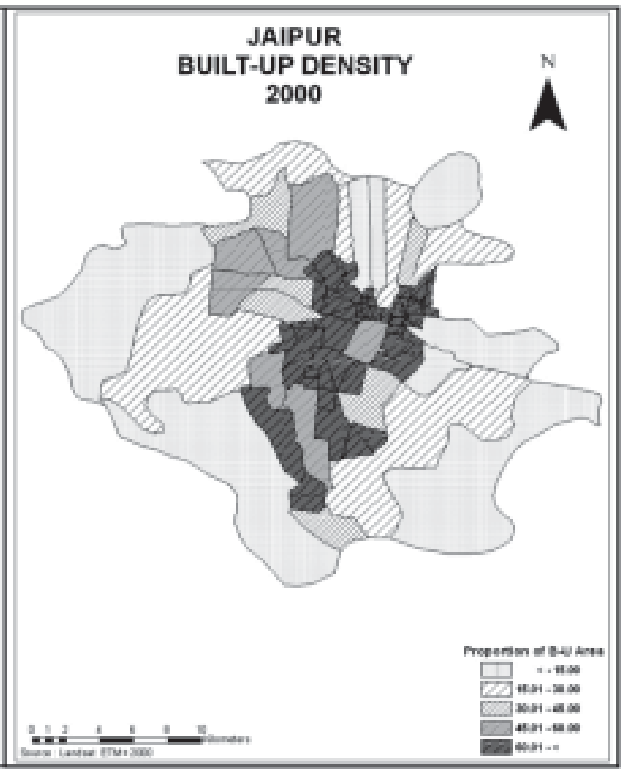
Intra-city Estimation of Built-up within Jaipur City

There is not only expansion of built-up towards exterior areas but it had increased in the interior and intermediate wards also. The proportion of built up had increased in all the exterior and interior wards. In the interior wards, it is reflected in the form of densification while in the exterior wards as expansion. This pattern of urban growth is captured by the built-up density of all the wards of Jaipur Municipal Corporation. Built -up density refers to the proportion of built-up area to the total area(Jat et al. 2008). The built-up area has been considered by many of the scholars as the most important indicator of urban growth. Thus, built up density becomes an important variable to quantify the urban growth.

Table 2 represents all the values of ward wise built up density from 1989 to 2011. Along with table, map number-1 also reflects that in the year 1989, there were total 16 wards in very low built-up density category and all of them were the exterior wards. There were 6 each in both low and moderate built up density class. These were the wards adjacent to exterior wards along with few intermediate wards. It reflects that built up was having low proportion in the exterior areas and the influence of urban growth was limited in the outer zone. There were total 7 wards in high built up category while 35 wards in very high built up category that is more than 60% of the total area was under the built up category. Most of these wards belong to the old fort city and adjacent to the fort city. But the development and availability of transport nodes and lines have contributed significantly in the progress of 19, 20, 21, 25 and 26 number wards. Railway lines to Delhi and Sawaimadhopur, Tonk Road, JLN Marg and NH 12 passes through this area.

Map 2 represents that in the year 2000, North West, Central West, central south and south-west had experienced the highest increase in built-up density. In this region ward no. 13, 16, 21, 22 and 25 had moved towards the very high built density and at the same time ward no. 11 and 14 had moved in the high built up density category. As mentioned earlier that transport facilities and employment opportunities, especially in Sanganer area, had played





Map 1-Jaipur Built-up Density 1989

Map 2-Jaipur Built-up Density 2000

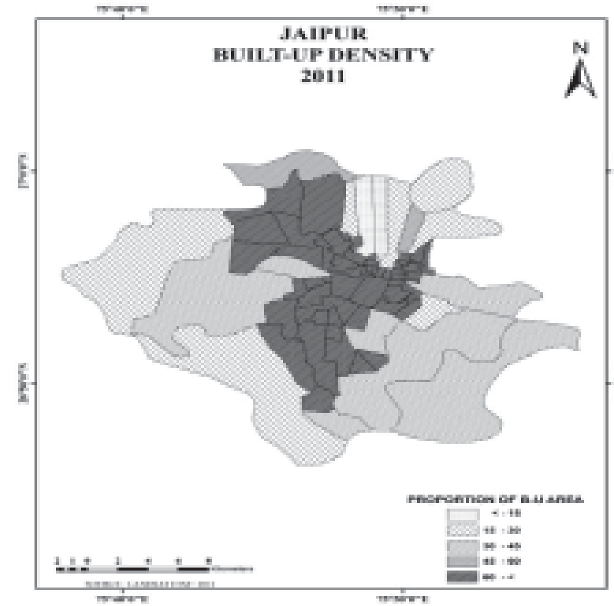
a significant role in the development of this region. In North West area transport factor, inside migration and developments of slums have contributed for high built-up density of this region.

Map 3 and Map 4 represents the status of built up in 2011.It reveals that almost 50 % area of the city is under the very high built up density category and the direction of development have remained the same as were in 2000 that is north-west and southern direction. Only two wards i.e. 63 and 59 are in very low built up density and that is again due to its location in Jhalana Dungari hills. Except for this ward

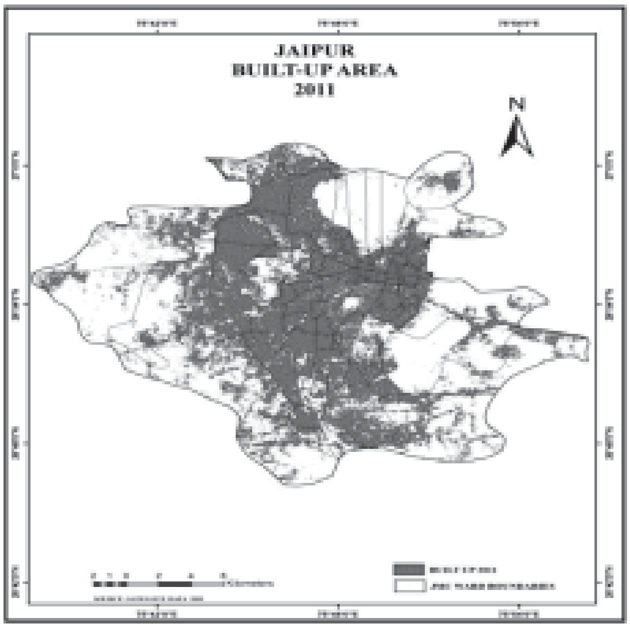
Table 2
Ward Wise Builtup Density Of Jaipur (1989-2011)

Ward	*Built Up Density 1989*	*Built Up Density 2000*	*Built Up Density 2011*	*Ward*	*Built Up Density 1989*	*Built Up Density 2000*	*Built Up Density 2011*
1.	8.95	37.84	86.95	36	73.01	74.19	85.46
2.	3.02	3.15	17.31	37	80.44	84.57	88.43
3.	5.17	15.94	44.76	38	95.32	96.84	97.49
4.	61.13	82.33	94.29	39	97.26	97.48	98.90
5.	79.31	85.68	92.06	40	100.00	100.00	100.00
6.	69.90	73.42	87.68	41	100.00	100.00	100.00
7.	32.42	33.18	43.57	42	99.20	99.36	99.52
8.	43.37	44.81	61.29	43	99.70	99.78	99.82
9.	14.65	59.02	88.72	44	100.00	100.00	100.00
10.	24.73	54.17	88.48	45	100.00	100.00	100.00
11.	20.52	56.02	81.32	46	100.00	100.00	100.00
12.	4.35	6.86	25.27	47	100.00	100.00	100.00
13.	43.30	61.66	83.84	48	12.02	14.31	35.53
14.	39.09	48.97	67.96	49	56.54	73.63	83.39
15.	50.85	90.10	94.17	50	94.47	96.84	98.99
16.	49.61	65.66	82.50	51	75.91	89.97	94.46
17.	73.49	80.71	90.24	52	13.35	17.17	27.66
18.	71.36	72.62	76.52	53	3.43	8.65	16.32
19.	91.32	98.30	99.59	54	29.57	41.96	47.01
20.	87.62	98.69	100.00	55	94.27	94.38	96.61
21.	46.63	68.91	79.71	56	100.00	100.00	100.00
22.	38.25	62.33	69.05	57	100.00	100.00	100.00
23.	9.35	31.62	42.02	58	16.69	17.34	18.15
24.	3.45	6.17	37.65	59	8.16	10.33	10.91
25.	58.83	77.00	85.58	60	100.00	100.00	100.00
26.	74.31	87.83	90.00	61	95.06	97.81	98.41
27.	28.84	33.80	42.65	62	83.85	86.96	89.16
28.	5.90	19.42	40.14	63	4.34	7.19	9.95
29.	10.86	13.97	17.29	64	90.40	95.48	96.03
30.	89.30	93.89	98.89	65	10.72	16.73	21.32
31.	85.38	86.41	88.25	66	76.98	84.90	84.99
32.	86.95	89.58	90.95	67	49.31	60.29	75.70
33.	88.58	91.79	93.74	68	34.14	51.36	75.32
34.	74.29	75.95	85.55	69	27.93	47.96	66.16
35.	50.33	50.91	64.75	70	9.60	18.79	54.64

Source: Satellite Data for Various Years.



Map 3-Jaipur Built-up Density 2011



Map 4-Jaipur Built-up 2011

all the other wards are having more that 15% percent built up area. There is a contiguous zone of very high built up density towards North West, Central and Southern areas. Ward 7 and 3 in the east, 70 in the north and all the wards of South (23), South East (24,26, 27 & 48) have shifted to the moderately dense wards. These are the areas where horizontal expansion of built up area had occurred in a very significant manner. These peripheral wards are the new areas of built up growth. The population is shifting in these areas from the interior wards. Apart from this, these wards are also providing space to the new incoming population. In the outer zone, there are 4 exterior wards west (ward 2) south west (12), 52 and 53 in north east are in the category of low dense wards. These wards are the future focal points of further urban expansion as they have the scope and space for further built up development.

Intra-City Estimation of Population within Jaipur City and Dasymetric Mapping

The decade 2001-11 witnessed remarkable changes in terms of both population and area in Jaipur. Several wards have been merged, while several have been fragmented creating wards. A village in the western part of the city has been removed from JMC boundary, which was sparsely populated. Due to this huge boundary readjustment during between 2001 and 2011, population comparison is not possible for this decade. Population comparison among the spatial units i.e. wards is very necessary to find out the pattern and extent of urban growth. There are only two ways for the comparison of population among spatial units.

1. Common Boundary Formation for Spatial Units
2. Areal Interpolation of Census Data

1. Common Boundary Formation for Spatial Units

There is a huge change in the ward boundaries during 2001 & 2011. Out of 70 wards, there are 11 wards which have not experienced any change in their boundary during 2001-2011. Rest all wards had experienced a change in their boundary. Ward 2 and 24 had a major change due to change in JMC boundary itself. There were few villages which were part of JMC in 2001 but got excluded from JMC in 2011. The population of 2011 of these villages got included in these wards so that they could be made comparable with 2001. There are also wards like 12, 48 and 52 which had change in their boundary due to JMC boundary change. Other than these, there are few wards which got split into 2 or more wards while few had merged into one. With the help of GIS, total 31 spatial units' area being formed which are comparable for the duration of 2001 and 2011. Units are as according to the table 3.

These spatial units/zones are being formed by keeping 2001 JMC map as a base. The wards which do not have any boundary change have same ward/ zone number as according to 2001 Census. Others which are formed by merging with other wards are being named as according to the small ward number. Like first zone has 4, 6, 7 and 17 in 2001 while 18, 19, 21 and 22 in 2011. It is named as 4 due to the smaller number of ward in 2001. The following table shows the average annual exponential growth rate of the zones.

Table 3
Zone Formation 2001-2011

Sl. No.	*Zone 2001 (ward as 2001)*	*Zone 2011 (ward as 2011)*
1.	5	20
2.	57	58
3.	42.43.45	59,60
4.	60.61	64, 65
5.	44	52
6.	39.40.41	61.62
7.	27.31	39.46
8.	62	66
9.	55	72
10.	19.20.21.25	37.40.41
11.	26	38
12.	38	63
13.	46.47	53,54
14.	50,56	56.57
15.	36.37.66.67	15.16.17
16.	64	68
17.	58.59.63.65	67.69.70.71
18.	30.32.33	47,50
19.	4.6.7.17	18.19.21.22
20.	14.15.22	24.25.30.42
21.	29	48
22.	11,16,18,35	23.43.44.45
23.	13	26.27.28
24.	34.48.49	49.51.55
25.	51.52.53.54	73.74.75.76.77
26.	9	9,10
27.	10	7
28.	8	8
29.	68.69	4.5.6
30.	1.2.3,70	1.2.3.11.12.13.14
31.	12.23.24.28	29.31.32.33.34.35.36

Source: JMC Ward Map 2001, 2011.

Growth rate ranges from -1.62 to 7.90. In the city out of 31 zones, 10 zones are having negative growth rate. After corroborating this information with the map number 6, a different phenomenon comes out. The city is not experiencing a uniform pattern of urban growth. As mentioned in the theories of urban growth, the city comes to a stage where the population in the core/ interior areas starts shifting to the exterior areas. As a result of this the old and core areas shows a negative growth rate while the exterior areas shows a very high growth.

Exterior areas have to carry both the shifted and the incoming new population. Jaipur is experiencing the same spatial pattern of urban growth. Zonal map number-6 shows that the old fort city, adjacent wards and densely populated wards are showing a negative growth rate. Few intermediate zones like 19 and 27 are also showing the negative growth rate. These are the areas from where the population is shifting to elsewhere. The process of de–urbanisation is occurring in these areas. The zones adjacent to these areas are also showing a moderate pattern of urban growth. Here growth rate varies from 0 to 1.06. Further adjacent to this area, thr zones represent a relatively high growth rate. These are 13, 14, 11, 29, 34 and 51. Most of these areas had experienced a very high growth during the last decade. So with that high base, the scope of growth is limited to these areas.

Table 4
Zone- wise Population Growth Rate (2001-2011)

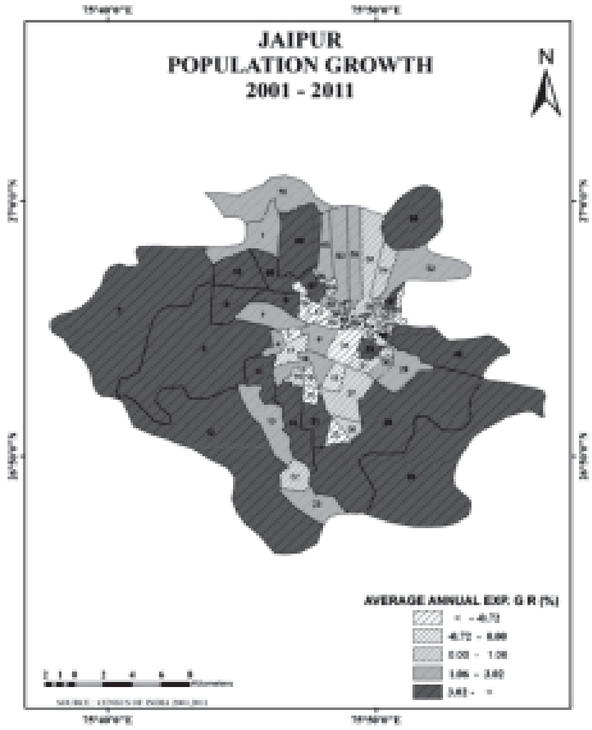
Sl. No.	*Zone 2001 (ward as 2001)*	*Zoone 2001 (ward as 2001)*	*Sl. No.*	*Zone 2001 (ward as 2001)*	*Zone 2001 (ward as 2001)*
1.	5	-1.62	17	58	1.01
2.	57	-1.42	18	30	1.03
3.	42	-1.35	19	4	1.06
4.	60	-0.98	20	14	2.14
5.	44	-0.91	21	29	1.51
6.	39	-0.76	22	11	1.69
7.	27	-0.72	23	13	2.16
8.	62	-0.52	24	34	2.24
9.	55	-0.40	25	51	3.02
10.	19	-0.13	26	9	4.00
11.	26	0.06	27	10	4.01
12.	38	0.31	28	8	4.14
13.	46	0.37	29	68	4.88
14.	50	0.40	30	70	6.52
15.	36	0.80	31	12	7.90
16.	64	0.99		Total	2.76

Source: Census of India 2001-2011; Satellite Data 2001-2011.

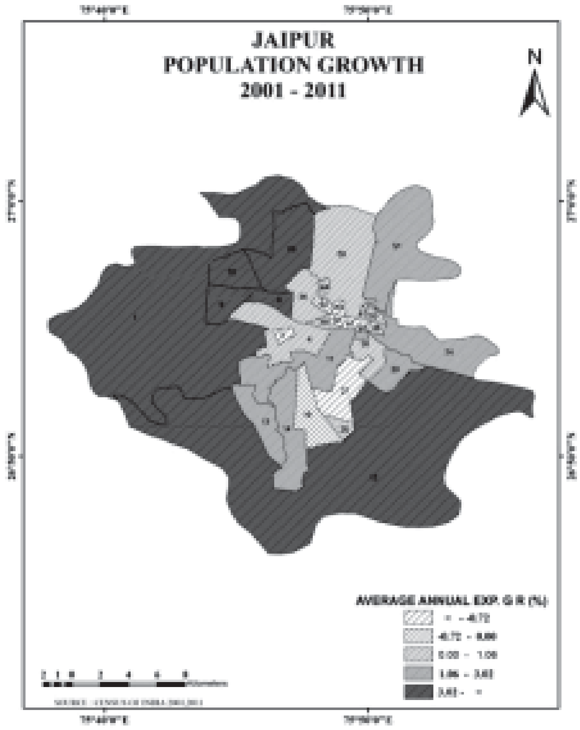
The highest growth is noticed in all the exterior wards except for 58, 51 and 34. These are the wards which show the impact of physical landscape on urban growth. Here the Jhalanadungari hills are located which make this place hard for settling. Except for this north and north east area, rest entire exterior wards of Jaipur are experiencing a very high pattern of urban growth. Thus the Spatial pattern of Jaipur's growth is experiencing two opposite and different patterns. De-urbanisation or negative growth in the interior, congested and older areas while high urban growth and spatial expansion in the exterior areas.

2. Areal Interpolation of Census Data

The redistribution of population from source zones (i.e., census boundaries) to target zones (i.e., populated land-cover) is known as areal interpolation. Areal interpolation functions are said to preserve the pycnophylactic property (i.e., volume preserving) in that "no data is lost or created during the transformation". Furthermore, Mennis, J. (2003) explains that all error is limited to variations within each original areal unit (e.g. census block, block



Map 5: Jaipur Population Growth Rate (Wardwise) 2001-11

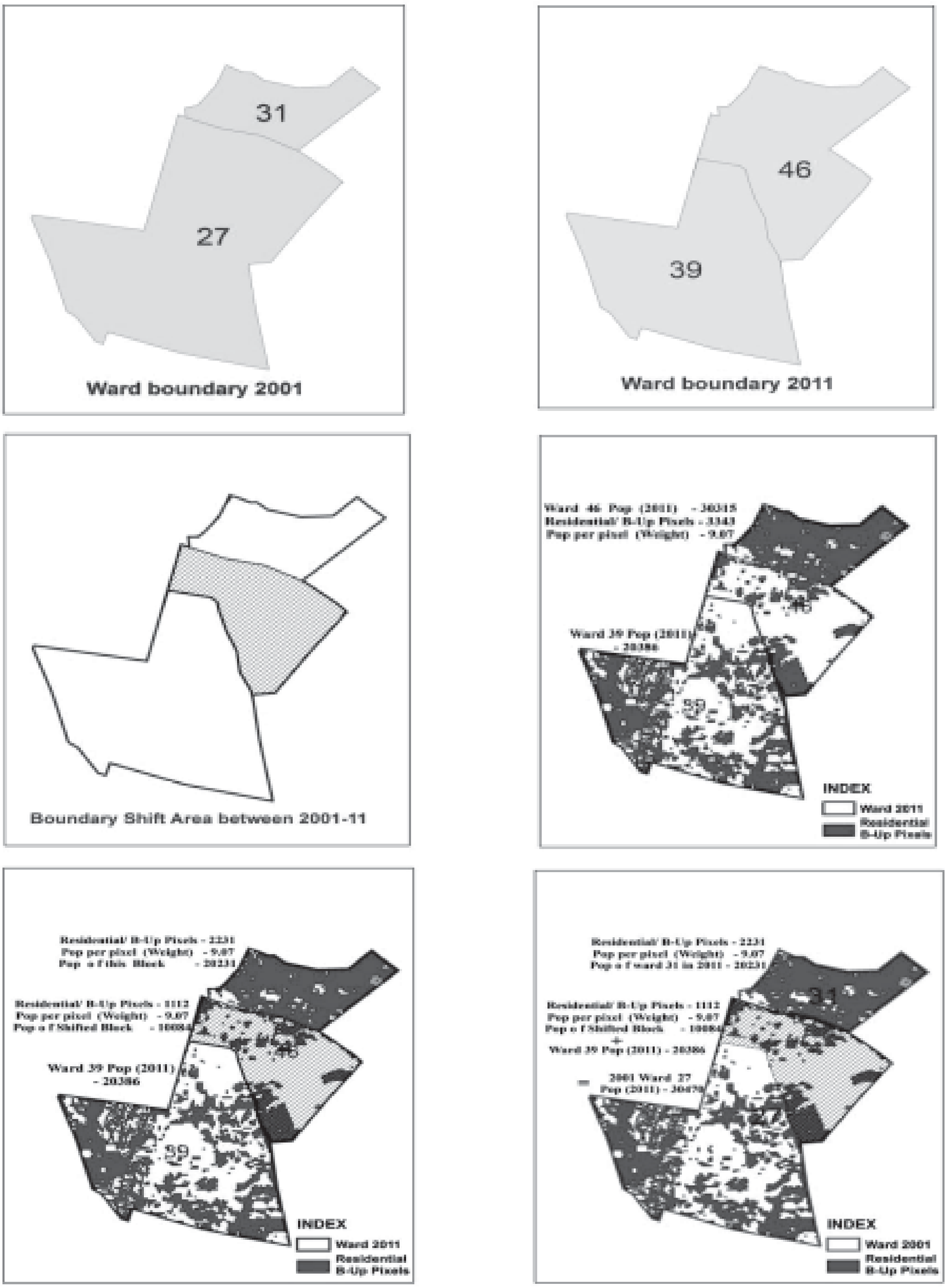


Map 6: Jaipur Population Growth (Zonewise) Rate2001-11

group, tract) since population is preserved through the transformation. Sleeter and Gould (2007) argue that even though the nature of a population distribution is more realistically represented through dasymetric mapping, its complexity and ancillary data requirements often deter cartographers from using this technique.

The basic procedure that we used in this is similar to the binary dasymetric procedure described by Langford and Unwin (1994). Fisher and Langford (1995) had also used this technique to assign weights to interpolate population for zones which had experienced a change in the boundary. The binary dasymetric procedure utilizes ancillary land-use/land-cover or satellite image to differentiate populated and unpopulated areas. The ancillary land-use/land-cover data is basically derived from a computer-assisted, manual, pixel-based classification of remotely sensed satellite data. Holt et al. (2004) explain that this simplest form of dasymetric mapping is also called as binary "populated" or "unpopulated" approach where population totals are uniformly reassigned to populated areas. The primary advantage of this technique is that the features such as lakes, rivers, agriculture, and uninhabited lands are excluded from the interpolation providing a more accurate representation of population distribution. Su et al. (2010) elucidated another advanced form of the binary technique which is a multi-class weighted dasymetric technique. This technique is based on the knowledge that populated areas consist of unique areas with different population densities such as multi-family developments versus single family neighborhoods. Weighting factors are assigned to each class technique that may include prior or expert knowledge, empirical sampling, or geo-statistical modeling.

The method binary dasymetric mapping used in this study is based on the assumption that population is uniformly distributed among existing built-up pixels in a particular ward. Eicher et al. (2001) explain that the accuracy of this method is more where the population distribution in households does not differ a lot. In the case of Jaipur, there is not much differentiation of population distribution within award. The high dense areas like fort city, slums, are having different wards from the intermediate areas like Mansarovar, Mahavir Nagar etc. On the basis of this interpolated population calculated by using the methodology mentioned in MAP Number-7, the average annual exponential growth rate is calculated to assess the status of urban growth in Jaipur.



Arteal Interpolation Using Dasymatric Weights

Table 5
Jaipur Wardwise Population Growth Rate (2001-2011)

Sl. No.	*Growth Rate*	*Sl. No.*	*Growth Rate*	*Sl. No.*	*Growth Rate*
1.	2.50	25	-2.98	49	-0.60
2.	7.72	26	0.06	50	0.79
3.	8.00	27	0.54	51	4.24
4.	2.03	28	7.78	52	2.96
5.	-1.62	29	1.32	53	3.42
6.	1.86	30	1.19	54	0.81
7.	2.52	31	-0.24	55	-0.05
8.	4.14	32	-0.26	56	0.38
9.	3.90	33	4.23	57	-1.42
10.	4.01	34	-7.33	58	0.06
11.	3.52	35	-1.53	59	1.38
12.	8.91	36	-0.86	60	-2.53
13.	2.36	37	-1.24	61	0.20
14.	4.40	38	-1.12	62	1.50
15.	0.22	39	-0.94	63	1.14
16.	1.91	40	2.29	64	0.99
17.	-0.30	41	-3.23	65	2.24
18.	-0.64	42	2.46	66	0.29
19.	-0.25	43	-2.13	67	4.34
20.	-1.53	44	-0.96	68	6.06
21.	3.61	45	-1.05	69	3.97
22.	0.99	46	0.08	70	1.29
23.	1.56	47	1.03		
24.	12.05	48	6.99		

Source: Census of India 2001-2011.

Table 5 shows the exponential growth rate of population in Jaipur during the decade 2001-11. A very striking phenomenon is noticed in the district. While many of the core areas have witnessed a rapid decline in the population, the outer areas have witnessed a considerable growth. This suggests that more and more population is moving outwards for better space, environment and de-congestion. Areas which were once sparsely populated are more preferred now. As a whole, the population of Jaipur has grown at the rate of 2.77 percent.

The spatial pattern of this growth is reflected by the map number-5. It also reflects almost same pattern of growth as like the zonal map-6. The walled city has witnessed the sharpest decline. Ward no 34 has recorded the highest decline of -7.33.The ward adjacent to the walled city was inhabited by congested road and houses. The sanitation condition, as well as the surrounding conditions, were also not very favorable. This may be cited as the reason for the sharpest decline in growth. This decline is followed by ward no 41, 25, 60, 43; all registering a decline of more than -2. In aggregation, 22 out of 70 wards registered a decline in the growth rate. It is basically the core city and also some intermediate wards as 5, 17, 18, 19, 20 and 25. These intermediate wards were having already had very high growth rate during the last decade. From this entire core and intermediate zone, the population is shifting especially in west, south and south east. Adjacent to this area are the wards which had experienced a moderate growth as their growth rate is 0 to 1. These are the wards as 22, 26, 27 46, 47, 50, 56, 58, 61, 64 and 66. Most of these are again intermediate wards adjacent to the zone of negative growth.

Next to this is the zone of high growth. This zone includes northern city and other wards like 4,6,7,13,16,23,29,30 and 52. Most of the growth in these was had occurred during the last decade only. But the highest growth in this decade had occurred in the entire exterior zone of City. Except for north, northeast and ward 23, all the other outer wards had experienced very high growth rate. Ward no 24 located in the south-western part has recorded the highest growth of 12.04%. In–migration from the neighboring districts is also a factor in the growth of this ward. Almost all the exterior wards of the city like ward no 28, 12, 48, 3, and 2 have registered a very high growth. It is an outcome of people shifting from the core city and intermediate areas to outskirts and also the migration. Thus, dasymetric mapping reflects that Spatial pattern of Jaipur's growth is experiencing two different patterns. De-urbanisation or negative growth in the interior, congested and older areas while high urban growth and spatial expansion in the exterior areas.

CONCLUSION

During last two decades, the population of Jaipur city had grown by about 117.46 percent, while the amount of developed land grew by about 170.34 percent i.e. more than the rate of population growth. The direction of urban growth has remained North West, west and south and through the road network city had started to expand in eastern direction also. The city had experienced the densification in core (walled city) areas while expansion towards the exterior wards. Areas which were already densely built became further dense and reflected high densification of built up. The dasymetric estimation of population growth had also reflected two different patterns within the city. The process of de–urbanisation i.e. the negative growth rate is occurring in old fort city, interior and densely populated intermediate wards while outer zone are getting an influx of population and showing a high positive growth rate.These spatial urban growth dynamics had efficiently been captured by GIS and remote sensing techniques with the help of built-up density and dasymetric mapping.

REFEENCES

1. Allen, A. (2009). Sustainable Cities or Sustainable Urbanisation. Retrieved April, 18, 2014.
2. Eicher, C. L., & Brewer, C. A. (2001). Dasymetric Mapping and Areal Interpolation: Implementation and evaluation. Cartography and Geographic Information Science, 28(2), 125-138.
3. Epstein, J., Payne, K., & Kramer, E. (2002). Techniques for Mapping Suburban Sprawl. Photogrammetric Engineering and Remote Sensing, 63, 913–918.
4. Fisher, P. F., & Langford, M. (1995). Modelling the errors in Areal Interpolation between Zonal Systems by Monte Carlo simulation. Environment and Planning A, 27(2), 211-224.
5. Hardin, P. J., Jackson, M. W., &Otterstrom, S. M. (2007). Geo- Spatial Technologies in Urban Environments (pp. 141–176). Berlin: Springer.
6. Holt, J. B., Lo, C. P., &Hodler, T. W. (2004). Dasymetric Estimation of Population Density and Areal Interpolation of Census Data. Cartography and Geographic Information Science, 31(2), 103-121.
7. Jat, M. K., Garg, P. K., & Khare, D. (2008). Modeling of Urban Growth Using Spatial Analysis Techniques: a case study of Ajmer city (India). International Journal of Remote Sensing, 29(2), 543–567.
8. Joshi, P. K., Lele, N., & Agarwal, S. P. (2006). Entropy as an indicator of Fragmented Landscape. Current Sciences, 91, 276–278.
9. Langford, M., & Unwin, D. J. (1994). Generating and Mapping Population Density Surfaces within a Geographical Information System. The Cartographic Journal, 31(1), 21-26.
10. Mennis, J. (2003). Generating Surface Models of Population Using Dasymetric Mapping*. The Professional Geographer, 55(1), 31-42.
11. Punia, M., & Singh, L. (2012). Entropy Approach for Assessment of Urban Growth: a case study of Jaipur, India. Journal of the Indian Society of Remote Sensing, 40(2), 231-244.
12. Sleeter, R., & Gould, M. D. (2007). Geographic Information System Software to Remodel Population Data using Dasymetric Mapping Methods. US Department of the Interior, US Geological Survey.
13. Su, M. D., Lin, M. C., Hsieh, H. I., Tsai, B. W., & Lin, C. H. (2010). Multi-layer multi-class Dasymetric Mapping to Estimate Population Distribution. Science of the Total Environment, 408(20), 4807-4816.
14. Sudhira, H. S., Ramachandra, T. V., Wytzisk, A., & Jeganathan, C. (2005). Framework for Integration of Agent-based and Cellular Automata Models for Dynamic Geospatial Simulations. Centre for Ecological Sciences, Indian Institute of Science Bangalore.

RESILIENT SMART CITY DEVELOPMENT: A HOLISTIC APPROACH

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ABSRACT

The impact of globalization and industrialization has been a subject for research around the globe due to huge paradigm shift caused by them. Such phenomena is also a cause of concern as cities consume close to three-quarters of the world's natural resources and generates three-quarters of its pollution and wastes. There is a need for the cities to get smarter through application of innovative solutions to address large-scale urbanization challenges and finding new ways for creating liveable, competitive and self-reliant cities.

In this direction, advent of Smart Cities could be a much larger wave of transformation which is about to splash the entire world. The definition and applications for Smart Cities vary with countries, cities, resources and ecosystems. Pilot projects have been taken up in almost all parts of the world to emulate such cities. Many countries have rolled out grand plans for development of both green field and brown field Smart Cities. There have been several agitations against such extensive infiltration of information technologies in societies due to fear of cyber-attacks, privacy threats etc. However, societies have decided to go ahead because of the great advantages as well as necessity of smarter systems for ensuring a quality life for citizens. The revolution of upcoming smart cities would thus be one of the most holistic movements which would require extensive participation from almost all fronts of the society, thus resulting in a truly substantive development.

Due to enhanced dependency on data sensors, automation technologies, information and communication technologies (ICTs), software analytical applications etc. any disruption/disaster may disintegrate whole string of services and jeopardise smart city ecosystem. Further, high concentration of population and economic activities make smart city vulnerable to severe damage in terms of human lives as well as financial breakdown. Therefore resilient measures for various natural and manmade disasters need to be taken care. Major portion of all urban areas on earth are coastal/riverside, exposing them to sea/river level rise and storm surges. Climate impacts such as cyclones, flood, drought etc. have financial impacts, with major disruption to business operations and city finances. This necessitates that at the onset of the development of smart city concomitant actions are needed to make them resilient to disaster as well.

This paper introduces the concept of a Smart City and discusses its various attributes. Technology span required for Smart City development has been analysed and presented. Integration of various utilities & services including energy, water, waste, traffic & transportation, safety & security, education, governance, infrastructure etc. have been deliberated. Stages for development of Smart Cities have been identified in view of the Government of India's ambitious program of establishing 100 Smart Cities on fast track. The planning and prioritization strategies necessary for the success and sustainability of such a program are discussed. To be really intelligent, cities must also consider the impacts of climate change. Therefore, disaster risk reduction is one of the key aspects in smart city development.

Accordingly, vulnerabilities associated with Smart Cities have been listed with a holistic and farsighted approach. These help in identification of mechanisms, policies and practices to be taken up by all the stakeholders to ensure that the Smart Cities serve their purpose of socio-economic development and citizen centric governance instead of procedural governance without posing a threat to security, stability and integrity of the individuals and the society as a whole. The paper also highlights the need for establishing Central Command Control Centre and the shift in administrative procedures as well as emergency governance structures to accommodate the of involving citizens extensively in building these cities, not only literally but also figuratively.

Keywords: *Smart City, Disaster Resilience, Emergency Governance, Open Government, Sustainability*

INTRODUCTION: NEED FOR SMART CITY

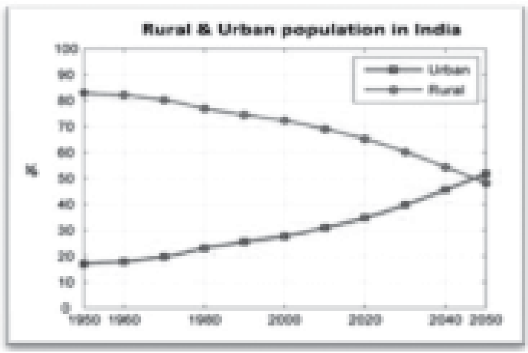
Cities are referred to as the engines of economic growth accounting for 80% of the global GDP. However, they consume around 75% of global primary energy and responsible for about 70% of the greenhouse gas(GHG) emissions[1].

Cities provide ample opportunities to its citizen for jobs, economic development, better living standard etc. and therefore migration of people take place from villages to cities. This continuous migration over the years has made cities densely populated and congested as they accommodate almost 54% population of the world confined in about 4% of the terrestrial surface. Further, global urban population is expected to rise to 70% by 2050. This urbanisation is also a cause of concern as cities consume close to three-quarters of the world's natural resources and generates three-quarters of its pollution and wastes.

Urbanization in India is increasing rapidly as never before. It is estimated that urban population would

1. Chief Vigilance Officer, Power Grid Corporatin of India Ltd., Gurgaon.

double to about 60 Crore in next 20-25 years. UN predicted that the number of people in India's towns and cities will almost double to 814 million by 2050. Urban population contributes over 60% of India's GDP and will contribute about 70% of the national GDP in the next 15 years[2]. Figure 1 shows the growth of urban & rural population.



Source : www.unpopoulation.org

Fig.1: Growth of Urbanisation

Rapid urbanization has brought forward many challenges like increased energy demand, tremendous waste generation, stress on existing infrastructure & resources, safety and security threats, increasing pollution levels, technology dependence etc.

Accordingly there is a need for the cities to get smarter through application of innovative solutions to address large-scale urbanization challenges and finding new ways for creating liveable competitive and self-reliant cities.

Features of Smart City

The precise definition or understanding of smart cities varies with ecosystems, countries, resource availabilities and most importantly major challenges. Broadly, a smart sustainable city is an innovative city that uses information and communication technologies (ICTs) coupled with intelligent sensors and other means to improve quality of life, efficiency of urban operation & services, and competitiveness, while ensuring that it meets the needs of present and future generation with respect to economic, social and environmental aspects. A smart city facilitates in generating employment opportunities, increased human productivity and realization of inherent urban potential through transparent processes, thus resulting in sustainable economic development.

Innovative use of infrastructure shall also be designed such as use of multi utility halls / labour chowks (place for hiring of daily wagers) as Rain Baseras during nights; physical activity facility for slum children also doubled up as an informal classroom; malodorous trash dump transformed to a scientific waste management facility. Smart cities aim at sustainable development with enhanced quality of life with clean air and water for all citizens at affordable prices

Government of India's Smart City Initiative

Government of India has embarked on an ambitious program of developing 100 Smart Cities on fast track with focus on building modern physical disaster resilient infrastructure that are scalable, intelligent and interoperable to build smarter cities and meet growing demand of various types of services. The Ministry of Urban Development (MoUD) has clearly stated that the fundamental purpose of a smart city is to drive economic growth and improve the quality of life of the citizens.

The strategic components of area-based development are city improvement (retrofitting), city renewal (redevelopment) and city extension (green field development) plus a Pan-city initiative in which Smart Solutions are applied covering larger parts of the city. A few key areas of development have been identified as shown in Fig. 2.

Source: smartcities.gov.in

Fig. 2: Indicative list for Smart Solutions

Smart City Development

Any city can be developed as a smart city. However quantum of efforts, investment and approach would differ according to existing status and envisaged smartness attributes. While for a developed city, investments for bringing competitiveness and environmental targets are enough, an emerging city may require addressing priority concerns and tapping opportunities. Greenfield city though require more investment, there exists an opportunity to meticulously plan the city incorporating all desired attributes in an efficient manner. These factors demand resilient planning for green-field Smart City projects and meticulous retrofitting & reinforcement for brown-field projects

Development of smart cities is a long term process and involves many stakeholders including government and citizen. Collaboration of stakeholders is outmost requirement. During initial stage of smart city development, small initiatives may be taken up to build civic confidence in the overall vision.

Infrastructure development is carried out in all the above stages of implementation. Attributes to be implemented in smart cities may be different according to requirement and geographical conditions. Some of the major smart city attributes and their subsystems are defined below:

Smart Grid

Smart Grids are conglomerate of electrical infrastructure with information and communication technologies thus establishing a bidirectional communication link between the utility and consumers. Thus utility can take an informed decision in case of any disturbance while better managing and monitoring its assets. Also, consumer convenience is ensured by active participation of the consumers.

Smart grids also ensure that disaster resilient electrical infrastructure are planned to promote colocation of generation and load to reduce the need of long haulage of power and increase efficiency. With advanced control and communication, Microgrids shall be developed to ensure continuous power availability even during disaster, by using locally available resources through islanding. Smart grids, thus aim at providing reliable and high quality service to consumers, while ensuring sustainability through use of renewable resources and energy efficiency measures.

Utilities, administration & academic institutions have a pivotal role in encouraging and enabling integration of renewable generation in the distribution grid. Net Metering schemes are being rolled out by several utilities as shown in Fig. 3.

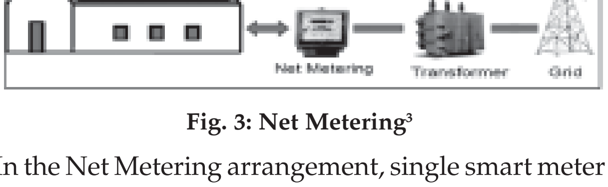


Fig. 3: Net Metering[3]

In the Net Metering arrangement, single smart meter shall be installed and when demand is more than the local generation at any premises, consumer draws the power from grid and when generation is more than demand, consumer injects the power into grid. Smart meter shall record net energy values and the same shall be used for billing by the utilities, thereby reducing electricity bills.

Smart Water Management

Water has made the difference when we wonder about life on earth. Life couldn't originate without it and neither can sustain in absence of water. Global population is growing, but our supply isn't. According to an estimate, water use is increasing at more than twice the rate of population growth. Demand for water will continue to increase dramatically as the developing world modernizes and industrializes with systems that fail to keep up. It's high time, that we value and manage water similar to the other. Smart Water Management System shall focus on the following three perspectives:

- Water Demand Management
- Water Resource Management
- Water Infrastructure Management

Different systems like Smart water meters/sensors, SCADA system, automatic billing system, grey water management, rain water harvesting, water treatment plants etc. are deployed to use water resources efficiently.

Smart Traffic and Transportation System

A city suffocates, once it stops. An hour is too long a duration to bring complete chaos if the traffic is seized. With number of vehicles increasing exponentially, it's time to adopt technology to the maximum possible extent in smooth handling of traffic and ensuring convenient commutation to the citizens. Further, to reduce vehicular pollution, use of electric vehicles is becoming popular. The issue of efficient traffic management has gained tremendous attention from city planners as well as researchers globally. NASA has collaborated with a few universities to develop a drone based traffic management system to address the challenge [4]. Some of the attributes of Smart Traffic & Transport Management are discussed as below:

Automatic Traffic Lights: These lights are designed with inbuilt intelligence such that the on and off time for a particular lane/road is dependent on the actual condition of traffic instead of the fixed time operation in conventional traffic lights. Also LED based smart lamp post/street light result in reliable operation and energy efficiency as well.

Online Traffic Monitoring: Real time monitoring through advanced control centres is based on informed decision with actual scenario governed by numerous CCTV cameras/ sensors/ drones. Thus to handle large traffic jams, diversions/ re-routing of traffic can be made based on overall picture of the area instead of local scenario. Geographic Information System (GIS) mapping of assets enables the administration to effectively carry out geo-spatial monitoring.

Emergency Kiosks/Counters: These shall be installed at regular intervals on highways or expressways to provide basic amenities like phone, first aid etc. and have accessible information regarding emergency aid contact numbers, location of nearby hospitals, police stations, maps, vehicle breakdown and towing services etc.

Advanced Information System: Public transport systems shall be strengthened with advanced visual information systems for schedules, routes, expected arrivals, present location of vehicles, helpline numbers etc. School buses shall be GPS tagged to enable online tracking by school administration and parents. SMS based tracking shall also be enabled. WiFi enabled public buses would enrich commuter experience.

Smart Waste Management System

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. In big cities waste disposal becomes a problem as quantum of waste is high whereas land or resources for disposal are less. Meticulous implementations of smart practices as below would help to efficiently handle the menace.

- *Reduction, Redeploy and Recycle[5]:* Waste Management can be effectively done by using 3R which includes Reduction, Redeployment & Recycle of waste. Waste can be reduced by increasing use of second hand items or repaired old items, avoiding disposable cutlery, etc.
- *Segregation:* Waste management can be easily done by proper segregation of waste into different categories like glass, paper, plastics, bio, metals, non-recyclable etc. Glass, paper, metals and plastics can be recycled to produce usable items. Bio degradable items can be used to produce compost or electricity.
- *Automated waste collection system:* Many cities are presently using automated system for collection of waste, which automatically transfers the collected waste from various collection points to disposal end.[6]
- *Waste to Energy:* Waste-to-energy (WtE) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste.
- *IIT Delhi - Green Initiative[7]:* Under the waste management initiative named 'Sustainable IIT-D', the institution has taken up several activities like hostel waste management, paper & plastic recycling, recycled cups campaign, poster re-use, conversion of PET bottles to light bulbs & chairs etc.
- *E-Waste Management:* Electronic waste (e-waste) comprising of old appliances like TV sets, computers, video games etc. have costly metal parts and large silicon & plastic volume. These shall be segregated at source and processed to extract valuable components and ensure proper disposal of the remaining non-biodegradable parts.

Smart Security System

Public security is an essential precondition for personal freedom, maintaining law & order situation, civil liberties, and the functioning of political institutions in a market economy. Whether people feel secure or insecure plays a crucial role for their individual well-being, influences their behaviour, and determines the demand for public security. Following initiatives shall enhance the security of smart cities:

- Electronic Surveillance at Central Command Control Centre (CCCC) through CCTV cameras placed at strategic locations
- Virtual monitoring of incidents, riots and decision making, without doing much leg work in the streets by Police
- Direct monitoring of law & order by top level officials
- Special monitoring of events like fair, festivals, religious processions
- Security Alarms in Public places & Vehicles
- E-filing of FIR such as theft of vehicle, phone etc.
- Real time monitoring of security/ patrolling teams

e-Governance

The backbone for implanting intelligence in various city attributes and services is based on the philosophy of data sharing in real time using Information and Communication Technologies (ICTs) through customized secured network between clients, city administration, public & private sector organisations. Governance mechanisms and systems shall also exploit these developments to bridge the gap between administration and citizens and bolster the concept of Open Government. Multiple service kiosks spread across the cities, providing all citizen services under a single roof have proved their usefulness in several cities like Barcelona, Bangalore etc. Such models shall be widely deployed.

Land record management, digital services, online service request / delivery, digital lockers, services through mobile application etc. would make smart city governance dynamic and citizen friendly. The introduction of web & mobile phone based services in the domains of banking, rail-ticketing etc. have already been substantiated as revolutionary development towards customers' ease. Incorporating similar platforms for other administrative and policy driven services, strengthening e-governance would thus ensure substantive values. Also, the entire channel of governance would be shortened to establish high level of transparency.

Deployment of above infrastructure /services would attract businesses, talent, skills and taxpayers because of ease of operation, in terms of cost efficiency, infrastructure (office space), broadband, telecommunications, as well as utilities such as energy, water and transportation, and general quality of life for residential, healthcare and education systems.

Open Government: Engaging Citizens through collaborative Organizations

The domain and structure of public administration has been substantially influenced by globalization and growth of capitalism. However, the paradigm shift has been explained by several authors, for instance Prof. Ali Farazmand, while answering the question - 'Why citizens have become so important in the process of governance' [8]. With extensive globalization and integration of economies, there has been a change in the role of government. While the welfare and security of citizens was always the motive of administrators, citizens didn't have much direct involvement earlier. With increasing exposure of citizens to market mechanism, it becomes inevitable to facilitate their involvement in governance, thus moving towards Open Government. The objective behind open government is that more governments increase their transparency, accountability, and responsiveness towards their citizens, with the ultimate goal of improving the quality of governance, as well as the quality of citizen services. Such approach demands for a substantial shift in norms and culture to ensure genuine dialogue and collaboration between governments and civil society. With such vision, a global Open Government Partnership (OGP) [9] has been formed to strengthen the collaborative efforts of countries in establishing a sustainable open government. At present 63 countries are contributing in the partnership. However, India not being a member yet, shall grab such opportunities to strengthen the policy platform for upcoming smart cities and attain substantive democracy.

Rise of smart cities would serve as a culmination of globalization, capitalism and consumerism. At this stage, an extensive involvement of citizens in public administration is a must to ensure sound governance. Thus, it must be ensured to put in place well coined collaborative mechanisms and organizations for citizen involvement in time for a chaos-resilient smart city environment.

Smart City - Vulnerabilities

Smart cities due to their various advantages in terms of social & economic benefits are magnet for large population searching for better living standards and employment generation. Therefore these cities would be centre of productive workforce and major economic activities. Because of enhanced dependency on data sensors, automation technologies, ICTs, software analytical applications etc. any disruption / disaster may disintegrate whole string of services and jeopardise smart city ecosystem. Very high concentration of population and economic activities make smart city vulnerable to severe damage in terms of human lives as well as financial breakdown.

Over 90% of all urban areas on earth are coastal / riverside, exposing them to sea level rise and storm surges. Climate impacts such as storms, flood and drought have financial impacts, with major disruption to business operations and city finances. To be really intelligent, cities must also consider the impacts of climate change. Disaster risk reduction is one of the key aspects in smart city development.

It shall be ensured that all buildings residential or commercial shall be built with disaster resilience as a basic necessity and shall be audited & certified by the relevant authorities. Researchers and engineers around the globe have come up with several innovative technologies and designs to develop efficient and disaster resilient infrastructure with minimal investment. Some of the examples are being discussed here.

*Building Base Isolation for Earthquake Resilience***:** The initial approach of civil engineers and structural scientists in development of earthquake resilient buildings was use of steel braces to a skyscraper's skeleton or beefier rebar to concrete shear walls. After absorbing the brunt of seismic shaking, however, the compromised structures often must be demolished [10]. With further research, it has been found that small structures fitted with wheels or spheres for little mobility, when placed on shaking test beds had better stability as compared with their rigid counterparts.

Building with Tyres for Energy Efficiency and Disaster Resilience: Millions of used tyres have been a menace for city administrators for waste disposal due to the issues of large landfill space requirement, and possibility of fire hazards etc. The trouble has however been transformed to advantage by engineers by developing techniques to use them as building material. Apart from being strong and durable, tires are quite flexible and this attribute gives significant advantage of using them to achieve shock resilience. Forming rubber bricks from used tyres through hydraulic pressing may be done for high rise commercial buildings. However, simple cutting and joining techniques may be used for building low-cost simplistic houses as shown in Fig. 4. Such earthquake resistant houses have been designed in several communities, for instance by Indonesia Aid Foundation to provide a buffer zone between the shaking earth and the houses[11,12].

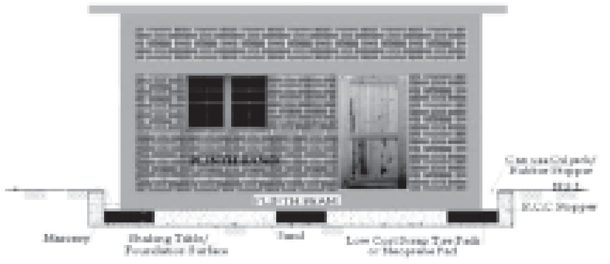


Fig. 4: Use of tyres in foundation for low cost earthquake resilient buildings

Fire Protection Planning: Apart from natural calamities, fire hazards are considered to be the most destructive incidents, particularly in densely inhabited cities. In metropolitan cities, high-rise buildings constitute major fire hazards, due to lack of adequate fire protection and evacuation plans. There was a shortage of 97.59% fire stations, 96.28% fireman and 80.04 % Fire Tenders and Rescue vehicles in India (NDMA Guideline, 2012, CR SFAC, 2011).

With such background, while moving towards smart cities it is imperative to consider planning and ensuring of fire prevention systems as a prime necessity for all buildings. Some of the basic activities that must be ensured include evacuation route planning, marking & drills, smoke detectors at critical locations, light/sound based fire alarms, special practice sessions with children, adequate fire fighting equipment & training etc.

Steps Towards Resiliency

A detailed pre-disaster plan is the core of building disaster resiliency and helps in mitigating the losses caused. Figure 5 shows the aspects to be planned before disaster to minimize the damages caused and speedy recovery.

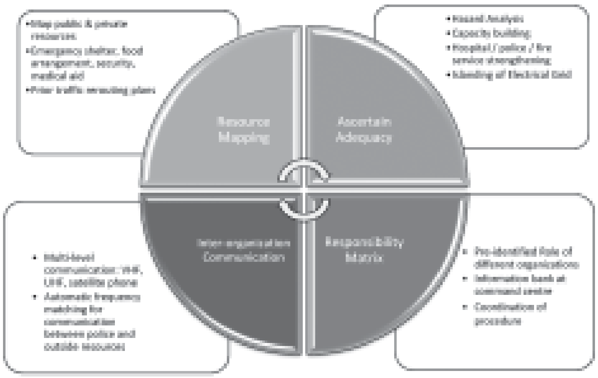


Fig. 5: Pre-disaster Planning for Risk Minimization

Emergency Management & Command Control Centre

Modernization has complexity as an inherent trait. Be it the societal structure, political interdependence, economic dynamics, social / technical networks or administrative systems, complex systems have been established at every front. While stability of all systems is the primary concern in all societies, it is well understood that complex systems give way to possibilities of chaos. Various authors have covered the critical subject of crisis and emergency management in several books and publications[13].

It is well discussed that smart city environment aims at the security and convenience of its inhabitants, but at the background is formed of several complex systems. Also the socio-economic development of these cities would lure people to move there and forming a clustered population. While all security and preventive measures aim to reduce the risk of any chaos, the complexity and population give way to great hazard even during the rare possibility of emergencies. The administration shall thus give high significance to adapt practices and systems for effective governance during emergencies to minimize loss to citizens as well as economy. Establishment of a central emergency command centre would have great advantages in management of such emergencies. Following facilities/attributes shall be included in such command centre:

- Pre-Identification of shelter & rescue camps, security arrangement etc. in case of emergencies
- Pre-planned responsibility matrix & sequence of actions for different bodies like police, hospitals, PWD, NDMA / SDMA, city administration, military etc.
- Multilevel communication chain and information centre to inhibit unwanted rumours due to emotionally surge situation during chaos
- Planned, practiced and documented rescue, evacuation & restoration plans periodically Police, being the first line of action, shall be specially trained for handling region specific emergencies like nuclear plants, mines, radioactive units, high heat furnace etc.
- 10-20% of police staff to be trained for first aid and evacuation in golden hour
- Continuous capacity building in Police Department for enhancing domain knowledge
- Elementary training to police personnel for fire handling
- Electronic Surveillance at Central Command Control Centre (CCCC) through CCTV placed at strategic locations facilitating:

a. Virtual monitoring of incidents, riots and decision making, without doing much leg work in the streets by Police

b. Direct monitoring of law & order by top level officials

c. Special monitoring of events like fair, festivals, religious processions

CONCLUSION

In the regime of global focus on advent of Smart Cities, it must be noted that development of the disaster resiliency for smart cities are inevitable towards sustainability. This paper discusses various attributes of smart cities and aspects for sincere consideration during their development. To summarize, following points shall be considered to ensure that the on-going advancements lead us to a safe and sustainable future:

- Very high concentration of population and economic activities make these cities vulnerable to severe damages from disasters
- Necessity is for building resilience in all domains to prevent, mitigate, prepare, respond to and recover from the impacts of disaster
- Open government & citizen centric governance and emergency management are needed in administration of these cities
- Efficient & innovative utilization of infrastructure is needed to alleviate the living standards of economically weaker sections of the society
- A comprehensive Emergency Command Centre shall be established with all administrative facilities for effective coordination & information sharing
- Pre-identified role of different administrative and disaster management agencies shall be laid out and coordinated
- NDMA/SDMA shall further strengthen/modify established legal framework to broaden the statuary role of police in disaster management
- Special training and capacity building of Police for medical aid and evacuation as per region specific requirements like mines, nuclear stations, radioactive units industrial environment etc.

REFERENCES

1. New Climate Economy Report 2014
2. Report on "Indian Urban Infrastructure and Services", March 2011
3. "Smart Grid Primer", Power Grid Corporation of India Limited, 2013; www.apps.powergridindia.com/flex/split_document.aspx?doc=A23508FE-EC7F-45E2-B3BE-4F94E138A22B.pdf
4. www.fortune.com/2015/08/07/nasa-drone-air-traffic-management-project-software/
5. United Nations Environment Program, Final Project Report on "Engaging Governments and Industry in Demonstrating 3R Principles through Integrated Waste Management", 2010
6. www.waste-management-world.com
7. Article in Business Standard dated 10/6/2015 on "Green initiatives galore at IIT Delhi"; www.business-standard.com/article/pti-stories/green-initiatives-galore-at-iit-delhi- 115100400118_1.html
8. "Sound Governance: Engaging Citizens through Collaborative Organizations", Ali Farazmand, Public Organization Review, September 2012, Volume 12, Issue 3, pp 223-241.
9. www.opengovpartnership.org
10. www.popularmechanics.com/technology/design/all759/earthquake-proof-building-that-is-built-to-collapse
11. Sustainable blog on "Building with Tires for Energy Efficiency and Disaster Resistance"
12. Vanak A.F, "Low-Cost Earthquake Resistance Techniques", NIT, Surat.
13. "Crisis and Emergency Management: Theory and Practice", Second Edition By Ali Farazmand

GEO SPATIAL TECHNOLOGIES FOR SMART CITY BHUBANESHWAR

Pramod Kumar DAS[1]

ABSTRACT

The smart city, Bhubaneswar is located between Latitude 20 ^{0} 10 ′ and 20 ^{0} 25 ′ and longitude between 85 ^{0} 45 ′ and 85 ^{0} 55 ′. Approximately, covering 410 sq km. The city has one airport , five art galleries, and museums, forty-eight important high rise buildings, six cinema theaters, seven firms and gardens, fourteen guest houses, thirteen Archeological monuments and twenty-one important hotels and restaurants, one hundred and four prominent intuitions, seventeen information and training centers, thirteen parks, fifteen prominent cell centers and markets, five stadiums, five universities, nine bus stands and railway stations covering around 200 villages and about 300 colonies. All these require Spatial Data Infrastructure (SDI) for instantaneous context-aware services for the geospatial community.

The user community of Geospatial Data always requires qualitative data. The completeness, the positional accuracy, unique address system of each property, its attribute is some of the important data quality. The property address is a fundamental component of any Government delivery system. Addressing helps in defining the administrative boundary and political setup. It also helps Government setup system for tax management. A cadastral infrastructure that facilitates efficient land and property markets protects the land rights of all and support long-term sustainable development and land information system (LIS).

This is the era of technologies. The launching of the high resolution of satellites has revolutionized map making process. These satellites provide data with high spatial resolution, multi spectral bands, wide field coverage, better revisit cycles, stereo capabilities with good radiometry with the help of which large scale map can be prepared and updated. Today, we have digital aerial cameras which can collect ground information with resolution better than 5 cm. Similarly, the availability of GPS and IMU data and the exterior orientation parameters of aerial digital camera position can be very accurately determined which helps the process of Aerial Triangulation much easier and faster with better converging solutions. Similarly, there is the availability of various H/W and S/W in the market which has got credibility to handle a large amount of data, processing, analyzing and providing tailor made solutions.

*The Information and Communication Technology (ICT) plays a vital role in data sharing, distribution, updating and maintenance of spatial data infrastructure. Digital Elevation Model, orthophoto generation, and virtual GIS help administrator, Government, the private sector and utility companies for the planning of public space, road management emergency services efficiently as when required in various phases of disaster management i.e. planning, mitigation, response and recovery.*Bhubaneswar with all these geospatial hubs can be made available to all end users provided there is a strategic realignment with SDI with the help of ICT.

Keywords- *Spatial Data Infrastructure, Land Information system, GPS, IMU, Information and Communication Technology*

INTRODUCTION

The Smart Cities Mission was launched by the Ministry of Urban Development, Government of India on June 15, 2015. The Mission's objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.

Smart Cities focus on their most pressing needs and on the greatest opportunities to improve lives. They tap a range of approaches – digital and information technologies, urban planning best practices, public-private partnerships, and policy change – to make a difference Developing smart visions and solutions requires leveraging all available assets. Security of citizens and health & education facilities involve the core infrastructure elements of the 'smart city' project.

SMART CITY MODEL

Adequate water supply, uninterrupted electricity supply, sanitation, including solid waste management, efficient urban mobility and public transport, affordable housing, especially for the poor, robust IT connectivity and digitalization, safety and many more

There are three main components which are responsible for smart city system. They are an Economic component, Environmental component, And social component. This course only possible with the integration of Geomatics technologies. The

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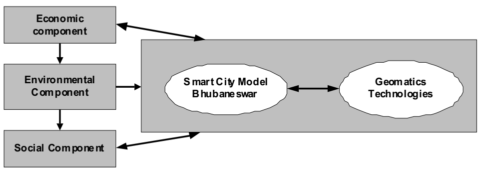
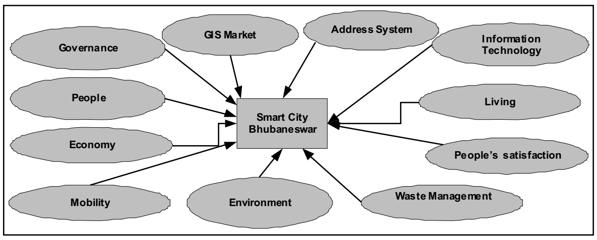
Economic component includes public administration and economy. Similarly, Environmental components include resources and managerial infrastructures including water air energy, waste management, public transportation, geographical information, buildings open spaces, climate change measurement, etc. Social components include citizens. Including digital education, creativity, tourism & culture, health, and safety, technology accessibility, etc. The use of geomatics is one requisite for establishing a smart city. Geospatial technologies are required for data management for the citizens and decision makers.



Key Drivers to Change Smart City

A smart city is a solution that allows a city to avoid a chaotic development and thus sustains its attractiveness and supports its positive development to assure an efficient management of resources etc. The Governance, Economy Mobility, Environment, people, and living are some of the key drivers for a smart city.

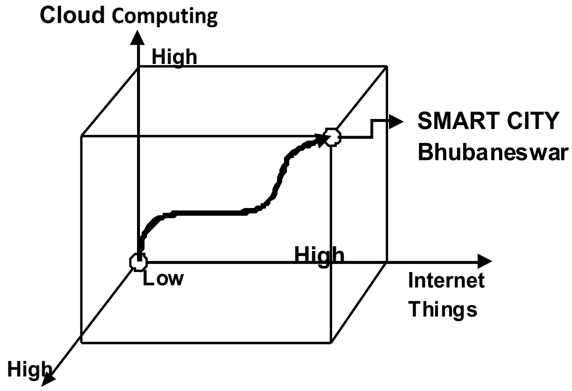


Geomatics Technologies

Geomatics applications are numerous and range from a broad variety of Domain such as Forestry, Health, Urban Management, Civil Security, Tourism, Cadastral, and many more. This is only possible if we have got topographical information stored in a server along with other departmental data as attribute attached to a feature. From the geomatics perspective, the fundamental and operational issues for a smart city are addressed, georeferencing of all the spatial features, integration of global position system,(GPS) Remote sensing and GIS, communication, service capabilities in a cloud environment. There are also technical difficulties with and challenges for location clouds and remote sensing clouds the integration of video and remote sensing platforms with GIS and the capabilities and potential utilizing smart phones in indoor navigation.

Digital City

Digital city evolved from the concept of digital earth. A Digital City is a seamless framework containing all kinds of information to ensure the city operates smoothly and orderly. It aims a Spatial Data Infrastructure (SDI) with a seamless framework containing all kinds of diverse information from various departments. A digital city is a copy of our real world. Particularly it consists of a 2D Digital map, 3D vertical data, 4D spatial-temporal database and points of interest along with all attributes. The supporting techniques are



3D Geo Spatial Frame Work (Digital City)

1. Collection of Control points
2. Selecting a suitable Datum
3. Selecting a suitable projection system
4. Aerial photographs
5. High-resolution imageries
6. Performing aerial triangulation with the help of control points
7. Creation of Digital Elevation Model (DEM)
8. Generation of Ortho photo
9. Extraction of features either in 2d/ 3d mode
10. Generation of contours
11. Field verification and collection of attributes
12. Correcting the data in house and attaching attribute
13. Storing the data in a database
14. Generating multi scale, multi dimensional visualization of geospatial data
15. Distributed spatial data archiving and management for federal database with interoperability
16. Spatial data analysis and mining techniques
17. Global navigation satellite system (GNSS) and location based service techniques

The ultimate goal of a digital city with the help of all the above technologies is to provide the right data to the right person at a right time and a right place.

Internet Things

Anything that can be connected through the internet adopting radio frequency identification (RFID) infrared sensors, GPS, and information sensing devices i.e., cameras and sensors. Such connections can be used for intelligent identification, localization, tracking, monitoring and management of things. The internet things are a combination of four layers. They are Distributed Sensor Layer, Ubiquitous Network Layer, Service Oriented Middleware Layer and Intelligent Application Layer.

Cloud Computing

Cloud computing is based on the Internet and is an extended concept beyond distributed and grid computing that has evolved with resource configuration on the internet. Through software re-use and flexible combining cloud computing makes information service interactive, professional, and infinitely shareable. Cloud computing can process massive amounts of global data quickly and provide services for a large user community. In addition cloud computing allows for a more user friendly, rapid and individualized interactive services. Users of cloud computing do not need to be aware of the operation system, database software platforms, hardware, location of computing centers, software providers, and service approaches. Cloud computing, generally includes four levels. i.e., Hardware, Infrastructure, Platform, and Application.

CHARACTERISTICS OF BHUBANESWAR FOR SMART CITY

Bhubaneswar city has got digital data for geometrics applications for Topo Sheets. Data are also available in 1: 25, 000 k in digital form. Apart from that Guide maps is available in the digital form best suitable in 1: 20K. These data is the basis of a Smart City. Apart from that Google imagery helps to provide a similar type of information. A lot of remote sensing data with various temporal resolutions are available for any kind of analysis. Combining GPS and video cameras with GIS techniques makes it feasible for the control center to monitor the streets of primary interest, update real time information and carry out GIS analysis. Apart from this integration of space borne, airborne and terrestrial sensors makes real time data actuation is also possible

Bhubaneswar City Administrative Setup

The entire city has been divided into 60 municipal wards and numbering from 1 to 60. The entire city is located in Khordha district.

Rivers & Nalas

The city is surrounded by many rivers i.e. Kuakhai Nadi, Bhargavi Nadi, Daya Nadi. Moreover, there are many perennial nalas like Tikra Nala, Jhumuka Nala, Baranga Dhar, Baranala Nala, Gangua Nala are in and around the City. Due to these, there is no water scarcity in the city throughout the year.

Industries

There are no such big industries located in the city. However, there are 25 small industries exist in the city which provides job opportunities to the local inmates. Rivers are not polluted due to the absence of Industries.

Communication

Very wide roads having dividers in between make the city very comfortable to the public. Bypass roads from Cuttack to Puri, Cuttack to Khordha make city decongestion for traffic flow. Railway line from Howrah to Puri/Chennai/Hyderabad/Bangalore passes through Bhubaneshwar. There is an International Airport situated in the heart of the city well connected from different corners where one person can reach within 30 minutes.

Topography

A small undulation in the city makes the city water drained within one hour even after a heavy rain. The city forms an integral link in the Golden triangle that incorporates Puri, (vast sandy beach and Lord Jagannath Temple), Konark (famous for Sun Temple, the Black Pagoda).

Agricultural Products

The city is surrounded by fertile lands harvests Rice, various kinds of fruits and vegetables, and milk products.

Fisheries

Central Institute of Fisheries & Aquaculture which is situated at the south-east of Bhubaneshwar providing fresh fishes to the whole community.

Reserved Forest

Bharatpur Reserved forest and Jagannath Prasad reserved forest are situated in the heart of the city providing the climate a better environment.

Offices Associated with Geomatics

Survey of India has got a digital map which is most suitable for 1:20 K hard copy maps. Apart from that SOI has got 1:50 K OSM and DSM maps. It has also got 1:25 K series maps. Similarly, there are GSI and State remote sensing center who have got their own maps. Photographs of temporal resolutions are available with various organizations. Remote sensing data and Orthophoto are also available with Survey of India. There are many organizations having their own data draped with a survey of India Topo Sheets.

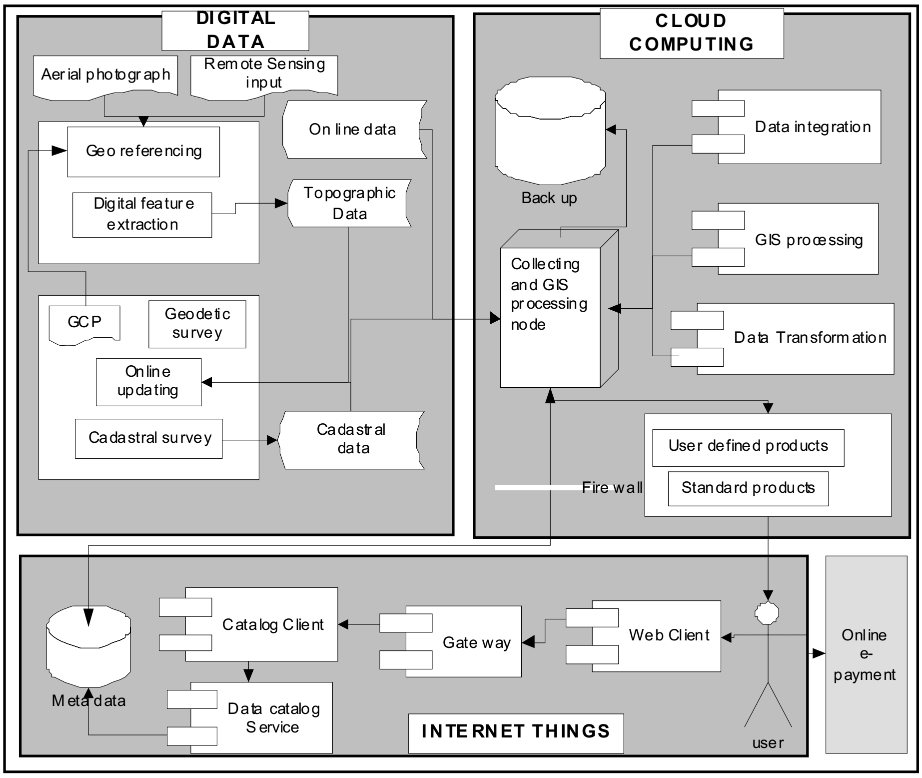
These data all together can help any planners to make necessary quarries for their applications.

NECESSITY OF SDI

Spatial data Infrastructure is very much required for handling all these huge data and to merge and to provide user community as per their requirements. Catalog service and Metadata service are prerequisite for handling SDI. For this achievement, all the organizations are to reorganize themselves. Geo information management concerns the development and management of tools and methods for collection, storage, and processing of spatial data and the dissemination and use of these data and the service derived from such data.

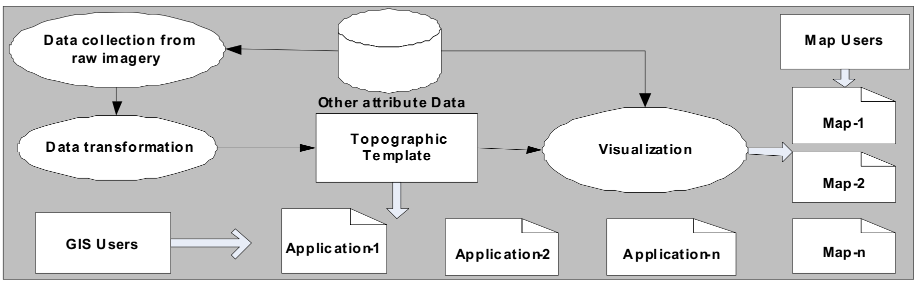
PROPOSED OPERATIONAL ARCHITECTURE

A proposed operational architecture has been shown below. Production workflow, service workflow, and geodatabase management are the three main components of proposed operational.



PRODUCTION PROCESS

The management will adopt production process in line with the requirements of the growing need of the user community for a diversity of products rather than standard one.



CONCLUSION

Massive amounts of geospatial data in real time in a city can be instantly analyzed and processed using cloud computing platforms which will ultimately provide support to urban management via smart sensor networks smart municipal supervision, smart transportation, smart environment monitoring and smart tourism will be managed effectively by GEO ICT with the help of data updation and providing right information at right time at right place can be provided.

COLLECTIVE EFFORTS TO URBAN DEVELOPMENT THROUGH PARTICIPATORY MODELS- LEADING TO A SMART CITY

Sagar DESAI[1]

ABSTRACT

Effective urban planning and management can only be achieved in the cities if one listens and reciprocates their people's knowledge, experience and understands their situations, requirements, and do not impose the predetermined models irrespective on their rate of success. When communities actively involve with the identification of their problems with solutions then the process of intervention starts. Participatory planning is based on networking among the majority of stakeholders who are related and may be affected by decisions. Therefore, integrating relations and reaching consensus are the major aspects of the planning process. In order to achieve this, a thorough understanding is required at various levels of participation in practice. The need of heterogeneous community is to be catered, in order to do so it is required to study the complexities involved, aspirations and limitations for guiding their growth and development.

***Keywords**: participatory planning, stakeholders, communities.*

INTRODUCTION

The economic growth in india has been the result of urbanization, which has acted as a catalyst. This growing india has contributed about 60 percent of the total gdp, which is projected to become 75 percent by 2020. Few prerequisites for the future growth and development is sustainability. Moreover, to continue efficient urban productivity for a country an efficient management is mandatory. This can be achieved by adequate urban infrastructure, land management and improving the environment for the people of the country. Therefore, planning becomes an imperative approach to inculcate investment both in public and private forms. These investments need to be kept in check with regulatory bodies, so adequate and right decisions are made.

While preparing the spatial decisions few things which may be required to address are the diversity in the interests of stakeholders on both working and living environments, which recommends inclusion of different stakeholders. These issues possess many challenges to the contemporary planners and architects to manage all the social, economic and environmental conditions. For planning an effective framework in the policy making process it needs to be supported with a social background and at the same time it should also reflect the society for which it is planned.

SCENARIO OF PLANNING IN INDIA

There is a huge dilemma when it comes to implementation of planning policies in india. Due to social diversity, demographics there is huge under-representation of the mass. The businessmen remain pessimistic about their hearing to the people who are managing the planning authorities. Many urban ill fits are due to the conflict in the planning authority and society as a whole which results in non-compliance of people's aspiration. There is a requirement of huge transparency at the urban level.

Many decades have passed away after independence with a question of participatory methods for urban land management. Still the question of the beneficiaries is still there. One of the sustainable ways that have emerged out, is land management through the urban development process. This has its own merits and demerits; it's quite important to learn and preach these planning process which involves people for assessment of conventional planning tools.

Throughout the world, the phenomena of physical planning have significantly widened and have included issues dealing with social crises, economic crisis and political agendas. Therefore, the modern approach to planning requires multiple mire approach to equate shareholders' resources and sustainable development. At many policy levels, the governments across the globe have tried to take the decentralized approach. The 73rd and 74rth constitution amendment act, 1992 has transferred many administrative and financial powers to the local bodies.

A commendable initiative was taken by the government of india with an alliance of the united nations centre for human settlements (unchs) and has launched good urban governance campaign (poptani, et al., 2005). The agenda behind this was to inculcate an environment for interactive discussions with local governments, service providers and all stakeholders. The campaign focuses on improving the quality of life of the city dwellers by designating them as inclusive cities. Civic management may succeed in a city by participation in forming the policies for the public, proper allocation of resources, service delivery and monitoring, civic discipline and removal of poverty.

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Urban Development Participation

Public participation in urban development and land management means the inclusion of all people and stake holders at all levels for sustained development. When people are included their approaches may be referred as bottom up planning, grass root planning, participatory planning, democratic planning and collaborative planning (poptani, et al., 2005).

It is almost impossible for a single body to execute all statutory administrative work in any metropolitan region. Therefore, here the strategic planning comes into force which adheres negotiation and cooperation with all organizations and also involves public responses. Reasons for in cooperating a participatory approach are manifold they are:

a. Complications raised due to planning frameworks authority,
b. Competitions raised due to multiple interests,
c. Issue raised due to a plan or policy,
d. Issues due to question of jurisdictions of authorities or more than one authority are involved.
e. The presence of an agency which is in favor of public engagement.

Different Forms of Public Participation

Engagements and consultations: this is a means of participation with public by addressing their thoughts, clearing any misconceptions, exchanging ideas and opinions while being sensitive to the power imbalances of the government.

Role of intermediary: role played by the authorities which act like a mediator by addressing other stake holders, identifying and clearing disputes and resolving disagreements.

Arbitration: when the disputes are not resolved by all means then a neutral third party comes into the picture to resolve the dispute.

Negotiation: this happens when all the concerned parties come to a common consensus, by exchanging information, bargaining and compromise. (poptani, et al., 2005 as mentioned in hauge and higgins, 2003)

Some Examples of Participatory Models

Participatory planning in urban context may be facilitated with fostering partnerships between various stake holders, development authorities, ngos, cbos and the private sector. Thus, partnership networking and understanding the complexities is the challenge involved in participatory planning. All these partnerships are essentially required for smooth governance, improving efficiency by empowering stake holders. All these models help in policy structuring, organizing and developing systems, improving in knowledge and training and overall create a platform for sharing experiences in urban planning and management.

The 74rth constitution amendment act has periodically led to three models in chronology. They are:

a. GCPP- government centered people's participation model.
b. NCPP- ngo centered people's participation model.
c. NLAP/tripartite model- ngo local level authority-people interactive model. (poptani, et al., 2005)

All these models have manifold issues for example:

The GCPP model has been applied in mumbai which shows a direct interaction between the local authority and the people. This comes into effect by the formation of committees that are formed within the jurisdiction and the territorial areas of the concerned municipalities.

The MCGM model introduced the concept of advanced locality management (alm) with an intent to involve citizens. This model is introduced and managed by the localities or a group of buildings which are motivated by ALM societies. The basic job for mcgm is to notice issues like water supply, sewerage, storm, cleanliness, etc. Another important work that alm has to do is proactive administration. I.e. Appointing officers at ward level, cities are divided into wards and further wards into beats.

This regular interaction is followed up by the additional municipal commissioner who would once a month meet the alm and review the whole movement. There are many issues that come up with this model like:

a. More emphasis is laid on the partnership model between citizens and mcgm instead of pressure groups.
b. This movement is also encouraging for garbage separation and overall maintenance. Further, it is also gradually taken up for metalling of road, illegal constructions, etc.
c. NCPP involves the participation of NGOs and CBOs invite civic services which the local authorizes are supposed to provide. One such group is shelter associates in pune which with the urban poor, particularly women in informal settlements has provided technical support to the community managed housing (slum rehabilitation) and infrastructure projects. (poptani, et al., 2005).

Shelter associates has involved in this project, there were 500 slum settlements and even the basic amenities like toilets were missing, there was only provision of one toilet for 2500 people. Therefore, they started the toilet building campaign. The project involved baandhani; collectives of men and women hailing from slums and other settlements to work for the project. There were series of demolition and built up of new toilets as per the existing and growing population. Shelter associates was only a guiding figure in the whole event where as all the work including site selection was done by the people. The toilets were well connected with the sewer and septic tanks were incorporated where the possibility was connection low. (poptani, et al., 2005)

The crux behind this success was that throughout all the planning the poor were involved at all stages of planning, design, implementation and maintenance. Otherwise, the project would have failed. The main reason for success were

a. A sense of belonging was established.

b. Since people participated the NGOs found it quite easy to work at grass root level.

The 74rth constitution amendment act had placed the NGOs as a non- powered body and on many occasion they were even tagged as an obstacle by the government. Therefore, the role of NGOs was quite limited.

Unlike the NCPP model NLAP provides a platform for intensive interaction with the urban development. In this model, the role of NGOs has risen. It varies from land tenure to infrastructure development via micro credit and housing provision. Pune's environmental status report (ESR) was based on the above model.

This movement involved an active participation of citizens for the determination of pune's environmental policies and used it as a guide for planning and financial decisions. This process helped in establishing a relation between the people of pune and the governance. A local NGO MASHAL was appointed as an assessment agency in the preparation of environment situation. (poptani, et al., 2005). The put come of this participation as quite positive like;

a. This movement was more effective because of the participation of municipal corporation.

b. The other credit goes to the ngo which took an initiative in providing technical support to the citizens.

The work in this kind of model need to be clarified since the beginning like financial and functional, further the issues can be dealt through sectoral understanding which leads to better role clarification.

There are many participatory models

NGOs

Our country has many organizations for civic engagements with the public and most of them are overburdened. Therefore, non-governmental organizations exist which deal with the issues like community development, social justice, gender inequality, natural resources, skill development, education, health and sustainable development. As many move from rural to urban and since the importance of panchayats is decreasing these organization seem to strengthen.

As far as NGOs are concerned their relationship with the local bodies are very important but due to change in policies and political governance this seem to deteriorate. NGOs have multiple donors and some are quite sector specific, so they often exploit the conditions by using their expertise for monetary benefits.

Generally, the NGOs focus on community development. Only handful have started to work on urban development and urban policy making. Off late few have been noticed to involve in the institutional development of local governments. The efficiency of these NGOS is considered on its effective capacity to participate in beneficiary groups for urban development programs.

Role of Professionals

Usually, appointed professionals negotiate between the government and the citizens to work out a solution. Another way to look at it is they must work at a base level and come up with strategies. The most prominent way is to have a web established between all the stake holders who are affected by the decisions.

Participation at Global level

Since more and more rural areas are turning up to become urban livelihood, therefore there is a requirement for city alliance with each other. The cities alliance was launched in 1999 with support from world bank and united nations centre for human settlements (UN-habitat). The agenda of these alliances is to improvise the living conditions for the urban poor, use the grant-aid as require and finally improve the coherence of effort among the on-going urban programs and by linking grant funded urban development. (poptani, et al., 2005).

UCLG- united Cities and Local Governments

UCLG is also a world organization composed of local authorities which work under the supervision of un-habitat to upgrade the role of local bodies at both national and international levels. UN-HABITAT urges mayors and leaders to work in collaboration in achieving improvised life for the citizens. (poptani, et al., 2005).

CITY NET

This model was established in 1987 as local bodies may make up a friendly alliance with each other for a sustainable, economical and participatory growth of the country. It comprises of local governments, NGOS, CBOS a municipal association. Local CITY NET members i.e. From the same country have established CITY NET national chapters, whereby cities collaborate and co-operate to come up with technical and other urban management issues. It also enhances participation between government and local bodies through web system.

CONCLUSION

The development plan is always concerned with fulfillments of people's aspiration, therefore, it is mandatory to consult the people who are affected by it in the process of policy decision making. It is suggestive that a relation is developed both the people for smooth government and facing criticism. Other voluntary organization may extend a helping hand but they must be identified and used in the correct sector. Citizens must be made aware of their rights and duties by doing so a clear voice shall be heard from them and they will also feel the sense of stakeholdership and belonging. This needs to be implemented to the entire country to see india as s developed nation.

REFERENCES

1. Baumann, boland, & hanemann. (1998). *Urban water demand management and planning.* New york: mcgraw hill.
2. Beneharo, r. (2009). *Attraction of petrels to artificial lights in the canary islands: effects of the moon phase and age class.*
3. Biswas, r., khare, d., & shankar, r. (2008). Alternative appraches to urban water management. *The spa journel of planning and architecture, 13*(2), 65-75.
4. Buckman, a., m. Mayfield stephen, & b.m. beck. (2014). What is a smart building? *Smart and sustainable built environment.*
5. Burn, desilva, & shipton. (2002). Effect of demand management and system operation on potable water infrastructure costs. *Urban water*, 220-240.
6. Cambell, & johnson. (1999). Some best bets in residential water conservation: results of a multivariate analysis, city of phoenix.
7. Deakin, m. A. (2011). From intelligent to smart cities. *Intelligent buildings international, 3.*
8. Gaur, s. (2010). *Total water management of chiksauli & maanpur. Training organization : the braj foundation, mathura students' work.* Ahmedabad: cept university.
9. Mcdowell, a., & sharma, a. (1987). *Vignettes of vrindavan.* California: university of california.
10. Stubbings, m. (1988). *Www.smart2020.org*. Retrieved from enabling the low carbon economy in the information age.
11. Y.j. siew, balatbat, m. C., & carmichae, d. G. (2013). "the relationship between sustainability.

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GEO-SPATIAL TECHNOLOGIES FOR PLANNING SMART CITIES

Swapna SAHA[2]

ABSTRACT

Geo-spatial technology means the technology which is related to the collection or processing of data with location. Main components of geo-spatial technologies are gps: a satellite based world wide geolocation system which is easily accessible to the public. Another component is rs: the acquisition of information from images (satellite imagery and aerial photo). Gis is the other component: a gis is a system or tool designed to capture, store, manipulate, analyze, manage and present all types of spatial or geographic data.

There are six characteristics in a 'smart' city. It has a smart economy, smart mobility, smart environment, smart governance, smart people and smart and sustainable living. The quality of life and sustainable management and development of environment are important values and goals for a smart city. Geo-spatial technologies are very important and essential for making 'smart city'. Digital master plan should be prepared to improve efficiency and capacity of city services.

***Keywords**: GPS, RS, GIS, Smart City*

INTRODUCTION

In smart cities, everything will be measured in real time and fine detail through the deployment of sophisticated sensors. Geospatial technologies will play a major role in integrating mountains of real-time data. It will improve applications that range from managing environmental quality and built environment to land use and transportation planning. The result will be better in the aspect of making decision, efficiency, and communication.

The location is a common dominator in every aspect, and geospatial technology is central to providing a technology platform that forms the backbone of the city. Smart cities are future to sustainable support population growth and urban expansion.

There are now various types of geospatial technologies:

- **Remote Sensing:** imagery and data collected from space or airborne camera and sensor platforms
- **GIS:** suite of software tools to map and analyze geo-referenced data; can be used to detect geographic patterns in other data, such as disease clusters resulting from toxins, suboptimal water access, etc
- **GPS:** a network of satellites that can give precise coordinate locations to civilian and military users with proper receiving equipment
- **Internet Mapping Technologies:** software like google earth and web features like microsoft virtual earth to view and share geospatial data.

The components of smart cities are greater automation, intelligent routing and transportation, better monitoring, and better city management. Geospatial technology will be play important role for planning smart cities for example vast municipal data management, the creation of sensor networks to improve infrastructure monitoring and performance, network connectivity and bi-directional communication with citizens regarding city services.

AIMS AND OBJECTIVES OF SMART CITY

Infrastructure Development: The concept of infrastructure development involves the combination of sensors, network connectivity, and software to monitor and analyze inputs for more efficient operations. This concept meshes nicely with advancements in geospatial technology that are moving toward more real-time data inputs, 3d visualization, and the ability to track change over time. The planner of smart cities can use geospatial technology for proper and sustainable use of infrastructure facilities i.e. Efficient use of water, use solar energy for control pollution, solid waste management, use battery base vehicle and well-connected road network system.

Development Urban Operating System: Increasingly cities are talking in terms of a single operating system to manage the city, rather than the old it construct of individual systems for specific services or applications. This change implies greater access and interoperability with an environment that takes in sensor readings and can be queried across different inputs and geographic scales. With the increasing importance of location to provide greater context, the mapping will be central to many visualizations of this increasing data volume. The interactive and open web services model for city management and citizen interaction plays right into the latest iteration of web-

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based mapping, where data and services are compiled online.

Operating systems are so useful that they are now being used in devices like mobile phones, tablets, televisions, washing machines and refrigerators. They are now set to migrate to a different kind of device: the city. Operating systems will soon be used to manage a city in portugal, near the tourist town of parades. Here, a five-year-old swiss startup, living plan it, is leading the construction of a new city spread over 17 square kilometers. At the heart of this city is the urban operating system (uos), the company has co-developed. The uos optimizes all the services in a city, just the way a computer optimizes all its resources. It constantly receives data inputs from around the city and makes sure traffic lights; air-conditioners and other appliances are all working optimally. During emergencies like a fire, for example, it guides people to exit routes and controls traffic signals so that the fire service can reach the area quickly.

Even in india, there are departments that are beginning to employ smart technologies. Bangalore's traffic police have 180 cameras around the city managed from a control room. "bangalore has the most advanced traffic management system in the country," says v ravichandar of feedback consulting, an urban development consultant in bangalore. In mumbai, the recent terrorist attacks have prompted the development of a city-wide security system. Many large private developments have begun to incorporate smart technologies. It companies now consider the delhi-mumbai industrial corridor to be a great opportunity to build several smart cities in the next two decades.

Development of Proper Designing: The megacities of developing countries (india) are the areas of high vulnerability. The rise in temperature could exacerbate the heat island effect of cities that already make them hotter than the surrounding countryside. High energy use and inefficient water treatment compound the detrimental impacts of human populations on the environment. So planning and designing of smart cities require a better understanding of how the built world impacts the natural world. Geospatial technologies can help us get a better handle on the balance needed to improve efficiency, and help us respond and manage the threats facing cities, and the threats cities pose to environmental balance. Major cities of india have already begun the transformation by retrofitting themselves with smart technologies.

Cities are adopting smart technologies for different reasons: amsterdam to reduce its carbon emissions, tokyo to become more competitive, and china to tackle its resource scarcity. Elsewhere, south korea is using cities like living labs to help domestic companies drive growth in other markets, specifically in india and china. In every case, the smart city is the beginning of initiatives that will drive big changes on the earth over several decades.

Geospatial technologies offer a potential of powering the smart city to capture, store, manipulate, analyze, manage and present all types of data in a geographical context. By creating a platform that is geo-enabled, cities can collect, organize, manage, fuse and analyze data from multiple disparate sources. As a result, a complete picture of the situation is available on a common operational platform at any given point in time. So these will help to take in smarter decisions towards faster and cost effective service.

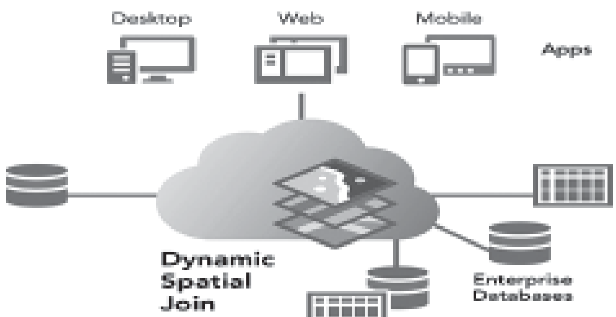

Fig. 1: Use of Geospatial Technology in Database Making of Smart City

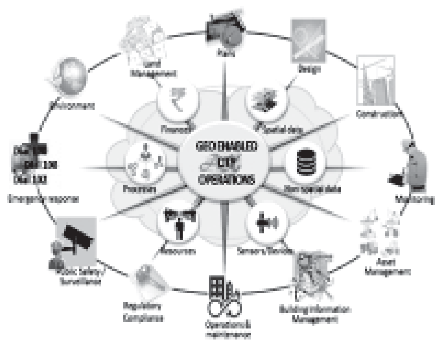

Fig. 2 : Geo- Spatial Technology in Smart City Management

Some Important Aspects of Smart City

(a) A city equipped with basic infrastructure to give a decent quality of life. A clean and sustainable environment through the application of some smart solutions.

(b) assured water and electricity supply sanitation and solid waste management, urban mobility & public transport, robust it connectivity, e-governance, and citizen participation, safety and security of citizens.

(c) To develop a public information system, grievance cell, electronic service delivery, citizens' engagement, waste water management, monitoring water quality, to introduce a renewable source of energy, green building, smart parking and intelligent traffic management system.

(d) Smart cities council in india has been formed as a part of u.s. based smart cities council.

(e) The basic criteria for selection of a smart city.:

  (i) implementation of e-governance.
  (ii) publication of e-newsletter.
  (iii) putting all government expenditure online for public
  (iv) swatch bharat
  (v) track record of paying salary to employees

(f) Area Based Development. Divide area, planning in an existing built-up area in a municipal ward for example new market in kolkata, connaught place in delhi.

(g) Greenfield: Introduction of smart solutions in a vacant land using innovative planning (example land pooling/ land reconstruction in salt lake city in kolkata). Redevelopment and replacement of existing built-up area and are preparing a new layout plan with enhanced infrastructure (rajarhat in outer kolkata).

In conclusion, it can be said that urbanity merges with digital information. Geospatial technology is based on interoperability, scalability, and flexibility. The goal of this smart city is to address urban problems while spatially enabling citizens with important information. The built environment becomes a living, breathing entity that can respond intelligently to new information or community needs thanks to real-time data analysis and connected information systems.

Fig. 3 Planning of Smart City Mapping Inconnaught Place in New Delhi

Planning of Smart City Mapping on Rajarhat (Outer Kolkata), West Bengal

The smart city is the sustainable urban model. It is sustained by the european commission. The cities consume 75% of worldwide energy production and generate 80% of co^2 emissions. India is rapidly urbanizing and developing the country. It is expected to increase urban population in india 600 million in 2031, which will be very alarming to the country's economic growth. Proposed 98 smart cities will be the oxygen supplier of the country. They integrate information and communication technology (ict) energy efficiency and sustainability to support the future generation.

REFERENCES

1. Role of Geospatial Technologies in Building Smart Cities by Pratappadode.
2. Program you City: Legal & Governance Issues of an Urban Integraded Open Data API, Berkmancenter for Internet & Society, Harvard University.
3. How Smart Tech are Drawing Cities of Tomorrow, the times of India, Nov.3, 2011.
4. What Smarts do Geospatial Technologies Offer Smart Cities by Matt Ball on Nov. 4, 2011.
5. How Smart Cities Use Geospatial Tech by Mary Velan.
6. Safe City Architecture for Citizen Centric Services for Smart Cities in India (Govt. Webcite).
7. Geospatially Enabled Urban Infrastructure and Governance Information System (UGIS) for 100 Smart Cities Mission (Govt. Website).
8. Sanjay Dutt, Executive Managing Director, Cushman & Wakefield, Five Essential Element of a Smart City, Published in 22.01.2015.
9. 'The Smartest Cities Methodology,' by Boyd Cohen.

Cartography for Population, Environment and Development

URBANISATION AND CHANGING CHILDHOOD: A CASE STUDY FROM SUBURBAN KOLKATA

Abhijit GHOSH[1], Siddhartha Sankar NANDY[2]& Joydeep SAHA[3]

ABSTRACT

In today's context of glittering lifestyle, burgeoning opportunities and consequently escalating urban land prices, built-up areas are expanded to meet the needs of growing population at the expense of open lands, a fraction of which was earlier used by children as their playgrounds. It curtails the scope for children playing outdoors. On the other hand, easy access to attractive electronic gadgets alternates outdoor play. Therefore, their pattern of Utilisation of leisure time has altered significantly. This study, planned in Barrackpur, a municipal town in the north suburbs of Kolkata, attempts to find the pattern of shrinking of open space; to identify the areas served by the existing playgrounds and to identify the leisure activities of the urban children. Using Remote Sensing, GPS and GIS, this paper analyzes the spatial and temporal change in the study area with special emphasis on the shrinking of the open spaces. Google Earth images of different time periods have been processed to depict past alterations and decipher the present status of open spaces. Individual playgrounds have been identified with subsequent demarcation of their respective hinterland. Questionnaire surveys and personal interviews with children, parents, teachers and other stakeholders have been used to elicit the required data used in this analysis.

Keyword(s)*: Urbanisation, Open Spaces, Playgrounds, Children, Right to Play*

INTRODUCTION

Although India has traditionally been viewed as 'rural', its urban population is absolutely huge (377 million as per Census of 2011 figures), and in recent decades, more and more people have in-migrated to cities and towns. Today, a large chunk of Gross Domestic Product share (66 per cent) comes from urban centres, thanks to manufacturing and service based economic activities (Ahluwalia, Kanbur and Mohanty, 2014). In terms of infrastructure and amenities, urban centres appear to be attractive, and thus today's socio-economic and political dynamics of India significantly revolves around urban centres. One of the most visible outcomes of Urbanisation is the prominent change in Landuse and Landcover (LULC), as built-up areas continuously engulf open spaces and water bodies. This large-scale change of LULC has a considerable impact on childhood. Children used to play outdoor games in playgrounds and other open spaces, some of which have been converted into built-up areas for residential and commercial purposes (Moore, 1997). Along with diminishing playing spaces, other factors like pressure of syllabi and school hours, parental pressure on pursuing other extracurricular activities, use of attracting electronic gadgets, problems of existing playgrounds also deter children from playing outdoor games.

In such a context, Indian cities may strive to become 'child-friendly', as few examples in developed countries show how city authorities can help children to play joyfully in open spaces, cycle safely and freely on roads. In fact, in the entire trajectory towards becoming inclusive and environmentally just city, the concerned authority can incorporate children's views and consider them as active members of positive change. In a nutshell, 'Child and youth-friendly cities welcome young people, enhance their well-being and safety, and promote ways to involve young people in civic politics, and planning and design initiatives' (Bridgman, 2004). A child-friendly city should ideally not restrict children to play spaces only, rather encourage exploration of public spaces freely and safely (Freeman, 2012 as cited in Moore-Cherry 2014; also see Björklid and Nordström, 2007). The United Nations has been a strong advocate of child rights, and a child friendly city guarantees the right of a child to various facets of natural and social environment (UNICEF, 2004). Among these, one may focus on their right to 'participate in family, community and social life' and 'meet friends and play' (also see Horelli, 2007). Although child-friendly cities are more common in more developed countries, fragmented efforts are also visible in India. The existing body of literature points out that there can be two approaches to making of child friendly cities – one that is specifically meant for children, and the second involves the entire community including children. In Kolkata, the municipal authority has tied up with state government departments and a host of organizations and NGOs to take care of poor children. This coordinated effort has focused on 'sanitation for all children, basic services and protection to street

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children, eradicating child labor and making schools "joyful learning centres"' (Bartlett, 2005). In Kolkata, particular attention has been laid upon education for poor children, and in this venture, middle-class children has searched and identified domestic child workers in high-rise environments who are not attending school. Child-friendly plans of actions have also been prepared by local governing authorities of Lucknow and Mirzapur. Kolkata Police have played a responsible role in attempting to protect children living on streets and railway stations (Riggio, 2002). Community-Led Environment Action Network (CLEAN) India promotes community participation for clean and green environment, which benefits all residents, including children and youth. In such an endeavour, children coordinate with NGO workers and act as key agents of environmental improvement (Varney and Vliet, 2005). On the urban policy making front, Government of India has, for the first time, highlighted 'special provisions for child friendly components' while developing green space and parks in one of its Atal Mission for Rejuvenation and Urban Transformation (AMRUT) Components. This Mission seeks to add 'amenity value' of cities through such well maintained green spaces and parks[1]. Very recently, National Institute of Urban Affairs (NIUA) has attempted to help Bhubaneswar Development Authority to get a tag of Child-Friendly Smart City (CFSC). NIUA has become a partner with the Bernard van Leer Foundation in this venture. This initiative seeks to 'promote a knowledge driven, advanced and effective urban management framework that would include children's participation and their perspective in the planning and management of the city and its growth'. Hence, it will focus on spatial planning particularly for parks, playgrounds, schools, public transport, housing and so on[2].

The structured plan of this article is as follows. Following this introduction, the second section chalks out specific objectives. The third section provides a brief description of the study area. The next section elaborately discusses data sources and methodological issues. The fifth section, comprising of four sub-sections, analyzes the changing LULC scenario, hinterland of playgrounds and Utilisation of leisure time by children and the roles of the different stakeholders involved in this nature-children interaction. The sixth and final section concludes with a summary of findings.

OBJECTIVES

This study attempts:

(a) To find the pattern of shrinking of open space;

(b) To identify the playground hinterland i.e. areas those are served by the existing playgrounds;

(c) To identify leisure time activities of the urban children.

STUDY AREA

This pilot study has been carried out in Barrackpur, a Class-I urban centre in the north suburbs of Kolkata. Over 1991-2011, its population has increased from 133265 to 152783, with an annual exponential growth rate of 1.37 per cent. The number of Wards has increased to 24 from 19. Just 20 km away from Kolkata, Barrackpur reveals how changing LULC scenario is associated with the process of suburbanisation. Even a casual look at the 'built-up' category of LULC belonging to Kolkata urban agglomeration shows that the 'spillover is associated with relatively low density sprawl', something termed as signs of 'messy Urbanisation'[3]. Barrackpur and Kolkata are well connected through high frequency suburban trains, and daily commuting is an important feature. Kolkata, as referred to earlier, also initiated a project to become 'child-friendly city'. Therefore, this study may be interesting as it looks at how such 'child-friendly' nature of urban development can be continued in suburban centres also, where most of the people are likely to reside in coming decades.

DATABASE AND METHODOLOGY

This study is basically dependent on spatial data extracted from satellite images and on a questionnaire-based primary survey, along with key-informant interviews and discussions. For this study, Google Earth images of the study area have been acquired for three years- 2003, 2008 and 2015. Visual interpretation of the 2003, 2008 and 2015 images reveals notable expansion of built-up area around the Barrackpur Municipality. These have been brought to Geographic projection, on the spheroid WGS 84. Landsat TM images were also used as reference. Detailed methodologies of LULC classification and map generation have been discussed in the concerned section below. With the help of a Garmin GPS device, ground control points of playgrounds have been gathered. To demarcate the area served by playgrounds, 150 m and 250 m buffers have been drawn. This study also draws on secondary data obtained from Census of India. Ward wise population data is collected from Primary Census Abstract (1991-2011). Age related data is also gathered from Census of India tables. It should be mentioned here that by the term 'children', 6-14 age group of 'boys' and 'girls' (12.7 per cent each to total male and female population in 2011) have been considered. Chatterjee (2005) notes that a friendly relationship in this age group involves mutual interdependence. But a bizarre incident or a serious issue can also break up the relationship. Actually, this is very true in case of any group of boys or girls playing outdoor games. The questionnaire-based survey follows the method of purposive random sampling, with a total sample size of 403 respondents. To fill the specified objectives, schools have been chosen carefully and purposively, as the children, teachers and parents were available in the same place and time during the survey. Apart

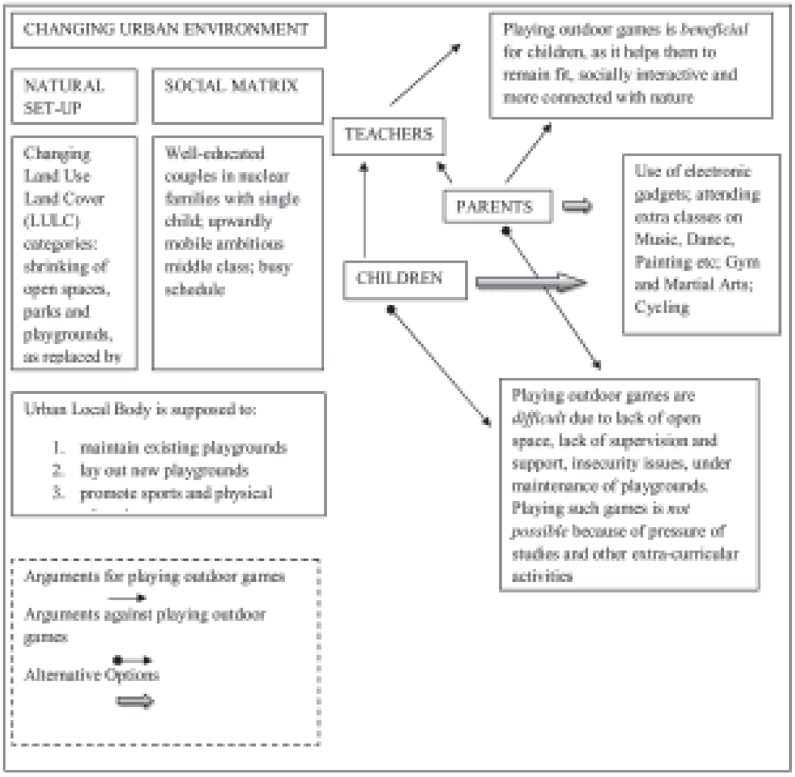


Fig. 1 Conceptual Framework

from this, short interviews have been arranged with a few Ward Councillors. One can get a glimpse of the types of sample respondents in the next page Table 1.

The questionnaires for children, parents and teachers have been prepared separately to elicit detailed information and opinions. However, all three questionnaires also have few common and synthesizing points. 'Mixed Method Approach' of research have been applied to extract quantitative and qualitative information. For the entire spatial analysis, two Remote Sensing and GIS software have been used. ERDAS IMAGINE 2014 has been used for the raster image processing. ArcGIS (version 10.2.2) has been used for the development of LULC classes and subsequently for change detection analysis of the study area. It has been utilised to compliment the display and processing of the data.

Statistical software i.e. SPSS has also been used for descriptive statistical measures like frequency distribution and cross-tabulation. Like any research work, this study also has its own limitations. Due to a limited period of available time, only 3 Ward Councillors and 50 parents have been considered within the sampling framework. Another limitation is the non-availability of any secondary data and information on initiatives taken by any NGOs towards making this urban centre 'child-friendly'. Hence, this study may be a pioneering effort towards raising issues and concerns of children in terms of playing rights and scope.

Table 1: A Brief Profile of Sampled Respondents

Category	*Sample Size*	*Sample Description*
Children	200	Entire Age Range i.e. 6-14 years; Mainly Hindus and Muslims, nuclear families with single child; middle class background
Parents	50	Mainly Hindus and Muslims; well-educated, middle class, nuclear families with single child
Teachers	50, (including 4 Games Teachers)	10 schools (ICSE English Medium Private: 2; CBSE English Medium Private: 2; WBBSE Bengali Govt Sponsored: 4, Primary level Private: 2)
Ward Councillors	3	Ward number 6, 8 and 18

Source: Primary Survey in Barrackpur Municipality, September, 2015

DISCUSSION AND ANALYSIS

Changing Land Use Land Cover Classes

Based on prior knowledge of the study area and following a brief reconnaissance survey, a LULC classification scheme has been developed for the study area. The main methods of spatial data analysis adopted in this study are as follows –

(i) Calculation of the geographical area (in sq. km.) of the LULC types for each study year and subsequently comparing the results.

(ii) Overlay Operations

(iii) Maximum Likelihood Classification

The comparison of the LULC statistics has assisted in identifying the percentage change, trend and rate of changes between 2003, 2008 and 2015. In achieving this, the first task is to develop a table showing the area in sq. km. and the percentage area for each year measured against each LULC type.

$$\text{Percentage area} = \frac{(\text{Observed area} * 100)}{\text{Sum of area}}$$

Percentage change to determine the trend of change can then be calculated by the following method:

$$\text{Percentage Change (PC)} = \{(A_{y2} - A_{y1}) / A_{y1}\} * 100$$

Where,

PC = Percentage change of area for certain landuse / landcover type between years y1 (2003) and y2 (2015);

A_{y1} = area for that landuse/landcover type in the earlier study year, y1 (2003);

A_{y2} = area for that landuse/landcover type in the later study year, y2 (2015).

In obtaining annual rate of change, the percentage change is divided by the number of study years i.e. for 2003 – 2008 (5 years), for 2008 – 2015 (7 years) and for 2003 – 2015 (12 years)

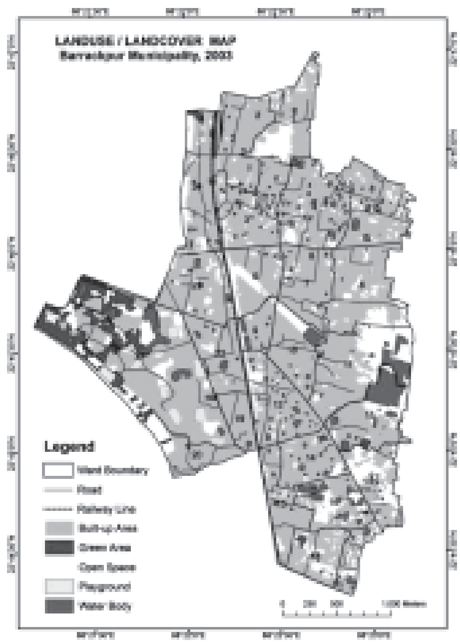
Table 2
Categories of Landuse and Landcover, 2003

Sl. No.	*Landuse and Landcover categories*	*Area (in sq. km.)*	*Area (in per cent)*
1.	Built-up Area	7.2638	68.46
2.	Open Space	1.6862	15.89
3.	Water Body	0.8221	7.75
4.	Green Area	0.6326	5.96
5.	Playground	0.2053	1.93
	Total	10.6100	100

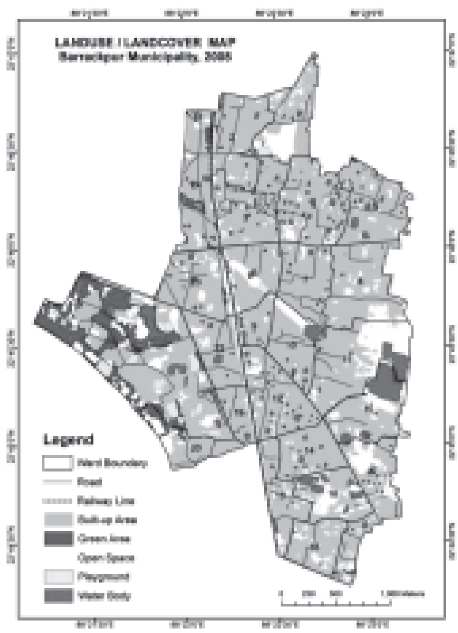
Table 3
Categories of Landuse and Landcover, 2008

Sl. No.	*Landuse and Landcover categories*	*Area (in sq. km.)*	*Area (in per cent)*
1.	Built-up Area	7.5609	71.26
2.	Open Space	1.5462	14.57
3.	Water Body	0.7154	6.74
4.	Green Area	0.6065	5.71
5.	Playground	0.1810	1.70
	Total	10.6100	100

Source: Authors' own calculations from Image Output



Source of Satellite Image: Google Earth, 2003



Source of Satellite Image: Google Earth, 2008

Note: Built-up Area – residential and commercial Areas; Open Space – vacant land; Water Body – ponds, lakes and rivers; Green Area – vegetation and plantation; Playground- grounds where children play outdoor games

Fig. 2: Landuse and Landcover Map, Barrackpur Municipality, 2003

Fig. 3: Landuse and Landcover Map, Barrackpur Municipality, 2008

Source of Satellite Image: Google Earth, 2015

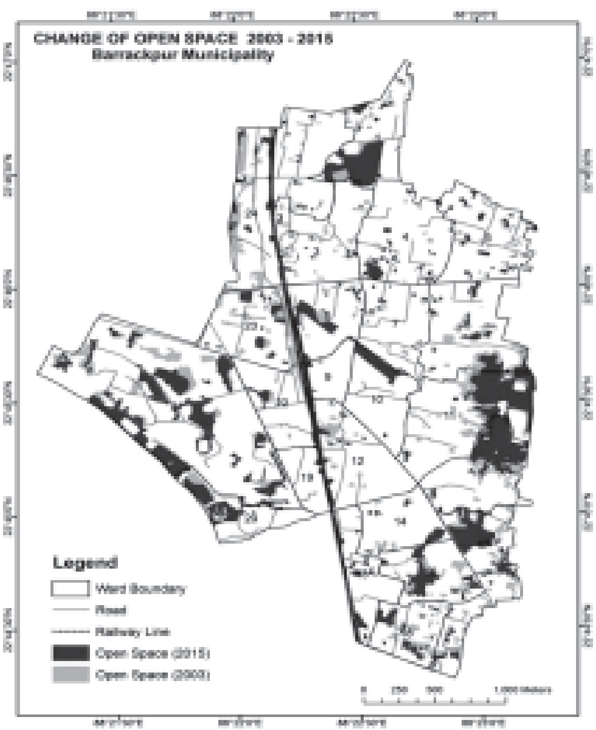
Fig.4: Landuse and Landcover Map, Barrackpur Municipality, 2015

Table 4
Categories of Landuse and Landcover, 2015

Sl. No.	*Landuse and Landcover categories*	*Area (in sq. km.)*	*Area (in per cent)*
1.	Built-up Area	7.8835	74.30
2.	Open Space	1.4154	13.34
3.	Water Body	0.5678	5.35
4.	Green Area	1.5917	5.57
5.	Playground	0.1516	1.42
	Total	10.6100	100

Source of Satellite Image: Google Earth, 2015.

Considering the change detection of two different year's data, one can see that in 2015 there has been an increase of built-up area compared to 2003. The amount of increase is about +0.62 sq. km. (+8.51 per cent change) i.e. a positive change occurred in 2015 image. This is because of its favourable location near to Kolkata city. At the same time, there is a decline of open space (Fig-5) as well as playground area in 2015 in comparison to 2003 image i.e. there is a negative change of -0.27 sq. km. (-16.06 per cent change) for open space and -0.05 sq. km. (-26.16 per cent change) for playground, respectively. This may have been caused due to the ever increasing pressure on land. In case of 2003, one can observe that there are various small patches of water bodies throughout the LULC map. But in 2015, there is a gradual decline in the amount of water bodies in the study area. It includes -0.25 sq. km. (-30.93 per cent change). Vegetation or green area occupies a very smaller share of the total study area. When one concentrates on two different year's map, there is a slight decrease in green cover having area of about -0.04 sq. km. (-6.46 per cent change) in 2015 map as compared to 2003 map.



Source of Satellite Image: Google Earth, 2008

Fig.5: Change of Open Spaces, Barrackpur Municipality, 2003-2015

Hinterland of Playgrounds

How much area a playground would serve is quite debatable. No widely accepted or popular methodology is available for such calculation. Parsons (2015) comments that the use of 0.25 mile buffer (i.e. 400 m) is considered to be a standard one, as a round walking distance of 0.5 miles (i.e. 800 m) can pull children to playgrounds. Children mostly walk to reach playgrounds and they would not prefer to walk a larger distance. But in the relatively more dense urban centres of India, this prescribed standard may not work. In fact, the radius of such a hinterland is the result of a complex interplay among a number of variables like size of ground, relative location of ground, population density, alignment of major transportation lines (roadways, railways, canals or streams) and other urban environmental factors like traffic situation and general law and order condition. These factors actually decide how much a child would travel to reach his or her playground. The age of the child is also a key issue. Younger children are hardly allowed to travel large distances.

Playgrounds of Barrackpur have been categorised into three size classes: large, medium and small playgrounds. Dimension and distribution of these grounds are given in Table no. 5. Interaction with children using playgrounds in the area under this study reveals that the small grounds are used by children residing very close (not more than 150 metres) to the grounds. In case of medium sized grounds, this distance is comparatively larger (250 metres). The larger grounds have the potential to serve much larger areas. But these grounds are dominated by older boys (usually above 14 years of age). This acts as a barrier for the younger children. However, younger ones (residing within 250 m) are found to play in these grounds.

Some of these grounds are restricted or partially restricted for the common use of children of the locality. For example, three grounds belong to schools whose gates remain locked after the school hours. Seven large playgrounds (in Ward no. 21) are situated within the territory of the State Armed Police. Two of these are used by Police personnel only. Rest are partially open for the children residing in the Police Quarters only.

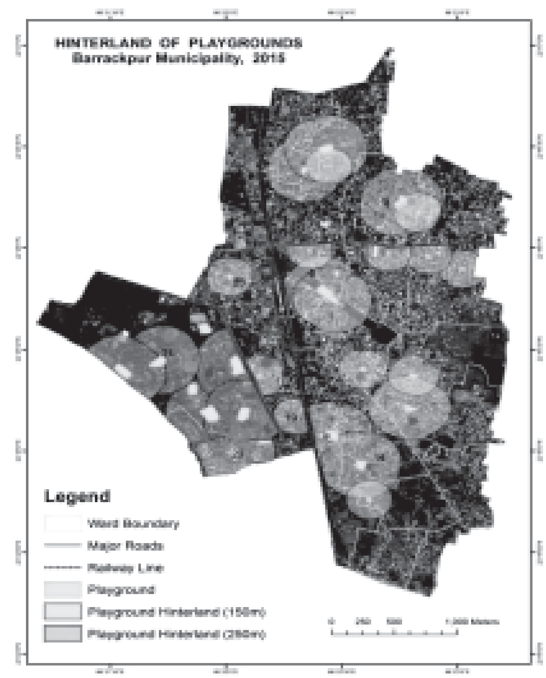
Table 5
A Short Profile of Playgrounds

Playground Type	*Playground size (square metres)*	*Number of Playgrounds*			
		Open	*Partially restricted*	*Restricted*	*Total*
Large	above 6000	4	6	2	12
Medium	3000 - 6000	2	2	1	5
Small	below 3000	12	0	3	15
Total		18	8	6	32

Source: Primary Survey in Barrackpur Municipality, September, 2015

Among the larger grounds, only six are more or less free for use of the common citizens. Pressure of children is, therefore, quite high on these playgrounds. Among these, the Anandapuri playground (actually two separate grounds, often called the *lungs of Barrackpur*) is owned by the Ministry of Defence. However, this is presently free for public use.

Playgrounds of Barrackpur have been identified by analysing satellite data products and direct field verification using GPS receiver. Thirty two playgrounds have been spotted. They are categorised into three size classes. Buffer areas are then created for all playgrounds except the restricted ones. Dimension of buffer is kept 150 m for small playgrounds and 250 m for medium and the large ones. Buffers are then clipped using barrier lines like major transportation lines (roads and railway line) and boundary wall of the police lines. Lastly, the areas of built-up land served by playgrounds are calculated for each of the wards and the wards are classified on the basis of availability of playground services.



Source of Satellite Image: Google Earth, 2015

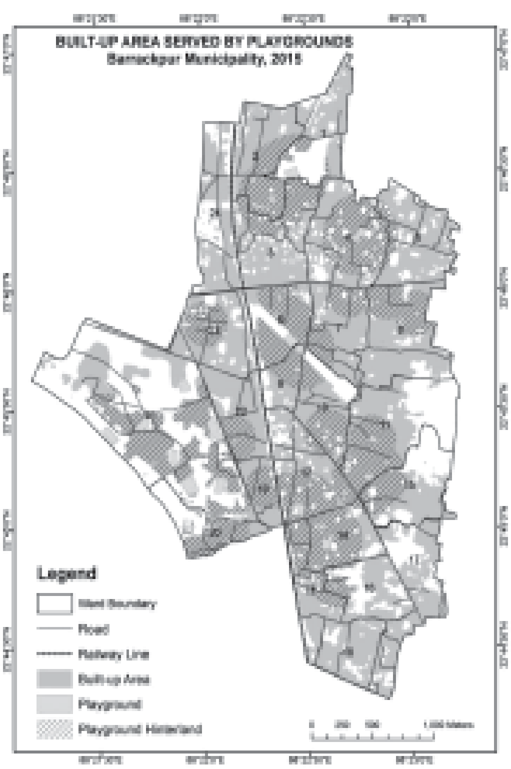
Fig.6: Hinterland of Playgrounds, Barrackpur Municipality, 2015

The hinterland maps (Fig-6 and Fig-7) and statistics reveal some interesting facts on availability of playground for the children. Only 40 per cent of total built up area in Barrackpur is served by playgrounds. In three of the 24 municipal Wards (Ward no. 17, 18 and 24) playground facility is completely absent. Almost similar situation is found in Wards 1, 5 and 16 where playground facility is not available for more than a quarter of the settlement area. Situation is quite satisfactory for Wards 14, 6 and 20 where more than 75 per cent of the settlement area is served by playgrounds.

Table 6
Playgrounds vis-a-vis Built-up Area

Availability of Playgrounds (in terms of percentage of area)	*Wards*	*Built-up Area (in per cent)*
75-100	14, 6, 20	8.34
50-75	9, 11, 19, 12, 10, 4, 21	32.40
25-50	22, 23, 8, 3, 15, 7, 13, 2	36.70
0-25	17, 18, 24, 5, 1, 16	22.56

Source of Satellite Image: Google Earth, 2015



Source: Authors' own calculations from Image Output

Fig. 7: Built-up Area served by Playgrounds

Children - Utilisation of Leisure Time

It needs to be noted at first that today's children are mostly busy with studies. Apart from school hours (including the time consumed for to and fro school journey), they also remain busy with additional private tutors who mentor them at coaching classes. This study shows that for majority of the children (i.e. around 74 per cent), the distance between their home and school is 1-2 km. Almost 43 per cent children have 2 and almost 41 per cent has 1 private tutor. All children visit coaching classes after school, and around 72 percent children spend 3-4 days per week for such coaching classes. Apart from this, around 49 per cent children spend more than 20 hours per week engaged in studies by themselves except school and tuition hours, while the corresponding figure is in between 15 to 20 hours for 34 per cent of the sampled children. All these figures clearly reveal that regular study is a serious issue for the conscious children, and in a typical Bengali urban middle-class family, parents are also very much concerned about their studies and associated paraphernalia.

Given such context, it would be interesting to look at how children spend limited available leisure time. Almost 49 per cent of children respond that they get around 15-20 hours of leisure time per week. As Figure-9 shows, a major chunk of children watch TV and a considerable share play games. Besides, internet and videogames are also one of the major tools for spending leisure time. It has been opined that even if a high-income class residential gated community boasts of its well maintained parks and playgrounds, these are hardly utilized, as children residing over there prefer using internet in bedrooms[4]. In a common Bengali urban middle-class social set-up, a significant share of children (mostly girls) performs music and dance. Although 22 per cent children plays game during leisure time, mobile games and computer games appear to be most popular. Among the games that children play most frequently, almost 70 per cent are indoor games and the respective shares of mobile games (39 per cent), computer games (16.5 per cent) and carom (6 per cent) are relatively higher. On the other hand, cricket (13.5 per cent) and football (8.5 per cent) are two most frequent outdoor games played by children in Barrackpur. Majority of children play in their neighbourhood playgrounds, however, playing in the 'streets and public squares' are equally popular along with 'corridors and rooftops'.

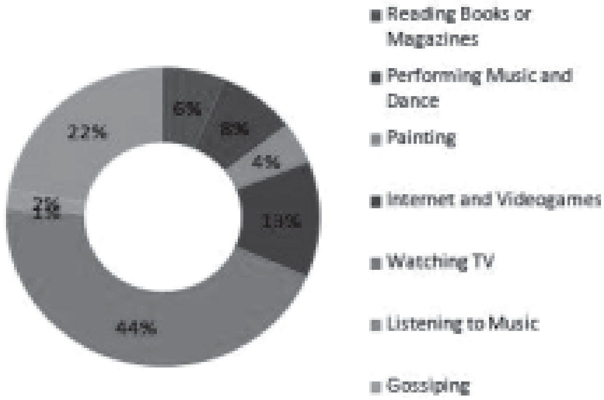


Fig.8 Utilisation of Children's Leisure Time, Barrackpur Municipality, 2015

Usually, children walk about 5 minutes to reach playground, and play with group of friends almost 3-4 days per week. Majority of parents like their children playing outdoor games, and they allow it up to a certain time limit like sunset. Children report to be playing in the same playground for a considerably longer period, and usually they change playgrounds when their residence also gets shifted. Only handful of children has experienced some problems in the playground. Such problems are related to under maintenance of playgrounds like unlevelled patches, water logging and garbage dumping. Those children, who used to play outdoor games but do not play now, cite 'pressure of studies' and 'attraction to gadgets' as significant reasons. Around 46 per cent children in this sample have not played outdoor games ever in their lives. According to their response, 'lack of playing space', 'lack of friend circle' and 'pressure of studies' are important reasons. Nonetheless, one thing appears to be quite interesting. Firstly, children prefer cycling, swimming and attending physical exercise training classes for different benefits. But one should also remember that 'swimming' and 'physical exercise' does not fall within the category of free and unsupervised play.

Role of Stakeholders

After observing interesting findings emerging out of the children's survey, an attempt has been made here to look at the views of other stakeholders also.

(A) Parents

A child is primarily dependent on parents, and their views, desires, expressions and cautions matter a lot to the child. A child or a group of children usually cannot express their articulated views and desires related to natural environment to influence policy decisions. They share different issues and problems with their parents. Parents then try to seek answers from other stakeholders like teachers, political representatives and media persons. Therefore, to get into the core of the discussion, an attempt has been made to talk to parents and to decipher their views on child's freedom to play outdoor games.

The sample survey of parents reveals a mixed scenario in terms of allowing children for playing outdoor games. 22 out of 50 parents allow children to play outdoor games, as most of them feel that outdoor play gives children a scope to get their personality developed and to socialize. Other group of parents i.e. 28 out of 50, who do not allow children to play outdoor games, mostly feel 'insecure' due to possibilities of injuries, traffic accidents, public nuisance and bullying. Basically, 'insecurity' issues are perceived prominently by parents who have younger child aged 6 and 8. A guardian questions back:

Bachhatar haat paa bhangle ba chot pele ki hobe?

(What will happen if the child's hands or legs are broken or injured?)

Another associated concern is lack of support (say, friend circle) and supervision (parents/guardians) in playgrounds or open spaces. They argue that in case some untoward incidents happen, their children may remain unattended or become victims of such incidents. Apart from this, lack of leisure time due to academic pressure is another issue with parents who have relatively older children (i.e. 13-14 age). Only 4 parents, equally from Ward 22 (*Shashitala*) and 23 (*Chiriya more*, *Pipe Road*) have cited the reason 'lack of open space' behind not allowing children to participate in outdoor games. However, one can find 'open spaces' in these two Wards. But such spaces are not fit for playing outdoor games. These open spaces are either small low lands or garbage dumping grounds. In few Wards like 19, 20, 22 and 23, children play on streets and bye-lanes, which are quite vulnerable due to higher traffic density. Interestingly, only 6 out of 50 parents have heard of any complaints regarding playgrounds from their children, and those complaints too are also regarding 'water logging' and 'garbage dump' in the playgrounds. Therefore, one has to ponder whether 'insecurity' or 'lack of support and supervision' is a real concern of parents. Another issue is parents' own observations on problems with the playgrounds or parks. Only 4 parents have personally observed water logging and smaller size of playgrounds as significant problems hindering children's outdoor play. Nonetheless, 44 out of 50 parents have asserted that outdoor games are 'very much necessary for all-round development of children', and 3 parents have emphatically recognized playing outdoor games as a 'right of every child'.

(B) Teachers

When a child faces any problem and looks for its solution, teachers are generally considered as next to parents. Another thing is the presence of an environment in school which encourages a child to play outdoor games. In fact, the whole coordinated network of games periods/physical education classes, advice of teachers, match practices on school playgrounds and participation in games competitions allows the child to conveniently and enthusiastically play outdoor games. Therefore, this study has also taken teachers' views into consideration.

This piece of research clearly reveals that the school environment act as a significant stimulus behind children's free play of outdoor games in schools. Majority of the teachers (33 out of 50) feel that outdoor games are 'very much necessary for all-round development of children' and 6 teachers consider such games as a 'right of every child'. Most of the schools, as captured in the sample survey, have playgrounds. The school authorities mostly allow children to play outdoor games without supervision and participate in games competitions. Unfortunately, most of the schools do not have the provision of games periods in time tables. All parents are reported to have insisted and cooperated in allowing their children to play outdoor games in schools. Perhaps, the reason lies in the fact that today's busy parents are not able to spend time on playing with children or supervising their playground, but find it convenient to allow children playing outdoor games in safe school environment. In fact, it is quite true that a city can become 'child-friendly' only when its schools ensure interactive and safe environment for the pupils. This study notes that in case a child gets injured, the concerned school authority provides first-aid, and summons doctors if urgent medical attention is required in serious cases.

(C) Urban Local Body (ULB)

Children need playgrounds and other open spaces like parks and public squares for playing outdoor games like cricket and football. Their need is supposed to be filled by the concerned ULB. West Bengal Municipal Act (1993) clearly mentions that the 'laying out and maintenance of public parks, squares, gardens or recreation areas' as one of the obligatory functions of ULBs. One should also note that the Act recognizes promotion of 'physical education' and 'sports' as one of the discretionary functions[5]. Hence, this study attempts to reflect the opinions of Ward Councillors, who are practically the bridge between common urban dwellers and ULB in present decentralized democratic structure of governance. All three councillors have opined that playing outdoor games is 'very much necessary for all-round development of children'. But, there is no specific scheme or/and budgetary allocation for maintenance / improvement of playgrounds. Although land use development is a sub-component of the Draft Development Plan (2007-2012)[6], the councillors do not know whether present municipal policies consider playground as an important factor in planning. However, in this DDP, there is no explicit reference to 'playgrounds' or 'parks' or 'open spaces'. The condition of playgrounds is not a significant issue in the political debates that take place in Councillors' meetings / Ward Committee meetings. Therefore, the Councillors have not done anything for the betterment of playgrounds over last one year. A councillor had arranged some State Government funds for the youth development associated with local club. Another important point that emerges is the conflicting power equations between the various governing authorities. In case of *Anandapuri* playground, the concerned Ward Councillor has received few complaints such as water logging and encroachment of space by petty shopkeepers every afternoon. Although the playground comes within the municipal boundary, the land ownership is in the hands of Ministry of Defence. Hence, the municipal authority will not be able to undertake any maintenance works or figure out any measures to remove the problems as noted above.

CONCLUSION

This study clearly exhibits a changing scenario of LULC - that area under 'open space', 'playground', 'water body' and 'green area' has gone down continuously from 2003 to 2015. But, there has been an increase in the area under 'built-up' category of LULC. Within the boundary of Barrackpur Municipality, one can see several small, medium and large sized playgrounds which mostly serve neighbourhoods at 150m-250m radius. Only extreme northern, southern and eastern parts of this urban centre remain outside the buffer. Even if playgrounds exist, other emerging reasons like pressure of studies, accessibility to gadgets like TV, mobile phones and internet services, and engagement in other 'supervised' activities like swimming keep children away from those playgrounds. Moreover, in today's nuclear family set-up, where a single child is born, and its parents remain busy, the absence of a friends' circle emerges as a deterrent factor. Again, issues of 'insecurity' and 'lack of support and supervision' hinder parents from sending a child to play outdoor games. In such a context, children gradually start getting attracted to gadgets or play indoor games like Carom. The school environment, especially teachers, is playing a significant role here. Children can play outdoor games freely on school playgrounds, and even if they get injured, first-aid or doctor-on-call service is provided by concerned school authorities. Urban Local Body officials and Ward Councillors can make a significant contribution towards maintaining playgrounds, so that children can safely play outdoor games properly. All in all, Barrackpur still has miles to go before emerging as 'child-friendly' in nature.

Notes

1. AMRUT aims to create sound urban infrastructure for ensuring better services to people, see http://amrut.gov.in/ for details, as viewed on 6th January, 2016
2. NIUA, being a top level think tank, working with Ministry of Urban Development, Government of India, is a key stakeholder in India's journey towards creating child friendly cities. (http://www.niua.org/jobs-tenders as viewed on 3rd October, 2015)
3. World Bank Group report titled 'Leveraging Urbanisation in South Asia – Mapping Spatial Transformation for Prosperity and Livability' (2015) notes that fast urbanizing South Asia should focus in improving economic productivity through large urban agglomeration, but provisioning of basic services is a major challenge.
4. see Jagan Shah's interview published in *Early Childhood Matters* November 27, 2014 as cited in https://bernardvanleer.org/publications-reports/small-children-big-cities/. This publication deals with number of issues like 'playground design', 'effects of noise and crowding' and 'public parenting'.
5. see the West Bengal Municipal Act, 1993, Section 63 for the list of obligatory functions and Section 64 for the list of discretionary functions. However, some of the ULBs do not perform all obligatory functions, and rather opt to execute a few discretionary functions.
6. see http://www.Barrackpurmunicipality.org/page.php?p=NDE= for details, as viewed on 4th October, 2015. A Draft Development Plan is often

showcased as a document that reflects ULB's intention and willingness for planned development and specific priorities.

REFERENCES

1. Ahluwalia, I. J., R Kanbur and P K Mohanty (2014): "Challenges of Urbanisation in India: An Overview" in Ahluwalia, Kanbur and Mohanty (ed.) *Urbanisation in India - Challenges, Opportunities and Way Forward* (New Delhi: SAGE): 1-28.
2. Bartlett, Sheridan (2005): "Integrating Children's Rights into Municipal Action: A Review of Progress and Lessons Learned" *Children, Youth and Environments*, 15(2): 18-40.
3. Björklid, P. and M Nordström, (2007): "Environmental Child-Friendliness: Collaboration and Future Research". *Children, Youth and Environments* 17(4): 388-401.
4. Bridgman, Rae. (2004): "Child-Friendly Cities: Canadian Perspectives", *Children, Youth and Environments*, 14 (2): 178-200.
5. Chatterjee, Sudeshna (2005): "Children's Friendship with Place – A Conceptual Enquiry", *Children, Youth and Environments* 15(1): 1-26.
6. Horelli, Liisa (2007): "Constructing a Framework for Environmental Child-Friendliness", *Children, Youth and Environments,* 17(4): 267-292.
7. Moore, R C (1997): "The Need for Nature: A Childhood Right", *Social Justice.* 24(3): 203-220.
8. Moore-Cherry, Niamh (2014): Review of 'Creating child-friendly cities: Reinstating kids in the city' (Gleeson and Sipe ed. 2012). *Planning Theory & Practice*, 15(1): 144-146.
9. Parsons, J E (2015): "Mapping Uniformity of Park Access using Cadastral Data within Network Analyst in Wake Country, NC", MSc thesis presented to the Faculty of the USC Graduate School, University of Southern California (http://spatial.usc.edu/wp-content/uploads/2015/03/ParsonJonathan.pdf as viewed on 12.02.2016).
10. Riggio, Eliana (2002): "Child friendly cities: good governance in the best interests of the child" *Environment & Urbanisation,* 14(2): 45-58.
11. UNICEF (2004): "Building Child Friendly Cities: A Framework for Action", Innocenti Research Centre, International Secretariat for Child Friendly Cities.
12. Varney, D and W v Vliet (2005): "Local Environmental Initiatives Oriented to Children and Youth: A Review of UN Habitat Best Practices" *Children, Youth and Environments* 15(2), 41-52.

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SECTORAL STRUCTURE OF ECONOMY AND WORKFORCE IN INDIAN STATES

Arvind CHAUHAN[1] & Divyanshi SINGH[2]

ABSTRACT

Indian adopt mixed economy model after independence which includes the participation from public as well as private sectors. Different sectors of economy viz. agriculture, industry and services have contributed to the development process of the country. Over the passage of time workers participation and GDP share contribution of different sectors change. This paper provides an overview of the sectoral contribution in nation's GDP as well as GSDP along with distribution of workers in different sectors across the Indian states. It shows that inspite of maximum share of services in GDP, the no workforce is involved in agriculture.

***Keywords**: Agriculture, Industry, Services, Planning Commission, GDP, GSDP*

INTRODUCTION

This paper provides an overview of the sectoral contribution in nation's GDP as well as GSDP along with distribution of workers in different sectors across the Indian states. It shows that inspite of maximum share of services in GDP, no workforce is involved in agriculture.

Economy of any country is based on the development of different sectors and economic development has been very oftenly defined as a process that combines economic growth with the changing share of various sectors in the overall national product at large scale and state product at small scale as well as changing share of labor force. In present scenario development is being defined in terms of structural change. "Structural changes permits viable growth to occur and growth provides the material for subsequent structural change" (Uphoff and Ilchman, 1972). The striking feature that needs mention here is that as the process of economic development goes on proceeding, with this the share of agriculture in GDP and employment with workforce – that remains high in early developmental stage – starts declining and at the same time the non agricultural sectors experience rise. This state is true for all the countries of the world and their economy; moreover this is a universal phenomenon which defines the development of an economy.

Indian economy is far more complex than the other economies of the world. This is the general trend that structural shift from one sector to another and their changing share are found to hold for both the GDP and labor force. To be precise on one hand the GDP contribution of different sectors has undergone an immense change and on the other hand there has been a shift from primary activities based economy to non primary activities based economy. The point to be noted here is that the shift has not been uniform and does not follow any pattern. In the last few decades non primary activities especially services has outbid the other sectors from the sectoral share in economy.

Indian economy has been primarily divided into three sectors based on the nature of activities –

- Primary Sector
- Secondary Sector
- Service Sector

All these sectors work together to form a strong economy and they are interlinked with each other on the one hand and on the other they have their own identity by contributing individually to the economy. All the three sectors have their own importance in national economy and state economy. Moreover their share in economy reflects the developmental phase of the state as well as national economy. Sectoral share also reflects the involvement of workforce in the particular sector. Primary sector includes agriculture and allied activities, fishing, forestry , quarrying & mining, etc; secondary sector includes manufacturing industry, construction, etc.; and service sector includes transport, storage, communication ,trade, hotel, restaurants, financial services like banking, insurance, real estate and business services, public administration and other services.

OBJECTIVE

- To analyse the Gross domestic Product (GDP) contribution of different sectors and involvement of workforce across the Indian states.
- To analyse the changing sectoral share of Gross State Domestic Product (GSDP) and workforce: Growth over a period of time.

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RESEARCH QUESTION

How have the structural shift and changing sectoral shares found to hold both for the gross state domestic product (GSDP) and workforce for those states.

METHODOLOGY

In order to show the pattern of change in contribution of different sectors in GDP over a period of time, statistical graph is used that is line graph which efficiently portrays the shift in share of sectors with time.

Moreover to show the changing sectoral share in GSDP across the Indian states, first of all the percentage of each sector in the total GSDP of particular state is calculated by applying the formula:

Percentage of share of sector in GSDP = share of the sector in (Cr Rs)/total GSDP of the state(Cr Rs)

In this way the percentage of each sector in the total GSDP is calculated for a particular period of time. Now to analyse the sectoral GSDP contribution across the states in a particular year, compound bar diagram is used which shows the total GSDP composition of the Indian states.

Not only for GSDP contribution but to show the involvement of workforce in different sectors across the states for a particular year, compound bar diagram is used.

On the other hand in order to show the structural shift in GSDP contribution over a period of time, the difference in share (%) of sector over a period of time is calculated by applying formula:

Change in share (%) of sector = share (%) of sector in 2009-10 – share (%) of sector in 2004-05

In this way sectoral shift in terms of GSDP contribution for the states over a period of time is calculated and in the same way the sectoral shift in terms of workforce is calculated by applying the formula:

Change in no of workers in the sector = no of workers in the sector in 2009-10 – no of workers in the sector in 2004-05

This shift is best represented by the GIS Technique and hence mapping for the states by using Arc GIS software is done.

Moreover superimposition is done in order to show the contrast in sectoral contribution and involvement of workforce in a particular state over a period of time.

LITERATURE REVIEW

Some of the ideas of the introductory part of the paper has been taken from the book" Growth and structure of Tertiary Sector in Developing Economies" written by Seema Joshi where she makes a universal argument about the development of an economy from agriculture based to non agriculture based. In her book she also explains the concept of traditional, transitional, and modern phase in the context of sectoral shift. Moreover she also explains some of the reasons behind the immense growth of services over the other sectors.

Paper by Arpita Mukharjee named" Services Sector in India: Trends, Issues and Way Forward" efficiently explains the condition of service sector as well as its growth pattern over a period of time in India.

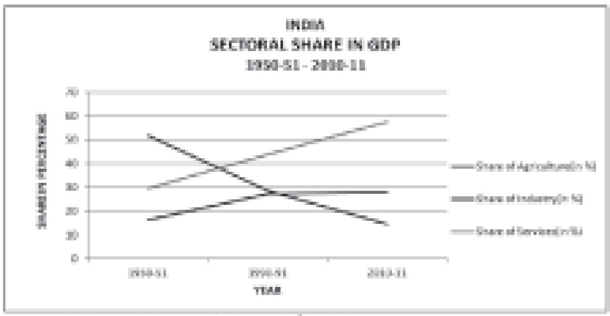
Paper by T.S. Papola and Partha Pratim Sahu named "Growth and Structure of Employment in India : Long Term and post reform performance and The Emerging Challenge" discusses the reasons for the contrasting situation that is visible in case of Indian economy where a large share of GDP comes from services but more than 60% workforce is involved in agriculture. Not only this but the implications of asymmetry in the rate of change of involvement of workforce and GDP shares of different sectors is also discussed raising the question of differences in earnings and income between different sectors.

Paper by Papola T.S. named "Structural Changes in The Indian Economy: Emerging patterns and implications" discusses the deviation in the share of different sectors and furthermore whether the deviation leads to sustainable growth. The primary concern is the service led growth. The paper also point out the implications of the high employment rate in agriculture inspite of contributing less. Not only this but also the possible reasons behind such kind of pattern in Indian economy.

Nation at A Glance

India has been agriculture based economy. Most of the contribution in GDP had been done by agriculture. In other words it was an agrarian economy where agriculture constituted 51.81% of the total country's GDP in the year 1950-51. Moreover at that time industry and services were lagging far behind and they were struggling to get their identity. Share of industry and services in GDP in the Year 1950-51 was 14.16, 33.15 respectively. The data shows, how the agriculture was shaping the whole Indian economy and major part of economy was coming from agricultural sector which reflects the position that agriculture had in Indian economy. That was the period of beginning of industrialization in developing countries and India was experiencing it at very slow pace.

From the year 1990-91 to 2011-12 the share of agriculture in GDP has declined by 11.53% on the other hand the share of industry and services has shown growth of 1.82% and 9.92% during the period. Graph 1 shows the trend of sectoral share in Indian economy from the year 1950-51 to 2010-11.The decline in agricultural share in GDP is very sharp whereas services have made its position by pushing agriculture on the backfoot. The striking feature that the data reflects is that economy is being shaped by only two sectors and that is agriculture and services. Whereas industry has been in stagnant position over a period of time. Since the period of economic reforms and accelerated growth rate from 1990, the growth pattern followed by Indian economy has been totally different from the one observed in the historical development of the developed nations also from that being experienced by developing world. Indian economy has directly shifted from agrarian to service based economy leaving industry far behind. This shows that still in the 21st century Indian economy has not performed in the industries as it should have been.



Source: Planning Commission, Govt. of India, CSO (31st October)

Fig. 1 Sectoral Share In GDP (1950-51 To 2010-11)

One of the basic reason behind this shift is that the surplus in agriculture leads to secondary and service sector moreover this is also the result of low income elasticity of demand for agricultural products and high income elasticity of demand for manufactured goods.

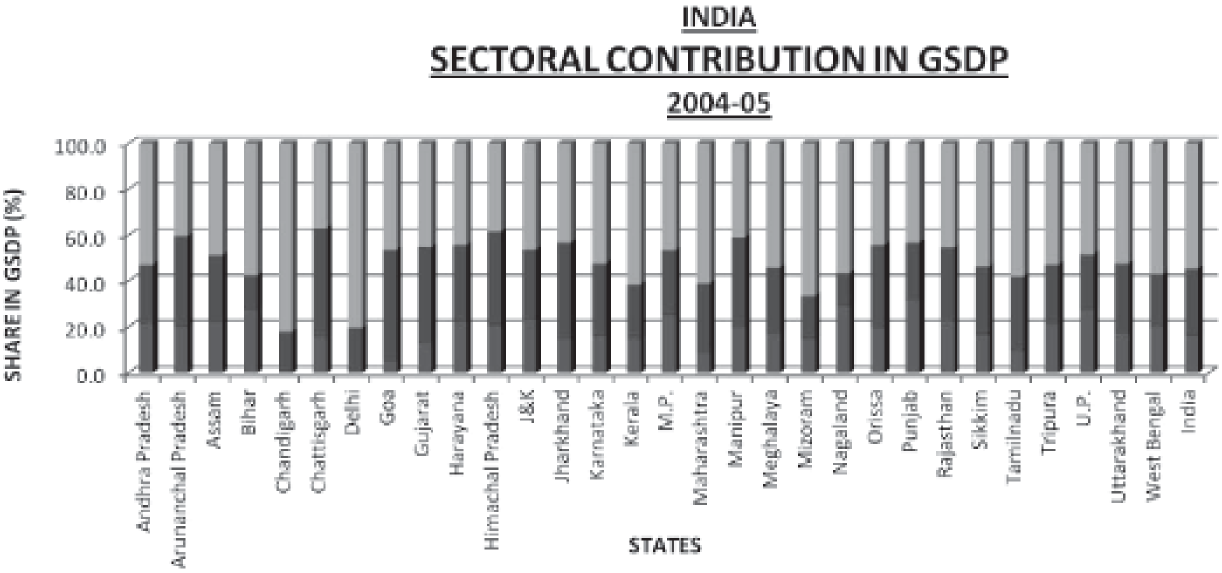
Sectoral Share: State Wise Analysis

Year 2004-05

When it comes to the states, the condition that prevailed for the country since 1990s remains same. In other words services has surpassed all the other sectors and this is also the condition in states where on an average the state economy is being shaped by services. On an average 17.2 % of the share of economy has been contributed by agriculture in the year 2004-05 in the states. Whereas in Punjab the share of agriculture in comparison to the other states has been the highest. Here the major activity practiced is agriculture. Moreover when we analyse the sectoral share then most striking feature that appears is that this region is mainly agriculture dominant and the possible reason for the major contribution of agriculture in economy is the introduction of green revolution technology, migration of labours from the other state like Bihar and U.P.

This has been the general trend for all the states that services' share is followed by industrial and then agriculture but there are states like Bihar, Nagaland and U.P. where the share of agriculture is more than the share of industry. These are the states where most of the economy is shaped by first services and then agriculture. One of the possible reasons for the dominance of agriculture over the industry in these states can be that the states Bihar and U.P. are the one where fertile alluvial soil is found. Moreover these regions are drained by numerous rivers, not only this but here the subsistence farming is practiced in order to feed the huge population base inspite of having small land holdings. These regions have not been very rich in minerals and natural resource base. Chandigarh and Delhi are the regions where the contribution of agriculture is totally negligible in other words it is less than 1 %, whereas the services cover more than 3/4th of the economy. These regions show something contrast from the nation's scenario where agriculture and services are the dominant one but here industry and services are the key sectors. One of the possible reasons for this trend can be that both the regions are union territories and they are highly urbanized. Chandigarh has been the first planned city of the nation where the main focus was on development of infrastructure that led to the growth of services and industry. Delhi is the highly urbanized with very high density of population. Moreover agriculture landholdings are very less here. Being the capital this is supposed to be highly developed in terms of connectivity, communication, governance and development of infrastructure leads to growth in industry. Chattisgarh and Goa are the states where the performance of industry is worth noticing as it is contributing to GSDP by nearly 50%. One of the possible reasons for development of industry in Chattisgarh is that the region is bestowed with natural and mineral resources that support the industrial base of the region.

When we analyse the north south divide then it is remarkable that the north has performed better in agriculture than south. Nearly 1/4th of the total contribution of northern states is by agriculture whereas the southern states contribution from agricultural sector in GSDP is less than 15%. Industry's contribution has been nearly equal for both the north and south. Condition of service sector in south has been better than the north and its share in state economy is more than half.



Source: Planning Commission, Govt. of India, CSO (31st October)

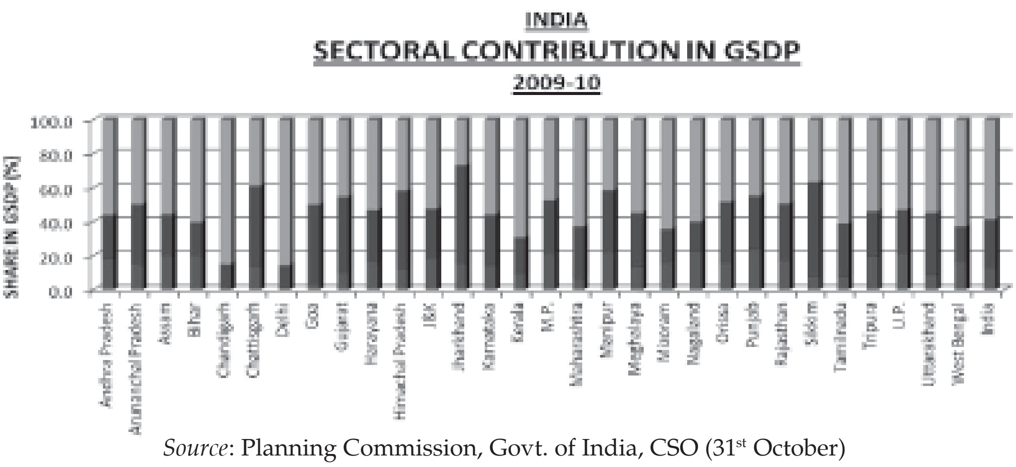
Fig. 2 Sectoral Contribution in GSDP (2004-05)

Year 2009-10

For the year 2009-10 share of agriculture in national income was 12.6%, share of industry was 28.9% and share of services was 58.2%. The situation of dominance of services over other sectors is observable for the states. The general trend has been that both the sectors (agriculture and industry) even together has not been able to surpass the services in most of the Indian states. Like the year 2004-05, agriculture has higher contribution in Punjab's economy than any other state. Bihar is the only state where contribution of agriculture is more than industry. The best possible reason for this can be the large tract of alluvial soil, lack of mineral resource base after being separated from Jharkhand, inefficient government policies and political reasons.

U.P. and West Bengal are the states where the share of agriculture and industry is almost similar. Most striking feature that the graph depicts is that the contribution of industry has been the maximum for the states like Jharkhand, Sikkim (the point to be cleared is that the share is even more than the services also). The possible reason behind this observation is that in the state Jharkhand, mineral resource base is found in abundance which has led to the development of industry. This is the state where major iron and steel industries are found. So here industrial growth has led to growth in services against the general trend. In Sikkim, there has been a drastic shift in the sectoral contribution from primary and tertiary to the secondary sector. Moreover it has been the fastest growing sector among the other sectors in Sikkim. There is dominance of agro processing industries, floriculture, tea industry and pharmaceuticals. It is one of the leading states in the northeastern region in terms of production and supply of cut flowers to mainland consumer markets.

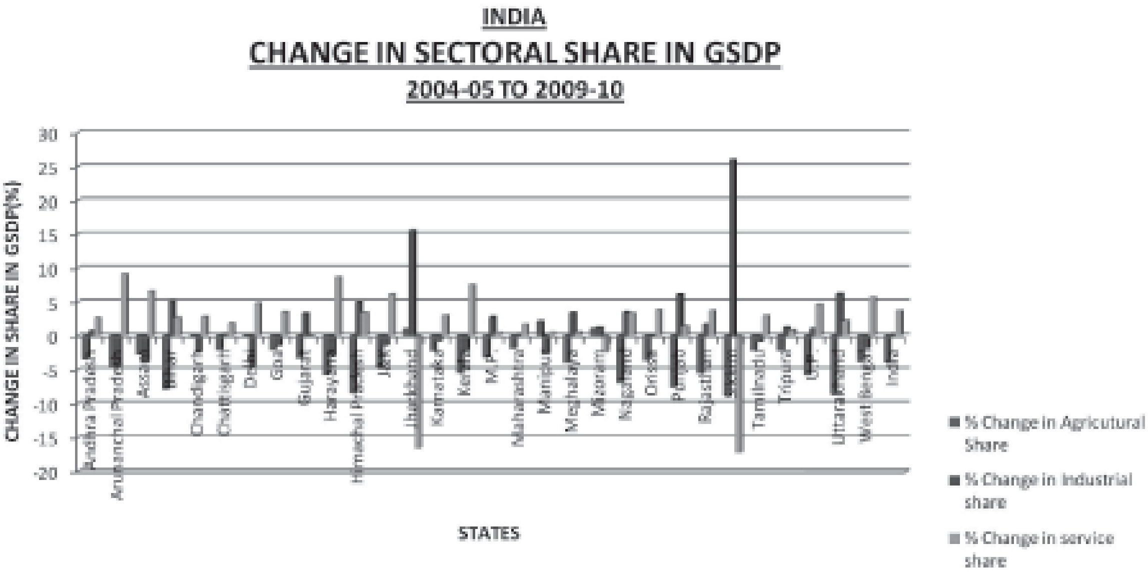
Like in the year 2004-05, Delhi and Chandigarh show



Source: Planning Commission, Govt. of India, CSO (31st October)

Fig. 3 Sectoral Contribution in GSDP (2009-10)

a great lead in services leaving behind the other states. In these regions the share of services is more than 85 % showing that the growth of services has pushed all the other sectors at back foot.



Source: Planning Commission, Govt. of India, CSO (31st October)

Fig 4 Changes In Sectoral GSDP (2004-05 to 2009-10)

Sectoral Shift: State Wise Analysis

The graph here depicts the major shift in the sectoral contribution in GSDP from the year 2004-05 to 2009-10. While analyzing the graph, it is quite evident that the share of agriculture has immensely declined over a period of time across the states. This clearly depicts the shift in sector. Service has been the sector which is continuously increasing its share in state economy. All the Indian states have clearly marked the phase of decline in agricultural share and increment in share of services. Jharkhand, Manipur and Mizoram are the only states where agriculture has shown a growth by approx. 2 %. This shift is very slight.

Jharkhand and Sikkim are the states where the services have shown a decline by approx. 17 %.Moreover these are the states also in which industry has shown a growth and the growth is unsurpassable. In these two states there has been structural shift from agriculture and services to industry unlike India. Jharkhand is very rich in mineral resources supporting the large industrial base and Sikkim has performed better in agro processing, tea industry and industry related to floriculture. It can be also interpreted that growth in sectoral share has led to decline in others.

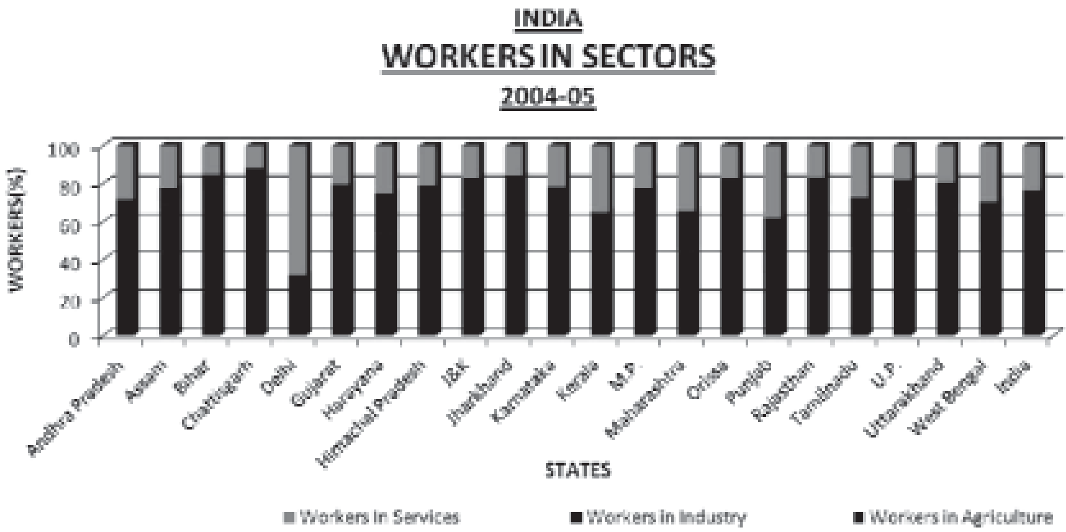
Services have been dominating the national economy as well as state economy since decades. Growths in services have been generally attributed to the liberalization and reforms of the 1990s. Moreover with the economic reforms, the removal of FDI restrictions, privatization came which encouraged the growth of service sector. Growth of producer services, growth of consumption services, demonstration effect, increase in urbanization, splintering of services and operation of Engel's law in India enhanced the service sector. Not only this but the advancement of technology and the availability of high skilled manpower resulted into the growth of services like IT. Moreover government's high expenditure on social, personal and community services which includes education, health, vaccination and awareness programme, all these have contributed in the growth and dominance of the sector. Change in demand from necessary to discretionary consumptions like educational and personal health care services (Mc Kinsey & company 2007), high income elasticity of demand of services has constituted to high growth of the sector (Bhattacharya & Mitra 1990 and Gordan & Gupta 2003). Increase in share of services is also the outcome of decrease in agricultural contribution. There are many possible reasons for decline in agricultural share and they are: technological fatigue, reduction in investment in water management, irrigation and research. Gradual breakdown of the agricultural extension system (Thamarajakshi 1999, Vyas 2001; Bhalla and Singh 2009), moreover the population explosion and shrinking resources has led to less share of agriculture in GDP as well as GSDP.

Workforce in Sectors: Statewise Analysis

Year 2004-05

It is clear from the graph that the majority of the workforce is involved in agriculture. This scenario is in almost all the states except Delhi where the no of workers in agriculture is about 1%. Delhi being the capital of India supports the services and industry very well. In this region services and industry has been successful in generating employment and this is the reason of maximum involvement of workers in services and industry. Apart from agricultural workers, next turn comes of services where the workers involvement is more than that of industry.

When we talk about the north and south states, it can be clearly observed that the no. of workers in agriculture in north is more than the south states. Even this case prevails for industry and services also. In north states subsistence type of farming is practiced, moreover whole family is involved in agriculture on same piece of land leading to disguised employment.

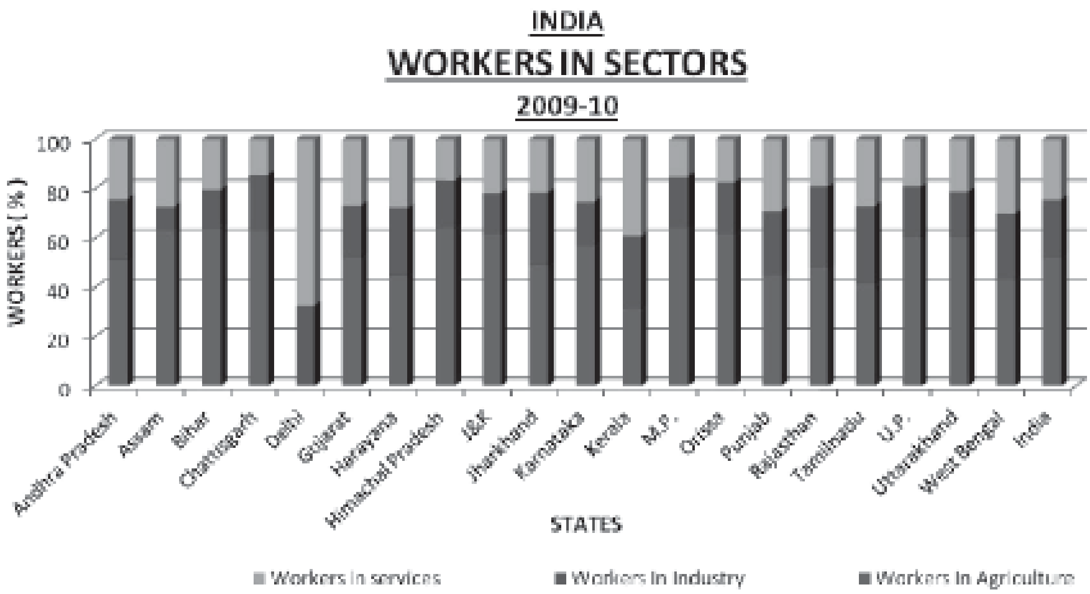


Source: Planning Commission, Govt. of India, CSO (31st October)

Fig.5 Workers in Different Sectors (2004-05)

YEAR 2009-10

The graph depicts the involvement of workforce in different sectors across the states for the year 2009-10. Like the year 2004-05 the involvement of agricultural workers is least in Delhi (0.2%) along with the involvement of maximum labours in services.



Source: Planning Commission, Govt. of India, CSO (31st October).

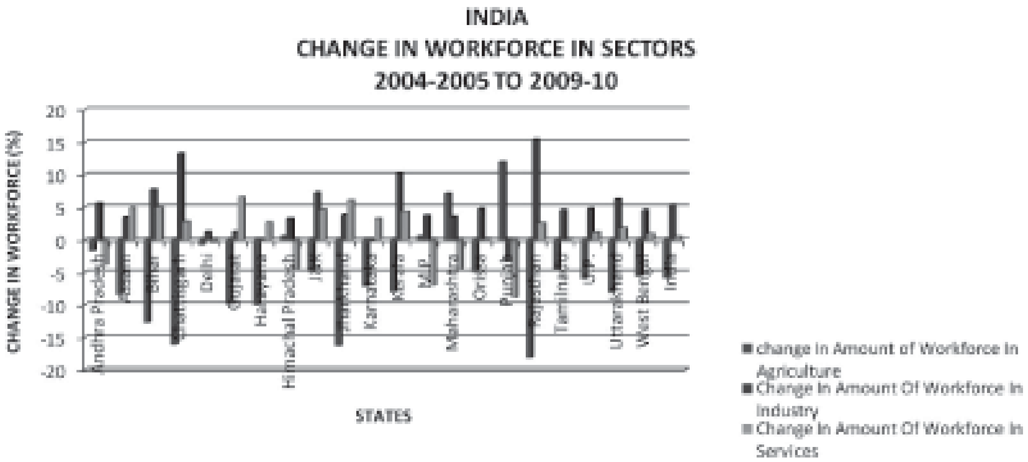
Fig.6 Workers in Different Sectors (2009-10).

Rajasthan is the state where the no. of industrial workers is more than the other states and this is due to better law and order, good infrastructure, investment friendly climate which has led to the development of industries resulting into the generation of employment. But inspite of this most of the workers are involved in agriculture. In the year 2009-10 also the maximum percentage of workers is in agriculture. The possible reasons for this can be:

- Majority of people are still employed in agricultural activities, as agriculture provides seasonal employment during cropping season.
- Industry and services have failed to generate enough employment opportunities which have resulted into the pressure on agriculture.
- Moreover most of the skilled and educated population does get employed in either services or industry but the rest of the unskilled and uneducated and semi-skilled have the shortage of employment opportunities. Hence they have no option except agriculture.
- India has been agro based economy and there has been the tradition of involvement of the whole family members in the agriculture on the same piece of land. This is also the reason of maximum workforce in agriculture.

Change In Workforce In Sectors: State Wise Analysis

Inspite of a large workforce involved in agriculture, but the graph clearly depicts that the % of workers in

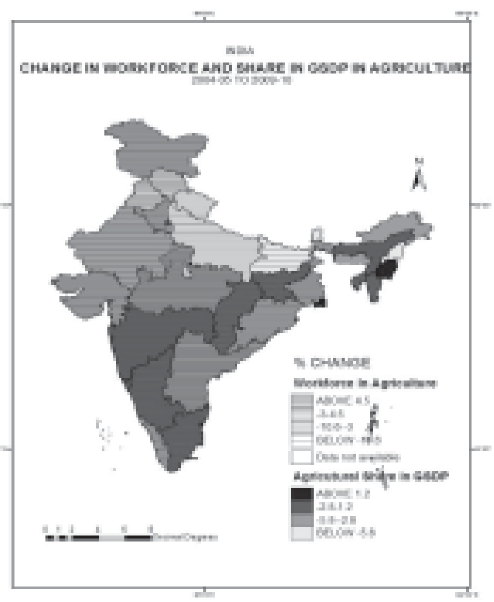


Source: Planning Commission, Govt. of India, CSO (31st October

Fig. 7 Change in Workforce In Sectors

agriculture has declined not only at national level but also at state level. Punjab is the only state where the workforce has increased in agriculture over a period of time and one of the possible reason of it is the migration of agricultural labours from the state like Bihar and U.P. the graph clearly depicts that there has been increment in workforce in industry as compared to services almost for all the states. The possible reason for this can be lack of efficient industrialization which has resulted in labour intensive industry

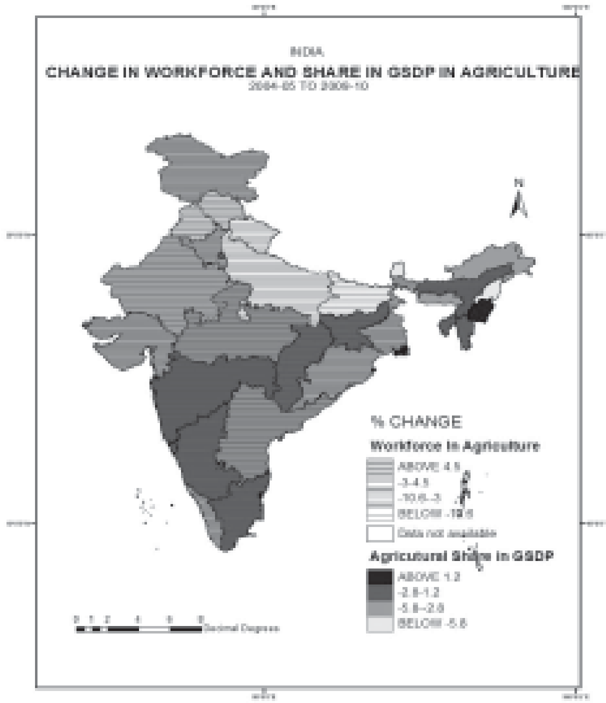
It is clear from the map that in Jharkhand where the share of agriculture in GSDP has seen growth but the workforce has greatly declined over a period of time. The reason behind this can be the large employment generation by industrial sector and people's migration to Jharkhand in order to work in industries which have resulted in decline in agricultural labours. There is another point to be noted is that Maharashtra and Punjab are the states where workforce in agriculture has increased but share of agriculture in



Source: Estimated from Planning Commission, Govt. of India, CSO (31st October)

Fig. 8 Change in Workforce and Share in GSDP in Agriculture

GSDP has declined. The reason could be large scale migration of people from U.P. and Bihar to Punjab as agricultural labours whereas in Maharashtra huge amount of GSDP comes from services and industry but the huge population is still involved in agriculture.



Source: Estimated from Planning Commission, Govt. of India, CSO (31st October)

Fig. 9 Change in Workforce and Share in GSDP in Industry

This is clear from the map that Punjab is the state where workforce in industry has declined but GSDP contribution has increased. One of the possible reason for this is the involvement of huge population in agriculture after migrating from Bihar and U.P. In Jharkhand the GSDP contribution of industry is huge as well as a huge workforce is also involved in industry as the industrial growth has been efficient to generate the employment.

The graph shows the distribution of change in workforce and share in GSDP in services. Although workforce in services has almost shown a remarkable increase in almost all states but in Gujarat and Jharkhand the growth is worth mentioning. Not only this but in Jharkhand the workforce in services has increased but share in GSDP has immensely decreased. Reason for this can be given that the most of the economy of Jharkhand is supported by industry (iron and steel). So relatively industries' contribution in GSDP is more than that of services. States like Punjab, Maharashtra, M.P. and Himachal Pradesh have shown decline in workforce in services. In Punjab most of the workers are in agriculture whereas in others workers are involved in either industry or agriculture.

Outcome of Low GSDP And High Employment in a Sector

High employment in agriculture whereas low share in GSDP is imposing a serious problem like disparity in per worker income in agriculture and non agriculture has sharply increased. Moreover the income of wage earners is growing at much slower pace than the income of the capital owner. There is increase in asymmetry between the income and employment share of agriculture. The increasing gap between share of agriculture and employment will lead to the stagnation in purchasing power, widening of disparity and deformity in the structure of economy. Not only this but this kind of situation leads to the poverty and disguised unemployment.

Implication of Tertiarisation

"A country like India cannot hope to build its future on the services sector alone though it can be and will be a major component of the economy. India cannot afford to build its strength in agriculture for reasons of food and nutritional security. Nor can it afford to ignore manufacturing strength for reasons of economic and national security. Based on strength of these 2 sectors, it can build a major economic infrastructure for the services and use it to generate great wealth and employment for her people" (A.P.J. Kalam and Y.S. Rajan 1998).

CONCLUSION

To conclude, high tertiarisation of the economy in terms of GDP and GSDP contribution with some exceptions and mass involvement of workers in agriculture with slight shift to services over a period of time is observed. Moreover somewhere the less GDP and GSDP contribution by agriculture is the result of mass population in it resulting into less productivity. In the end the whole analysis raises the huge question mark on the sustainability of the tertiarisation of economy.

REFERENCES

1. Data Book Compiled for Use of Planning Commission, Govt. of India (2014)
2. Dev, S. Mahendra, "Agriculture, Employment and Social Sector Neglected", Economic and Political Weekly, Journal of Economic and Political Weekly (2003): 1353-1356
3. Joshi, Seema, "Tertiary Sector Driven Growth in India: Impact on Employment and poverty", Economic and Political Weekly, Journal of Economic and Political Weekly (2004): 4175-4178.

4. Kapila, Uma, “Indian Economy since Independence”, Academic Foundation, (2002): 650-660.
5. Kumar, Arun, “Indian Economy Since Independence”, Vision Books (2013): 295-336.
6. Mukharjee, Arpita, “Service Sector in India: Trends, Issues and Way forward”.
7. Mulji, J. Sudhir, “Agriculture and Unemployment”, Economic and Political Weekly, Journal of Economic and Political Weekly (2003): 1463-1466.
8. Papola, T.S. “Structural Changes in The Indian Economy: Emerging Patterns and Implications”, Institute for Studies in Industrial Development (2012).
9. Papola, T.S. and Sahu, P. Pratim, “Growth and Structure of employment in India: Long Term and Post Reform Performance and the Emerging Challenges”, Institute for Studies in Industrial Development (2012).
10. Ravallion, Martin and Dutt Gaurav, “How Important to India’s Poor Is the Sectoral Composition of Economic Growth”, the World Bank Economic Review, Oxford University Press (1996): 1-25.
11. Seth, K. Vijay and Seth, K. Ashok, “Lobour Absorption in the Indian Manufacturing Sector”, Indian Journal of Industrial Relation, Shri Ram Centre for Industrial Relations and Human Resources (1991): 19-38.
12. Suvakkin, M., and G. Ganasekaram, “A Study on Spectacular Growth of Services Sector In India”, International Journal of Management Research and Review, (2012).
13. Thamarajakshi, R, “Agricultural Growth, Rural Development and Employment Generation”, Economic and Political Weekly, Journal of Economic and Political Weekly (1989): A5-A8.

AN ANALYSIS OF URBAN GROWTH OF COCHIN CITY REGION USING GIS AND REMOTE SENSING TECHNIQUES

Mereena C.S.[1]

ABSTRACT

Cochin is one of the largest and most important commercial and industrial centres and the most promising growth oriented development region in the state of Kerala. Developments in the city and surrounding area have taken a fast stride in the last two decades. Hence an attempt has been made to monitor the urban growth of the city region over space and time.Two sets of Landsat TM images (1990/2000, resolution 30 m, seven bands) and one Landsat ETM+ (2010, resolution 15m, seven band) were used in the study. These images were processed with ERDAS IMAGINE software, which involves geometric correction, unsupervised classification and GIS reclassification.The base map (Cochin City Region Development Plan, 2031) of the study area was imported and georeferenced in GIS environment and shape files were generated.The sub-setting of satellite images were performed for extracting the study area by taking geo-referenced outline Cochin City Region Development Plan boundary of 2031 map. The subset image was then re-projected. All three images were then classified using ISODATA unsupervised classification algorithm. Thirty spectral clusters with 95% convergence value were selected to perform unsupervised classification. Through visual examination of satellite imageries, and by using toposheets, Google earth images and by field survey digitally classified images were interpreted and reclassified. The urban area was extracted, which include high density residential areas and newly developed zone. To measure and quantify the magnitude and pace of urban growth Urbanisation Proportional Index (UPI) and Urbanisation Intensity Index were developed. GIS-based buffer analysis was adopted in this study. ArcGIS software was used for buffer analysis. Each buffer zone was employed as a basic spatial unit to characterize distance-dependent urban growth behaviour with their UPI and UII values for a given time period. Two different systems were established. The first was a circular buffer zone system with a buffer width of 2 km covering the entire region. The second system consists of direction wise analysis of entire city region. From the study two distinct phase of urbanisation is identified: 1.Phase of rapid urbanisation (1990-2000) and 2. Phase of diffusive urbanisation. The study reveals that the urban area in Cochin city region has increased from 40.23 sq. miles in 1990 to 93. 71 sq. miles in 2010.The major directional growth was observed to be in the ENE and ESE direction as new developmental activities and projects are undertaking in this zone. The study proved the effectiveness of remote sensing and GIS techniques in the spatio- temporal analysis of urban growth trend.

***Keyword(s)**: Urban growth, Remote Sensing, Geographic Information System, Buffer zone system.*

INTRODUCTION

Urbanisation represents a revolutionary change in the whole pattern of social life and itself is a product of basic economic and technological development. (Davis) Urbanisation in developing countries is the product of population explosion in rural areas which accelerate massive migration of population to the urban centres (Hagget, 1972). The process of population growth in the urban areas along with the commercial, industrial and transport preferment have favoured the recent spurt of urban development throughout the world. This has been accelerated with the overwhelming growth of population in urban areas through migrational accelerations and natural growth. Urban areas are characterized by a central feature: they concentrate population, energy and materials, industrial and commercial activities, and buildings and infrastructure. It is not any single one ofthese factors, but the conûuence of them that deûnes urban area. Indeed, although there is no uniform or globally consistent deûnition of "urban", most countries deûne urban according to a criteria pertaining to some aspect of a region's population, economy, or built infrastructure (UN, 2007). According to the World Urbanization Prospects (United Nations, 2012) most population growth will be absorbed by urban areas on a global perspective which leads to increasing proportions of the population living in cities.

Assessment of urban growth and landscape change involves the procedures of inventorying and mapping that require a reliable information base and robust techniques. (Yang,2003).Urban and landscape patterns are observable and therefore can be mapped through remote sensing (Lindgren,1985; Jensen and Cowen,1999) Digital change detection is the process of determining and/or describing changes in land-cover and land-use properties based on co-registered multi-temporal remote sensing data. The basic premise of using remote sensing data for change detection is that the process can identify change

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between two or more dates that is uncharacteristic of normal variation. (Muc-honey and Haack, 1994; Singh, 1989; Shalaby and Tateishi, 2007).

The proportion of the world's population which is urban has been growing rapidly and a larger fraction of the total population lives within cities now that at any previous period in history (United Nations, 2007, *Principles and Recommendations for Population and Housing Census*). Over the past two or three decades this urbanisation trend has been fastest in developing countries and, as a broad generalisation, the faster the rate of economic growth, the more rapid has been the trend towards urbanisation of the population. Globally, 3.6 billion people live in urban areas (UNPD, 2011). The next few decades will be the most rapid period of urban growth in human history, with 2.6 billion additional urban dwellers expected by 2050 (UNPD, 2011).

Asia is highly populous and has experienced sustained growth for the last 3 decades; its urbanization gave birth to some of the largest and densest cities in the world, supported by massive investments in infrastructure.As of 2010, Asia had 12 out of 22 mega cities in the world and the number of megacities is expected to rise considerably by 2025, to 20 in Asia.

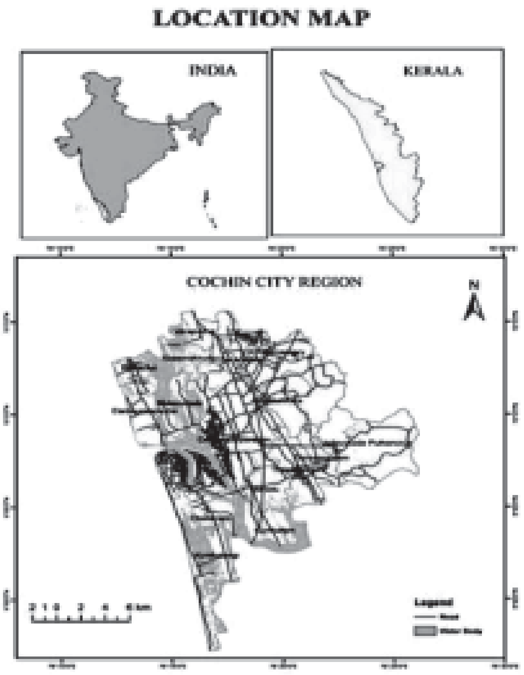
India is at acceleration stage of the process of urbanization. Urbanisation process in India, as a whole is dominated by large cities and metropolitan towns. Kerala urbanisation is unique in its spatial structure and organisation. Kerala shows a distinctive pattern of rural-urban continuum throughout the state where it is difficult to demarcate urban and rural area. In Kerala, the main reason for urban population growth is the increase in the number of urban areas and also urbanization of the peripheral areas of the existing major urban centers. The district of Ernakulam has the maximum of urban area than other districts of Kerala. Cochin is the commercial capital of Kerala. Cochin is the most promising growth oriented development region in the state of Kerala. Developments in the city and surrounding area have taken a fast stride in the last two decades. The present study addresses urbanisation in both spatial and temporal contexts and explores urban expansion of the Cochin city.

OBJECTIVES

1. To analyse the spatio-temporal changes of urban growth of Cochin city region.
2. To identify the urbanisation intensity of Cochin city region based on urban intensity index and urban proportional index
3. To understand spatio-temporal characteristics of urban expansion of Cochin city region based on direction.

STUDY AREA

Cochin is one of the largest and most important commercial and industrial centres of Kerala. Its strategic importance over the centuries is underlined by the Arabian Sea. Cochin city region is situated on the south-west coast of Indian peninsula with an administrative area of 369.72 sq. km which fall within the geographical co-ordinates 9° 47′ 14"N to 10° 5′38" N and 76° 12′22"E to 76° 25′ 50"E. The Cochin Corporation, five municipalities and nine panchayats fall in the present Cochin City Region. The core area of Kochi Region is the Kochi City. Consequently urban development has been more rapid in the City and in its immediate suburbs. Five other Municipal towns included in the Region are small urban enclaves, as compared to the core City. They are linked to the core city through the transportation corridors. Spatially the intervening villages separated them. It is located on the south western coastal strip of India.



Map 1

DATABASE AND METHODOLOGY

Two sets of Landsat TM images (1990/2000, resolution 30 m, seven bands) and one Landsat ETM+ (2010, resolution 15m, seven band) were used in the study. These images were processed with ERDAS IMAGINE software, which involves geometric correction, unsupervised classification and GIS reclassification. The different bands of imageries were stacked to produce a False Colour Composite (FCC). The Panchromatic data were merged with multispectral FCC. The base map (Cochin City Region Development Plan, 2031) of the study area was imported in computer environment and georeferenced in GIS environment. By using this shape files were generated. The sub-setting of satellite images were performed for extracting study area by taking geo-referenced outline Cochin City Region Development Plan boundary of 2031 map. The subset image was then re-projected. All three images were then classified using ISODATA unsupervised classification algorithm. Thirty spectral clusters with 95% convergence value were selected to perform unsupervised classification. Through visual examination of satellite imageries, and by using toposheets and Google earth images, digitally classified images were interpreted and reclassified. Through the use of spectral classification, the urban area was extracted, which include high density residential areas and newly developed zone.

To measure and quantify the magnitude and pace of urban growth and Urbanisation Proportional Index (UPI) and Urbanisation Intensity Index were developed and employed (Liu, 2000) which expressed as

$$UPI_{i,\, t\sim t+n} = (ULA_{i,t+n} - ULA_{i,t}) *100/ TLA_i$$

$$UII_{i,t\sim t+n} = [(ULA_{i,t+n} - ULA_{i,t}) /n] *100/ TLA_i$$

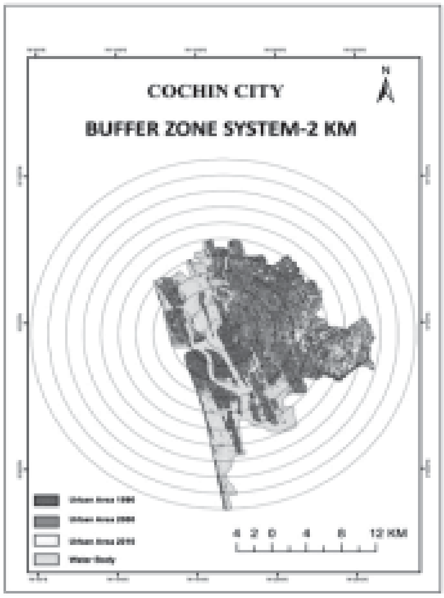
The variables $UPIi_{,t\sim t+n,}$ $UIIi_{,t\sim t+n}$, $ULA_{i,t+n}$ and $ULA_{i,t}$ are indices of the proportion of urbanization and the intensity of urbanization within a spatial unit i during a time period t~t+n, and the areas of urban land-use for years t+n and t, respectively. TLA_i is the total area of the spatial unit i. The UPI expresses the percentage of the total area occupied by urban expansion for a given spatial unit over the entire course of the study from 1990 to 2010, and it reveals the total magnitude and spatial distribution patterns of urban expansion throughout this period. The UII is used to compare the pace and intensity of urban expansion over various periods.

GIS-based buffer analysis was adopted in this study. ArcGIS software was used for buffer analysis. Each buffer zone was employed as a basic spatial unit to characterize distance-dependent urban growth behaviour with their UPI and UII values for a given time period. For the purpose of the study, one buffer zone system and one direction wise were established. The first was a circular buffer zone system with a buffer width of 2 km covering the entire region. This was designed to explore the overall urbanisation process over the city region comprising the Cochin city and its suburbs. The second system consists of aeolotropic analysis of entire city region. For this, the entire region was divided into eight parts based on direction. Calculations of the UPI and UII were made separately for each part to explore the directional trends in urbanisation process. The division was (in clockwise order): north-northeast (0° to 45°), east-northeast (45° to 90°), east-southeast (90° to 135°), south-southeast (135° to 180°), South-southwest (180° to 225°), West-southwest (225° to 270°), West-northwest (270° to 315°) and North-northwest (315° to 360°). In all analysis urban areas of Cochin city region indicated by Landsat data from 1990, 2000 and 2010 were extracted and used to represent the urban centre as a baseline for creating buffer and aeolotropic zones.

DISCUSSION AND ANALYSIS

Spatiotemporal Trends of UII Based on Buffer Analysis during 1990-2010.

Map 2 displays the expansion of urban area for the entire Cochin city region over each time interval. Fig. 1displays the UII resulting from buffer zone analysis for the entire Cochin region over each time interval. During 1990-2000 buffer zone within 2 km shows a gradual upward increase in UII. This is the core of the city and it is well developed from very earlier



Map 2: Buffer system surrounding Cochin city

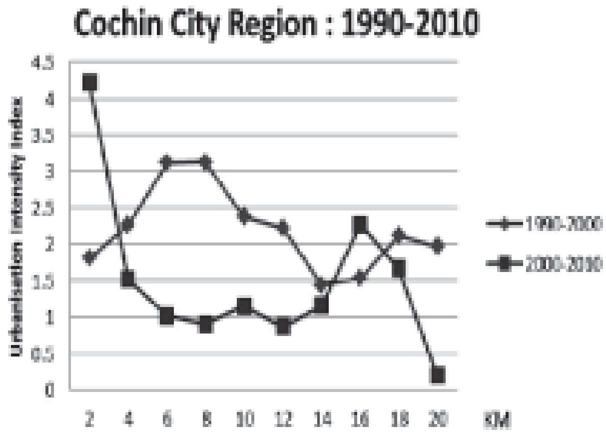


Fig: 1 Changes in UII with Distance from Urban Centre over the Cochin City Region From 1990-2010

days and has developed as CBD. Well-connected transportation network added more advantage to the urbanization of this region. Between 2-4 km it shows a slight increase. This is because this zones which include Mattancherry is well developed from the historical times itself. The earlier settlements of Cochin were developed at Mattancherry. The zone had developed as a typical orient market town, with commercial activities distributed along the waterfronts. Mattancherry grew into a market town with cosmopolitan character attracting foreign traders. UII shows a sharp increase between 4 to 6 km. The opening of Cochin International airport boosted the urban growth of this zone. Port based developments in Elamkunnappuzha also accelerated the urban growth. Edapally, Vytilla and Kudannur along NH 47 developed as active note of the city. The UII curve between 6-8 km shows a uniform trend of increase having a peak value. The zone includes major towns like Maradu, Thripunithura, Thrikkakara, Kakkanad, Fort Cochin and Thoppinpadi. Thripunithura has developed as commercial centre of importance. The NW3 being developed from the northern side of Cochin city, causing marginal growth in the surrounding area. Apartment housing is a major trend in Maradu and Thrikkakara. The urban expansion is less in between 8-12km compared to other zones. Although the UII rate is less the zone is a hub of large scale industries which prevent further urban expansion. The urban intensification is high between 12km to 18 km. This zone has developed due to its geographical location and the physical development activities implemented by the government. Fishing and tourism provide economic base for the economic development of this region. The UII between 18-22km shows a gradual decline as the land area is limited.

In 2000-2010 the UII is at its peak in and around 0-2km of the city region. It shows a high intensification of urbanization within 2 km of city region. In between 4-8 km it shows a steady declining trend from the city centre because the zone is already well developed and the vacant space for expansion is negligible. Again the UII shows a gradual rise than the previous buffer zone between 8-10 km because the zone is concentrated with diversified economic activities such as IT parks and related developments, banking and other financial institutions, Cochin Stock Exchange and tourism. The next zone between 10-12 km shows a gradual decline. The zone between 12-16 km shows a steady growth due to major investments like Smart city, Brahmapuram Power Plant. There is a huge potential for development of heavy industries and land intensive developments in this area. The buffer zone between 16-22 km shows a sharp decline as the zone is mixed with rural economic activities and also the land area is limited.

Spatial Aeolotropy of UII Based on Buffer Analysis During 1990-2010

Map 3 and Fig 2 displays the spatial aeolotropy analysis of the UII for Cochin city region. During 1990-2000 NNE and ESE direction slices shows a

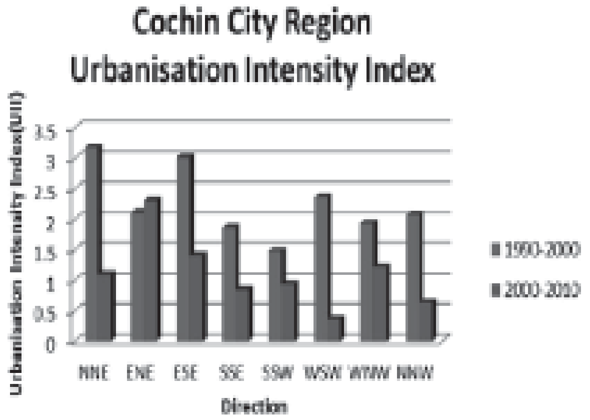


Fig 2: Changes in UII in Different Aeolotropic Zones in Cochin City Region

Map 3: *A direction wise aeolotropic zone system was established measuring the overall spatiotemporal trends of urbanization gradients and associated spatial heterogeneity in the Cochin city region, which divided the study area into eight aeolotropic areas: NNE (north-northeast),ENE (east-northeast),ESE (east-southeast), SSE (south-southeast), SSW (south-southwest),WSW (west-southwest), WNW (west-northwest), NNW (north-northwest).*

similar trend of high urban growth. Aluva industrial belt is located on the North north eastern direction which accelerates the urban growth to that direction. The well-developed road and rail network as well as the industrial activities in Ambalamugal region hasten the spread of urban area in ESE direction. ENE, WSW and NNW direction shows comparatively high UII during the period 1990-2000.The ENE slice which covers Ernakulum town and Edapally reaches its peak value as the residential population is more concentrated in this zone.SSE, SSW and WNW direction shows a similar trend of UII and higher values the other period.The apartment villa projects in Maradu and further expansion activities speed up the urbanisation process in SSE direction. WNW slice including Vallarpadam, Njaraikkal and Elamkunnappuzha where a number of developmental activities have taken place accelerated the urban growth in this zone. SSW zone comprises Mattancherry, Fort Cochin, Willington Island surrounding the city centre has already developed and urbanised.

During 2000-2010 all slices except ENE shows a declining trend, The development of IT parks, industries and commercial activities, institutions and transport development in Kalamassery, Eloor and Thrikkakara led to the spread of urban area in ENE direction.WSW direction shows the minimum UII.Due to physiographic constraints further urban expansion is hindered in WSW direction. Urban expansion has already caused considerable growth of urban area, as well as outward expansion of the urban-suburban transition zone. This is reason why UII is declining in other slices.

Spatial Aeolotropy of UPI Based on Buffer Analysis During 1990-2010

Based on the results of buffer zone analysis, the spatial aeolotrophic characteristics of Cochin city region

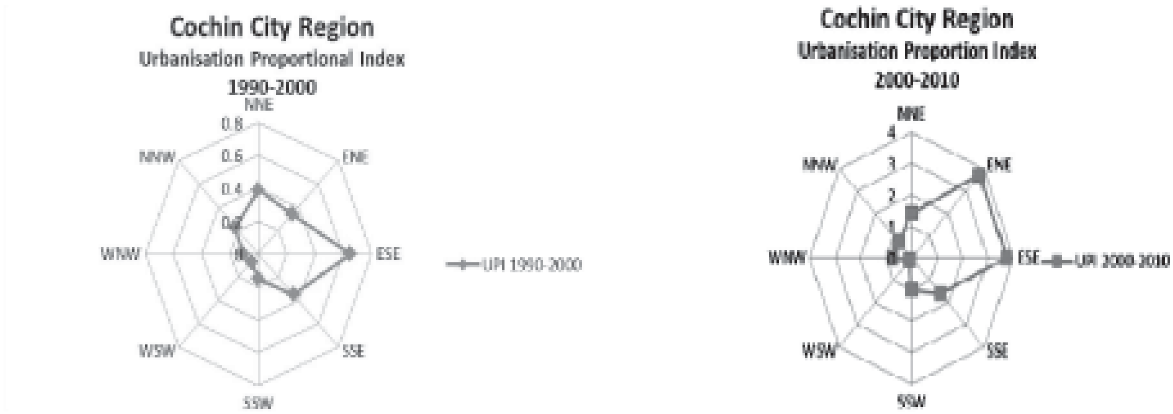


Fig 3: Spatial aeolotropy of UPI based on buffer analysis during 1990-2010

displayed in Fig: 3is summarized as follows. In 1990 - 2000 urban expansion is concentrated mainly to four directions- NNE, ENE, ESE and SSE directions. The urban expansion is limited in other directions due to the physiographic constraints (water bodies). Aluva industrial belt is located on the North north eastern direction which accelerates the urban growth to that direction. In ENE direction the developmental activities in Edapally, Thekkumpaddy, Thrikkakara and Kalamassery boosted urban expansion. The well-developed road and rail network as well as the industrial activities in Ambalamugal region hasten the spread of urban area in ESE direction. The apartment villa projects in Maradu and further expansion activities speed up the urbanisation process in SSE direction.

For the period of 2000-2010 urban area is spread over ENE and ESE direction. The development of IT parks, industries and commercial activities, institutions and transport development in Kalamassery, Eloor and Thrikkakara led to the spread of urban area in ENE direction. While in ESE direction the urban spread is due to launch of residential buildings in Thripunithura and heritage tourism in Thripunithura and Thiruvankulam, Smart City, Brahmapuram Power Plant, Solid Waste treatment plant in Vavucode-Puthencruz.

CONCLUSION

With economic development and population growth, the process of Urbanization of Cochin city had accelerated and the area of urban land increased quickly.

Two distinct phases of urbanisation are discernible

(a) Phase of Rapid Urbanisation (1990-2000)

This phase is characterised by large scale urban expansion and the urbanisation intensity increases as a whole. There is a rapid expansion in the urban expansion zone. This is because the city centre, Mattancherry, Fort Cochin, Ernakulam regions immediately surrounding the city centre has already developed and urbanised and the areas surrounding it like Maradu, Edapally, Eloor , Kalamassery, Thrikkakara, Thripunithura partly transformed into new urban centres, the urban expansion zone rapidly moves outward with a drastic increase in area. On the outer side of urban expansion zone the urban expansion intensity decreases.

(b) Phase of diffusive urbanisation (2000-2010)

Urban expansion has already caused considerable growth of urban area, as well as outward expansion of the urban-suburban transition zone. The extent of urban expansion zone also continues to increase and the top values of UII are at points further from the original urban centres but with lower values. The urbanization is characterized by a transformation from being localized, high intensity and uniform to diffusive, regionalised and complementary. Therefore UII peak values are lower than those in earlier phase.

The major directional growth was observed to be in the ENE and ESE slice as new developmental activities and projects are undertaking in this zone. Earlier it was also observed in NNE because of the IT industries and Special Economic Zone in Kalamassery.

The developmental activities such as Cochin metro rail, Port related activities in Wellington Island, Elamkunnappuzha, Mulavukadu, Njaraikkal, Kadamankkudy, Heritage and tourism activities in Fort Cochin and Mattancherry, Fishing and tourism in Chellanam and Kumbalangy, industrial activities in Vadavucodu- Puthenkurisu, Kalamassery and Thrikkakara, Residential activities in Maradu, Kumbalam, Thripunithura and Thiruvankulam accelerates future.

Acknowledgement

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REFERENCE

1. Asian Development Bank (2014). Sustainable Urbanization in Asia and Latin America.Phillipines.
2. Belal A.A.,F.S. Moghanm (2011).Detecting Urban Growth using Remote Sensing and GIS Techniques in Al Gharbiya Governorate, Egypt. *The Egyptian Journal of Remote Sensing and Space Sciences*, 73-79
3. Cui Linli and Jun Shi(2012), Urbanization and its Environmental Effects in Shanghai, China, Elsevier, *Urban Climate,* 1-15
4. Das Samarjit, Chetan Ghate and Peter E. Robertson (2014). Remoteness, Urbanization, and India's Unbalanced Growth. Elsevier, *World Development Vol. 66,* pp. 572–587.
5. Deep Shikhar and AkanshaSaklani(2014), Urban Sprawl Modeling Using Cellular Automata, Elsevier, *The Egyptian Journal of Remote Sensing and Space Sciences*, 179-187.
6. Development Plan for Kochi City Region 2031(2010). Department of Town and Country Planning (Draft), Vol 1
7. Dhanuraj D, Madhu S, Yogi Joseph(2012). A Study of Inland Water Transportation in Kochi City Region, Centre for Public Policy Research, Working paper series.
8. Estoque Ronald C. and Yuji Murayama (2011), Spatio-Temporal Urban Land Use/Cover Change Analysis in a Hill Station: The Case of Baguio City, Philippines, *Elsevier, Procedia Social and Behavioral Sciences*, 326-335
9. Guo Z., S.D. Wang, M.M. Cheng and Y. Shu(2012), Assess the Effect of Different Degrees of Urbanization on Land Surface Temperature Using Remote Sensing Images, *Elsevier, Procedia Environmental Sciences*, 935- 942
10. Han Lijian, Weiqi Zhou, Weifeng Li and Li Li (2014), Impact of Urbanization Level on Urban Air Quality: A Case of Une Particles (PM2.5) in Chinese Cities, *Elsevier, Environmental Pollution, 194,* 163-170.
11. Ismail Wan Hashimah Wan (2011), Sustainable Urbanisation on the Western Side of the Historic City of Malacca, Elsevier, *Procedia Social and Behavioral Science,* 632-639
12. Kundu Sridhar and Sanchita Deb Roy (2012) Urbanisation and de-sanitation: A De-compositional Analysis by Taking A Case Study of Few Indian Cities, *Elsevier, Procedia Social and Behavioral Science,* 427 -436.
13. Li Xiaowen, Lina Zhang, Chen Liang (2010). A GIS-based Buffer Gradient Analysis on Spatiotemporal Dynamics of Urban Expansion in Shanghai and its Major Satellite Cities. *Procedia Environmental Sciences 2 (2010),* 1139–1156.
14. Li Ying, Tingting Guob and Jing Zhou (2011), Study on the Development of Rural Urbanization in Beijing, *Elsevier, Procedia Environmental Sciences*, 893-898
15. Mikovits C, W. Raucha and M. Kleidorfer (2014), Dynamics in Urban Development, Population Growth and their Influences on Urban Water Infrastructure, *Elsevier, Procedia Engineering,* 1147-1156
16. Mohan Manju and AnuragKandya (2015). Impact of Urbanization and Land-use/Land-cover Change on Diurnal Temperature Range: A Case Study of Tropical Urban Airshed of India Usingremote Sensing Data, *Elsevier, Science of the Total Environment*, 453-465.
17. Narain Vishal (2009), Shrinking Hinterland: Land

Acquisition Transition and Conflict in Peri-urban Gurgaon, India, *Environment and Urbanisation, Vol 21,* 501-511.

18. Oana Petrov Laura, Shahumyan Harutyuna, Williams Brendana and Convery Sheila (2011), Scenarios and Indicators Supporting Urban Regional Planning, Elsevier, Procedia Social and Behavioral Sciences, 243-252.
19. Oindrila Datta Gupta (2014). Global Integration and Developing Indian "Smart Cities": New Hopes and Challenges. *International journal of Innovative Social Science Humanities Research, Vol (1), Issue-2,* 30-42
20. Pons Antoni and OnofreRullan (2014). The Expansion of Urbanisation in the Balearic Islands (1956–2006). *Journal of Marine and Island Cultures.*
21. Price Bronwyn, Felix Kienast, Irmi Seidl, Christian Ginzler, Peter H. Verburg and Janine Bolliger (2015). Future landscapes of Switzerland: Risk Areas for Urbanisation and Land Abandonment, *Elsevier, Applied Geography, 57*, 32-41
22. R.Suja, J.Letha and Jiji Varghese (2013).Evaluation of Urban Growth and Expansion Using Remote Sensing and GIS. *International Journal of Engineering Research & Technology (IJERT), 10(2*), 2772-2779.
23. RamachandraT.V, A.H. Bharath and M.V. Sowmyashree (2015). Monitoring Urbanization and its Implications in a Mega City from Space: Spatiotemporal Patterns and its Indicators. *Journal of Environmental Management (Elsevier), 148*, 67-81
24. Salleh Siti Aekbal, ZulkifleeAbd.Latif, Wan Mohd. Naim Wan Mohda and Andy Chan (2013). Factors Contributing to the Formation of an Urban Heat Island in Putrajaya, Malaysia, *Elsevier, Procedia Social and Behavioral Science*, 840-850
25. Sha Moquan and Guangjin Tian (2010). An analysis of Spatiotemporal Changes of Urban Landscape Pattern in Phoenix Metropolitan Region, *Elsevier, Procedia Environmental Sciences,* 600-604
26. Thakur Baleshwar, George Pomeroy, Chris Cusack and Sudhir K Thakur (2007). City Society and Planning. *Concept Publishing Company,* New Delhi
27. Thomas George, Sherin A.P, Shareekul Ansar and E.J. Zachariah (2014), Analysis of Urban Heat Island in Kochi, India, Using a Modified Local Climate Zone Classification, *Elsevier, Procedia Environmental Sciences,* 3-13
28. Tian Hanqin, Kamaljit Banger, Tao Bo and Vinay K. Dadhwal (2014), History of Land Use in India during 1880–2010: Large-Scale Land Transformations Reconstructed from Satellite Data and Historical Archives, *Elsevier, Global and Planetary Change,* 78-88.
29. Vij Dimpal (2012), Urbanization and Solid Waste Management in India: Present Practices and Future Challenges, Elsevier, *Procedia Social and Behavioral Science*, 437-447
30. Wu Shaohua, Shenglu Zhou, Dongxiang Chen, Zongqiang Wei, Liang Dai and Xingong Li (2014). Determining the Contributions of Urbanisation and Climate Change to NPP Variations over the Last Decade in the Yangtze River Delta, China, *Elsevier, Science of the Total Environment*, *472,* 397-406.
31. Yang Xiaojun (2011). Urban Remote Sensing Monitoring, Synthesis and Modeling in the Urban Environment, *Wiley- Blackwell,* Oxford U.K.
32. Zhan S.F., X.C. Zhang C. M and W.P. Chen (2012), Dynamic Modelling for Ecological and Economic Sustainability in a Rapid Urbanizing Region, *Elsevier, Procedia Environmental Sciences,* 242-251
33. Zhang Qingling and Karen C. Seto(2011).Mapping Urbanization Dynamics at Regional and Global Scales Using Multi-temporal DMSP/OLS Nighttime Light Data, *Elsevier, Remote Sensing of Environment*, *115*, 2320–2329.
34. Zhong ping Wang, Shi Changliang, Li Qiang and Wang Gang (2011), Coupling Trending Analysis about Urbanization and Urban Resource in Beijing, *Elsevier*, *Energy Procedia,* 1589-1596
35. Zhou Di,Ping Shi, Xiaoqing Wu, Jinwei Ma and Junbao Yu(2014). Effects of Urbanization Expansion on Landscape Pattern and Region Ecological Risk in Chinese Coastal City: A Case Study of Yantai City, *Hindawi,*1-9.

IMPACT OF IN-MIGRATION ON ENVIRONMENTAL QUALITY OF DELHI

Md. Safikul ISLAM[1] & Lubna SIDDIQUI[2]

ABSTRACT

Migration is one of the major components of population growth apart from fertility and mortality. The in-migration in Delhi is due to pull factors like employment, education, business, tourism etc. Being the capital of India, Delhi attracts migrants from Uttar Pradesh, Bihar, Punjab, Haryana, Rajasthan, Madhya Pradesh, West Bengal, Jammu & Kashmir etc. Migration fulfils the demand of labour and skills in economic activities but on the other hand it also degrades the quality of natural environment. This paper is an attempt to examine the impact of environmental degradation in Delhi due to increasing number of migrants since 2001. The present study is entirely based on secondary sources of information and data such as Census of India and various other study reports. The results show an increasing trend of migrants during the last decade (2001-2011). The students and employment aspirants are predominant among migrants, thus the pressure on infrastructural facilities such as education and economic sectors is increasing day by day and it affects the quality of Delhi's environment. An intense analysis is necessary to examine the impact of migration on environment in Delhi and its surrounding area (NCR).

Keyword(s): *Pull Factors, Migration, Impacts, Environment, Sustainable Development.*

INTRODUCTION

In-migration has become one of the most important factors for rapid population growth since the evolution of urbanisation.It hasalso become one of the leading factors behind urban sprawl of mega city like Delhi in India by creating an environment of huge population within a limited geographical area. People are migrating to Delhi from all over India and even from abroad but most of the migrants are coming from the surrounding states like Uttar Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh, Bihar, West Bengal, Jharkhand etc. Out of total migrants, more than 75 per cent migrants are occupied by two states named Uttar Pradesh and Bihar.The population of Delhi has increased from 40.66 lakh in 1971 to 167.5 lakh in 2011. The in-migration during same period has increased from 8.76 lakh in 1971 to 32.36 lakh in 2011while the share of out-migration from Delhi has slightly increased from 2.42 lakh in 1961-71 to 3.82 lakh in 2001-2011. Therefore, the net migrants (In-migrants – Out-migrants) to Delhi have steadily increased from 6.34 lakh during 1961-71 to 28.54 lakh during 2001-2011. Such kind of emerging phenomena has resulted in a continuous urban sprawl and deterioration of the urban environment in Delhi. The effects of rapid growth of population, urbanization and urban sprawl on physical environment, amenities and infrastructure of Delhi have created a vulnerable environment against sustainable development of urban lives. There are many large scale economic activities for survival and development of urban people on one hand but rapid growth of population due to in-migration has created lots of environmental problems regarding air contamination (air pollution), ground water scarcity, heap of solid waste etc. on the other hand. There must be some important pull factors which encourage migrants to migrate from other states to the National Capital Territory of Delhi (NCTD).

Pull Factors

Employment: Delhi that being the Capital of India generates enormous job opportunities for labours, skilled and unskilled workers. Therefore people who are not paid well or who do not have enough job opportunities in their native place or the once who are looking for growth and better job opportunities are attracted towards Delhi.

Education: It is one of the most important pull factors for migration towards Delhi. Delhi is seen as the best destination for higher and tertiary education. Delhi has India's best colleges and universities like University of Delhi (DU), Jawaharlal Nehru University (JNU), Jamia Millia Islamia (JMI), Jamia Hamdard University, IGNOU etc. and other technical (IIT) and medical (AIIMS) universities. Delhi also has been created a hub of IAS coaching centres.

Marriage: Generally women migrate from one place to Delhi after getting marriage if their husband's native place is in Delhi or husband is doing job in Delhi. That is why women are relocated after marriage.

Business: frequent migration towards Delhi are found for business purpose. Such kind of migration are generally are of short duration.

Administrative Work: Delhi is the Capital of the

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country, all the administrative works in Supreme Court, High Court, Secretariat, Parliament etc. are performed here. So, people also migrate to Delhi for Administrative works.

Others: Delhi is also the hub of architecture and sculpture like Red Fort (Lal Qilla), Qutub Minar, Jama Masjid, Akshardham Temple, Lotus Temple etc. Tourists from all over the country and even abroad visit here.

LITERATURE REVIEW

Ishtiaque, A. and Sofi Ullah, M. (2013) in their research paper "The Influence of Factors of Migration on the Migration Status of Rural-Urban Migrants in Dhaka, Bangladesh" have highlighted several factors which are responsible for rural-urban migration influencing the migrant's migration status. Their main objective of this paper to discuss the influence of migration factors on the determination of migration status of the rural-urban migrants'. They have purposively selected the largest slum of Bangladesh according to single criterion- high concentration of rural-urban migrants. A total of 263 face to face interviews and 5 FGDs have been conducted. According to results, multivariate analyses have shown that both push and pull factors influence the migration status of migrants', however, social factors, except occupation at rural origin, do not have any considerable influences.

Okpara, E. E. (1986) in her research paper "Rural-Urban Migration and Urban Employment Opportunities in Nigeria" has demonstrated that most studies of rural-urban migration in Third World economies are basically modelled after the European experience of rural-urban labour transfer during the Industrial Revolution. Ideally, most rural-urban migrants of the time found wage employment in a rapidly growing modern industrial sector while this process has not been fully replicated in most Third World countries like West Africa where the pace of industrialization appears to lag behind the rate of urbanization and rural to urban labour transfers in essentially tertiary service centred. A sample of traders has been used to illustrate two facets of this induced behaviour, namely, self- employment in the informal sector and the long run merchandise traders. She finally has argued that many potential migrants to the city especially those poorly qualified to seek employment in most formal sector establishments are generally aware of this unfavourable urban job situation, and this knowledge affects their migration behaviour.

Brockerhoff, M. (1994) in his article "The impact of rural-urban migration on child survival" has suggested that rural families can improve their children's survival chances by leaving the countryside and settling in towns and cities to minimize large rural-urban child mortality differentials in many developing countries. He has used data from Demographic and Health Surveys in 17 countries to assess the impact of maternal rural-urban migration on the survival chances of children under age 2 years in the late 1970s and 1980s. Results have been shown that before migration, children of migrant women had similar or slightly higher mortality risks than children of women who remained in the village. Children born after migrants had settled in the urban area, however, gradually experienced much better survival chances than children of rural non-migrants, as well as lower mortality risks than migrants' children born in rural areas before migration. The author has concluded that many disadvantaged urban children would probably have been much worse off had their mothers remained in the village, and that millions of children's lives may have been saved in the 1980s as a result of mothers moving to urban areas.

Banerjee, A. and Das, S. (2006) in their paper "Population Environment and Development: Some Issues in Sustainability of Indian Mega-Cities of New Delhi and Kolkata (Calcutta)" have highlighted that rapid population growth fuelled by in-migration has been the hallmark of the leading mega cities of India, creating a "top-heavy" structure of India's urbanisation. They also emphasised that rapid population growth has resulted in a continuous urban sprawl and deterioration of the urban environment in most of parts of New Delhi and Kolkata. Their paper is an attempt to decipher the effect of rapid growth of population, urbanization and urban sprawl on physical environment, amenities and infrastructure of two Indian mega cities viz.New Delhi, the present capital of India and Kolkata (Calcutta), the earlier capital under the British rule in India.

Jahan, M. (2012) in her article "Impact of Rural Urban Migration on Physical and Social Environment: The Case of Dhaka City" has highlighted the fact that-rural urban migration is the principle component of rapid and unplanned growth of towns and cities in the developing countries. She has further added that gross disparities in socio-economic opportunity between urban and rural areas and frequent natural disasters in some regions encourage large flow of migrants from rural Bangladesh to the large cities. Dhaka is the capital of Bangladesh and her focus on this article is migration to this city for being the capital which identifies the factors contributing to the migration process. She has also discussed the impact of migration such as economic, demographic, environmental and socio-cultural impacts which are diverse both at the urban destination and at the rural origin and she has focused on the urban end. The author has finally examined the overall conditions of the underprivileged, poor migrants and the consequences of migration on the physical and social environment on their choice of destination.

Hua, Q. (2012) in his research paper "Environmental Effects on Rural to Urban Migration in China" has emphasized that migration process has become increasingly important in recent research on population and the environment. A majority of the existing migration and environment literature has been focused on the environmental causes and determinants of migration. With account of the largest rural-to-urban migration flow in world history and growing concerns about the environmental problems accompanying its fast economic development, China has provided a particularly important case for migration and environment research. The author has based his study on review major migration theories and recent research on environmental effects on migration and has paid specific attention to the influences of environmental factors on rural-to-urban labour migration in China. A comprehensive multilevel conceptual framework has been developed for studying the environmental causes of rural-to-urban migration in China. He has concluded his paper with showing some important effects of land resources on household labour migration decisions in rural China.

Adams, H. (2012) in her article "Impact of migration on urban destination areas in the context of climate change" has analysed the impact of climate change that may have on urban migrant receiving areas as well as their population and has provided possible steps in addressing the substantial policy challenges in this area. Environmental factors are clearly in some cases already contributing to wider patterns of rural-urban migration, but it is also the case that cities themselves are often vulnerable to environmental change and extreme weather. In this context she has ensured that migrant vulnerability is a function of exposure to hazard and adaptive capacity as well as the degree of policy support to mitigate risk. Finally, she has suggested that a key policy requirement is to plan for continuing rural-urban migration in the context of environmental change.

STUDY AREA

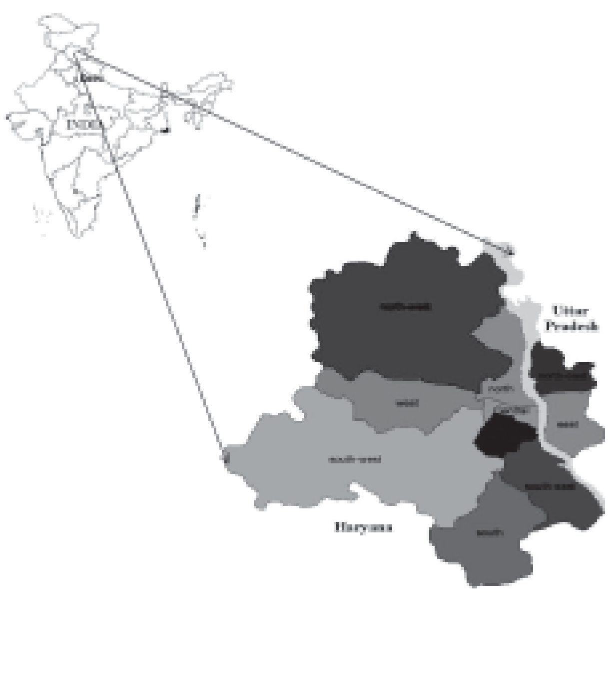
Delhi as a capital of India is situated in northern part of country between the latitudes of 28° 24′ 17″ and 28° 53′ 00″ North and longitudes of 76° 50′ 24″ and 77° 20′ 37″ East. Delhi shares its borders with the States of Uttar Pradesh and Haryana. Delhi has an area of 1,483 sq. kms. Its maximum length is 51.90 kms and greatest width is 48.48 kms. Delhi is situated on the right bank of the river Yamuna at the periphery of the Gangetic plains. The meandering course of the river Yamuna meets the ridge of Wazirabad to the north; while to the south, the ridge branches off from Mehrauli. The main city is situated on the west bank of the river and Delhi constitutes 10 districts such as North, North-East, West, South-West, New Delhi, Central, South, South- East, East and North- East.

Physiography

There is a variation in the physiography of Delhi with some major features like the river Yamuna, the Aravalli range and the plains in between is made of alluvium deposits of recent formation. The Delhi Ridge and its four sections, the northern, the central, the south central and the southern covers the farthest extension of the Aravalli range, its spurs meeting the Yamuna at two points in the north and the east. Ecologically, the Ridge acts a barrier between the Thar Desert and the plains and slows down the movement of dust and wind from the desert. Moreover,The Yamuna River and terminal part of the Aravalli hill range are the two main geographical features of the city. The Aravalli hill range is covered with forest and is called the Ridges; they are the city's lungs and help maintain its environment. The Yamuna River is Delhi's source of drinking water and a sacred river for most of the inhabitants.

714 mm and out of total rainfall, three- fourth falls in monsoon season, i.e., July, August and September. Heavy rainfall in the catchment areas of the Yamuna can result in a flood like situation for the city. During the summer months of April, May and June, temperatures can rise to 40-45 C; winters are typically cold with temperatures during December and

Location Map of Delhi



January falling to 4 to 5 C. February, March, October and November are climatically the best months. Apart from this, the entire climatic condition is same as of Delhi. As regard the soil types, western part of Delhi covers heavy rocky soil while soil becomes light and loamy towards bank of Yamuna River.

Population

Delhi has been rewarded one of the most popular cities in the country since ages. The Population of Delhi according to 2011 census, stands at about 16 million, making it the 18th most populated State/UT and second highest populated metropolitan city in India. But according to 2015, the population is over 20 million and is considered as the highest populated metropolitan city. The Union Territory of Delhi is the capital of India and as a result it is a home to considerable amount of population. Literacy rate and sex ratio in Delhi are recorded as 86.34 per cent and 866 females per 1000 males respectively.

OBJECTIVES

The main objectives of the present study are:

- To assess the changing attributes of in-migrants in Delhi since 2001
- To trace out the impact of in-migration on urban infrastructure and morphology in Delhi
- To examine the impact of in-migration on urban physical environment in Delhi
- To find out possible solutions and suggestions for overcoming the emerging environmental issues

DATABASE AND METHODOLOGY

The present study is entirely based on secondary sources of data that have been collected from Census of India (2001, 2011), Statistical Abstract of Delhi (2014), Central Pollution Control Board of India (2011), Indian State of Forest Report (2009), Economic Survey of Delhi (2013) etc. Simple percentile method has been used to show share and growth rate. As per as the cartographic drawing is concerned, simple graph, pie diagram and bar diagram have been drawn.

DISCUSSION AND ANALYSIS

Decadal Growth of Migrants

Table 1 clearly shows that in-migrants are increased from 22.22 lakhs in 2001 to 32.36 lakhs in 2011 with 45.63 per cent decadal growth while out migrants are decreased from 4.58 lakhs in 2001 to 3.82 lakhs in 2011 with -16.59 per cent negative decadal growth. So, the net migrants are increased rapidly from 17.64 lakhs in 2001 to 28.54 lakhs in 2011.

Table 1
Decadal Growth of Migrants

Migration	*Census Year (Projected)* 2001	2011	*Decadal Growth (in Percentage*
In-migrants (lakh)	22.22	32.36	45.63
Out-migrants (lakh)	4.58	3.82	-16.59
Net Migrants (lakh)	17.64	28.54	61.79

Source: Census of India, 2011.

State-wise Share of Migration

Out of all the states from where migrants are coming to Delhi, Uttar Pradesh and Bihar are predominant. The percentage of migrants of Uttar Pradesh has increased from 43.13 percent in 2001 to 46.5 per cent in 2013 and in case of Bihar; migrants have increased at alarming rate from 13.63 per cent to 30.7 per cent. The contributions of other significant states like Haryana, Rajasthan, West Bengal etc. have slightly decreased (Table-2).

Table 2
State-wise Share of Migration in Delhi
(Migrants in Percentage)

States	*Year* 2001	2013
Uttar Pradesh	43.13	46.5
Bihar	13.63	30.7
Haryana	10.43	4.1
Rajasthan	5.16	2.9
West Bengal	3.22	2.9
Others	24.43	12.9
Total	100	100

Source: Statistical Abstract of Delhi, 2014.

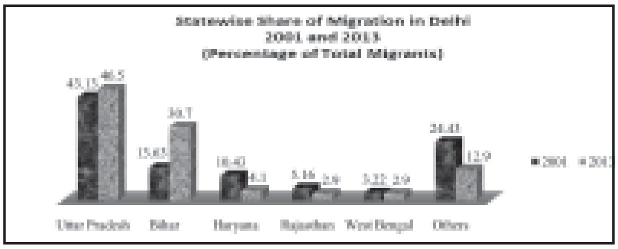


Fig. 1: State-wise Share of Migration in Delhi

Reasons of Migration

According to table 3, about half (51 per cent) of the total migrants have changed their native place due to searching of employment and job opportunities in Delhi. Out of rest of the migrants, 23 per cent is migrated for better employment, 17.6 percent for education and training, 4.4 percent for taking up better employment and 4.2 per cent for other reasons including marriage, business etc.

Table 3
Important Reasons of Migration

Reasons of Migration	*Percentage of Migrants*
In search of employment	50.7
In search of better employment or higher salary and wages	23
To take up better employment or higher salary and wages	4.4
Education and Training	17.6
Others (including marriage, business etc.)	4.2
Total	100

Source: Statistical Abstract of Delhi, 2014.

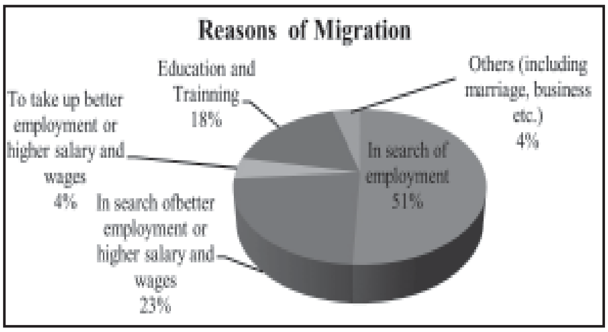


Fig. 2: Reasons of Migration

Trend of Land use Change

Table 4 is representing the trend of land use change since 1980-81. Fallow land and Net Area Sown have decreased from 22.18 percent and 39.7 per cent in 1980-81 to 13.03 per cent and 15.7 per cent in 2014-15 respectively. As a result, Built-up Area has subsequently increased from 35.31 per cent to 62.85 per cent during the same period of time to accommodate the huge number of population.

Table4
Trend of Land use Change in Delhi
(1980-81 to2014-15)

Census Year	*Fallow Land (percentage)*	*Net Area Sown (percentage)*	*Built-up Area (percentage)*
1980-81	22.18	39.7	35.31
1990-91	8.72	32.79	50.34
2000-01	7.83	23.08	60.81
2010-11	13.59	15	62.85
2014-15	13.03	15.7	62.85

Source: Census of India, 2011.

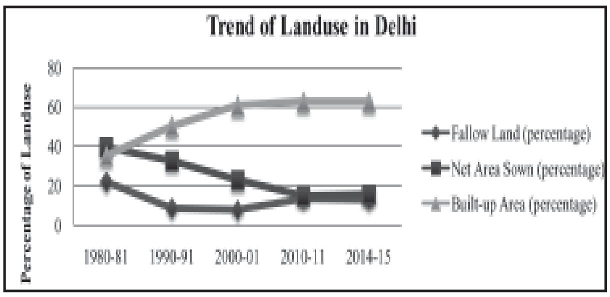


Fig. 3: Trend of Landuse in Delhi

Impact on Air Quality

The composition of air has been disturbed at an alarming rate due to contamination of pollutants like different gases, smokes, suspended particulate matters (SPM), respirable suspended particulate matters (RSPM) etc. According to table 6, SO2and NO2have increased from 14.1 and 41.8 to 15 and 66 respectively during last decade while CO has decreased from 4183 to 2020. As far as the proportion of particulate matter in the air is concerned, SPM and RSPM have also increased from 382 and 150 to 438 and 281 respectively.

Table 5
Air Quality Index and Its Distinctive Characteristics

Air Quality Index (AQI)	*Levels of Health Concern*	*Colours*	*Possible Impact on Health*
0-50	Good	Green	Minimal Impact
51-100	Moderate	Yellow	Minor Breathing Discomfort to Sensitive People
101-150	Unhealthy for Sensitive Groups	Orange	Breathing Discomfort to the People with lungs, asthma and heart diseases
151-200	Unhealthy	Red	Breathing Discomfort to the Most People on prolonged exposure
201-300	Very Unhealthy	Purple	Respiratory Illness on Prolonged Illness
300-500	Hazardous	Maroon	Effects healthy People and Serious Impacts to those with Existing Diseases

Source: www.google.com (google image).

Table 6
Air Quality Levels in Delhi

Year	*SO_2*	*NO_2*	*CO*	*SPM*	*RSPM*
2000-01	14.1	41.8	4183	382	150
2004-05	8.8	55.9	2541	373	168
2010-11	15	66	2020	438	281

Source: Department of Environment GNCTD/DPCC & CPCB.

Table 7
Increasing Number of Registered Vehicles

Census Year	*Total Registered Vehicles (in Lakhs)*
1980-81	5.21
1990-91	17.64
2000-01	34.56
2010-11	74.38

Source: Census of India, 2011

There are so many reasons of air pollution but the most important and devastating reason is smoke caused by burning of fuels from vehicles. The highest percentage of pollutants is contributed by vehicles. The numbers of vehicles are still increasing since 5.21 lakhs in 1980-81 to 74.38 lakhs in 2010-11 without stopping anyhow. It means that number of vehicles has increased 15 times more within last four decades. So, as a result increasing numbers of vehicles are gradually adding the amount of pollutants and smoke in the air decade by decade.

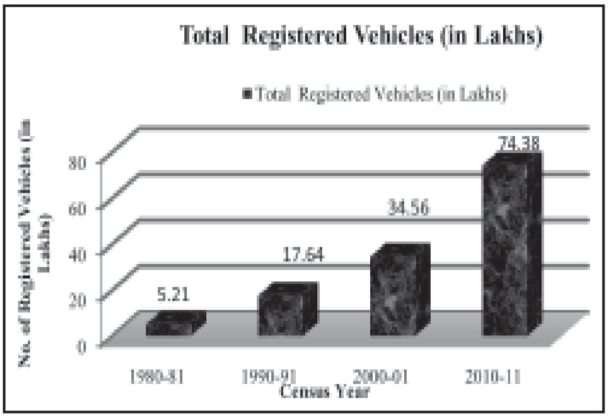


Fig. 4: Total Registered Vehicles (Lakhs)

Increases in Solid Waste

According to table 8, the amount of municipal solid waste per day has increased with increasing population of Delhi due to enormous in-migration. The above table is showing the fact that solid waste has increased from 4000 tonnes per day in 1999-00 to 5922 tonnes per day and subsequently it has reached to 6800 tonnes per day. Rapid population growth has widened the world of consumption in one hand but as a result it has also increased the heap of solid waste on the other hand.

Table 8
Increase in Municipal Solid Waste

Year	*Municipal Solid Waste (tonnes/day)*
1999-00	4000
2004-05	5922
2010-11	6800

Source: Municipal Solid Waste Study, CPCB, 2011

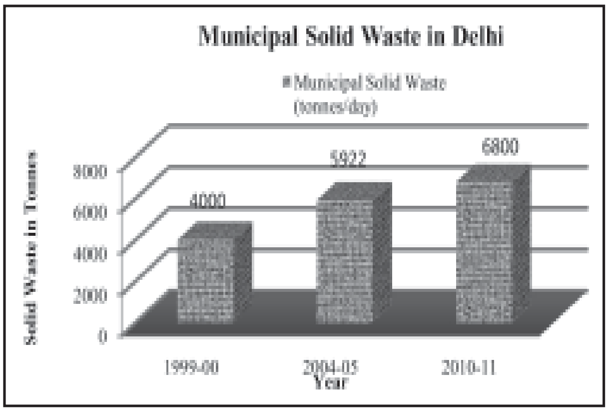


Fig. 5: Municipal Solid Waste in Delhi

Forest and Tree Cover

There is good news for Delhi that it has been covered by green forest and tree covers. Furthermore, the area under forest and tree cover has increased from 22 sq. km (1.48 per cent) in 1992-93 to 299.59 sq. km (20.2 per cent) in 2008-09. The tree cover is still increasing continuously with the effort of Plantation under Green Delhi. In 2011-12, it targeted 15.96 lakhs plantation and has achieved 17.34 lakhs plantation.

Table 9
Expansion of Forest and Tree Cover Area

Year	*Forest and Tree Cover (Sq. Km)*	*Percentage in Total Area*
1992-93	22	1.48
2000-01	151	10.2
2008-09	299.59	20.2

Source: Forest Department, Government of National Capital Territory of Delhi

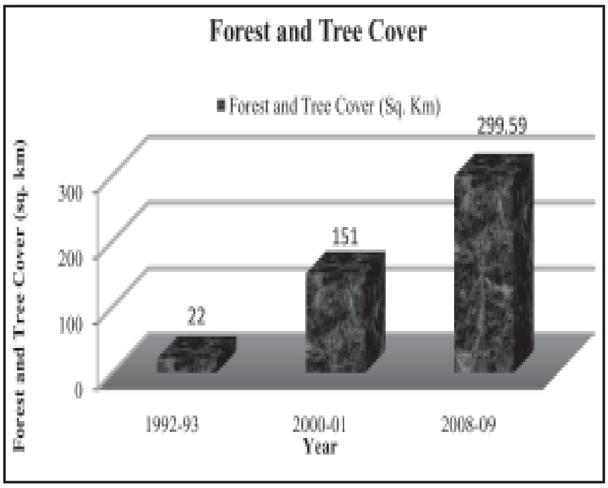


Fig. 6: Forest and Tree Cover

CONCLUSIONS

The present study has examined the impacts of in-migration on urban environment in Delhi and one thing should be noted that the same kind of impacts due to in-migration are prevailed in other mega cities like Mumbai, Kolkata, Chennai, Hyderabad, Patna etc. The main findings of the present study are as under:

- Decadal growth of in-migrants in 2011 has been found near about half of the total in-migrants of 2001. Contrary to this, the growth of out-migrants has declined. So, more numbers of in migrants lead to pressure on population of Delhi.
- More than 77 per cent of migrants are contributed by Uttar Pradesh and Bihar combined.
- There are many reasons behind in migration but the most important reasons are search of employment and education in Delhi.
- Since 1980-81, the area under residential built-up has increased while fallow land net sown area has decreased proportionally.
- According to Air Quality Index in 2011, the level of Delhi's air is very unhealthy leading to respiratory illness on prolonged illness.
- The amount of solid waste per day is still increasing at an alarming rate due to huge consumption.
- It is very pleased to share that the green forest and tree cover increasing with great effort.

SUGGESTIONS

- Enough job opportunities and education should be provided at native place by the combined co-operation of union and state government. So, there will be less migration as compared to present rate. As a result, the pressure on population as well as resources will be reduced.
- The area under residential built-up and cultivable land should be regulated by government.
- There must be an ordinance for availing eco-friendly (CNG) vehicles.
- The plantation effort under Green Delhi should not be stopped in future.
- There must be possible advanced technologies to dispose and recycle of solid waste quickly.
- Last but not the least, self -consciousness or awareness about optimum resource utilisation towards sustainable development must be attained.

REFERENCES

1. Adams, Helen (2012): "Impact of migration on urban destination areas in the context of climate change. *UK Government Office for Science,*European Commission roundtable, Session 1.
2. Annual Report, (2011): *Central Pollution control Board*, Ministry of Environment and Forest, Government of India.
3. Banerjee, Anuradha and Das, Sharmistha (2006): "Population Environment and Development: Some Issues in Sustainability of Indian Mega-Cities of New Delhi and Kolkata (Calcutta)."
4. Brockerhoff, Martin (1994): "The impact of rural-urban migration on child survival." *Health Transition Review,* Vol. 4, No. 2, pp. 127-149.
5. Census Report (2001, 2011): *Census of India,* Government of India,New Delhi.
6. Economic Survey of Delhi (2013): *Directorate of Economics and Statistics,* Government of NCT of Delhi.
7. Hua, Qin (2012):"Environmental Effects on Rural to Urban Migration in China."*Chinese Journal of Population Resources and Environment,* Volume 10, Issue 3.
8. India State of Forest Report, 2009: *Forest Survey of India,* Dehradun; Ministry of Environment and Forest, Government of India
9. Ishtiaque, Asif and Sofi Ullah, Md (2013): "The Influence of Factors of Migration on the Migration Status of Rural-Urban Migrants in Dhaka, Bangladesh." *Journal of Studies and Research in Human Geography,* 7.2(2013), 45–52. ISSN-print: 1843–6587.
10. Jahan, M. (2012): "Impact of Rural Urban Migration on Physical and Social Environment: The Case of Dhaka City."*International Journal of Development and Sustainability,* Volume 1 Number 2, Pages 186-194.
11. Kainth, Gursharan S. (2010), Push and Pull Factors of Migration: A Case Study of Brick Kiln Migrant Workers in Punjab,*Munich Personal RePEc Archive (MPRA), Paper No. 30036.*
12. Okpara, Enoch (1986): "Rural-Urban Migration and Urban Employment Opportunities in Nigeria." *Transactions of the Institute of British Geographers,* Vol. 11, No. 1 (1986), pp. 67-74.
13. Statistical Abstract of Delhi (2014): *Directorate of Economics and Statistics*, Government of NCT of Delhi.
14. www.google.com
15. www.jstor.org
16. www.wikipedia.com

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URBANISM AND HISTOGENESIS OF CAPITAL CITIES IN INDIA

Prakriti PRIYA[1]

ABSTRACT

Capital cities are the centre of political, economic, cultural and symbolic function. The evolution of both the state as well as the capital city is closely associated with the process of urbanisation. The present paper provides a detailed description of the formation of Indian state and its organisation through ages along with its capital cities. India with a unique blend of unitary and federal characteristics has a intricate system of capital cities. Tracing through the historical roots of urbanisation, the process of organisation of India as a State with a quasi-federal structure is observed through the rise of Janpadas and Mahajanpadas, in north and Mandalams, Nadus and Kottams in south India followed by rise of powerful dynasties like Maurya's, Gupta's, and Mughal's which brought political organisation in India with the centralisation of power at the capital city. However, India failed to emerge as a single political unit throughout its olden times. It was only after it independences in 1947, the Indian Territory emerged as a single political entity with establishes political system and structure. After independence and partition, the country went through a lot of deliberations to acquire the present political structure. With a quasi federal structure, NCT Delhi, serves as the centre of Indian Union. While each of the 29 States and the Union Territories centralised their political power in their respective capitals.

Keywords: *Urbanisation, Capital Cities, Janpadas, Mahajanpadas, Political Centralisation, Quasi Federal Structure*

INTRODUCTION

Capital Cities are figurative to the nation's ideals and way of living. They serve as the medium of economic and political development and the cultural locus and a connecting link between the local and the larger national culture **(**Campbell**,** 2014**)**. These cities are at the top of the power hierarchy representing the larger political system around them **(**Daum**,** 2005**)**. The identity of capital cities is defined by the state to which it belongs. The evolution of both the state as well as the capital city is closely associated with the process of urbanisation. In most cases both urbanisation and state formation go side by side. Hence the examination of capital city growth and evolution can only be done in the circumscription of urbanisation.

The nature of capital cities is largely based on the nature of administrative system. In a unitary form of government due centralisation of power at the national level the national capital has a very strong hold in the political functioning and decision making of the state. This often leads to the birth of capital as primate city. On the contrary, in a federal form of government there is no centralisation of power; rather the power is divided between the centre and the provinces/regions and the regional government is credited with huge responsibilities. Therefore a federal form of government is characterised by a lighter and less rigid national capital (Dikshit, 1999; Slack & Chattopadhyay, 2009)**.** The regional capitals have their own level of significance in the entire administrative structure.

India with a unique blend of unitary and federal characteristics has an intricate system of capital cities. In order to understand their structure and organisation it is essential to look into the political structure and organisation of Indian state at the same time the urban history of India which helped shaping up the current political system . The present paper thus, provides a detailed description of the formation of Indian state and its organisation through ages. It also throws light on the organisation and structure of Indian capital cities.

PHASES OF STATE ORGANISATION

India is a unique country owing to its rich cultural tradition. Much unique is its political system. The country is a unique blend of both unitary as well as federal system (federal in structure; unitary in functioning) (Dikshit, 1999). The politico-administrative power is divided between the Centre with its base in the National Capital Region at Delhi and twenty-nine state governments. The country also has seven centrally administered Union Territories. However, the political map of India has not always been the same. It has greatly modified since independence. Before independence, the political structure was greatly fragmented.

The political evolution and development of Indian state has a long history of over 5000 years. 'It is an endless succession of invasion by various people, all contributing to the geographical mosaic' (Tiwari, 2007, p.885). The territory of India was torn into numerous political units, which were in constant

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contention of power and control over each other territory. Time and again powerful dynasties like Maurya's, Gupta's, emerged bringing dominant part of the state under a single political system. However, the political unity crumbled as soon as the authority weakened. Hence, India in her 5000 years of history, failed to emerge as a single sovereign political unity (Tiwari, 2007). It was only after its independence from the British Imperialism in 1947, the Indian territory emerged as a single political entity with establishes political system.

The history of urbanisation and state organisation in India can be divided into five phases on the basis of the temporal discontinuities. They are as follows:

- The Prehistoric Period (2350 BC - 1800 BC)
- The Historical Period (600 BC - 500 AD)
- The Medieval Period (600 AD – 1800 AD)
- The British Period (1800 AD – 1947)
- The Post Independence Period (1947 – till date)

The Prehistoric Period

The earliest inferences of settled and politically structured human habitation with capital cities in India dates back to the time of Indus Valley civilisation(2300-1800BC), which is considered as the birthplace of urbanisation in India. The Harappan Empire had over hundred of urban centres like Lothal, Kalibangan, Rupar, Banwali, Rojdi, Surkota, etc. but they were not at par with the two capital cities Mohenjo-Daro and Harappa. The twin capital city, Mohenjo-Daro and Harappa, were expressive of the cultural and political grandeur of the Indus Valley civilisation. Located on banks of navigable rivers these two cities formed the centre of the political, social and cultural tradition of the empire (Misra, 2013; Ramachandran, 1992). They not only housed the rulers and other bureaucratic members but the majority of Harappan people also lived in these two cities.

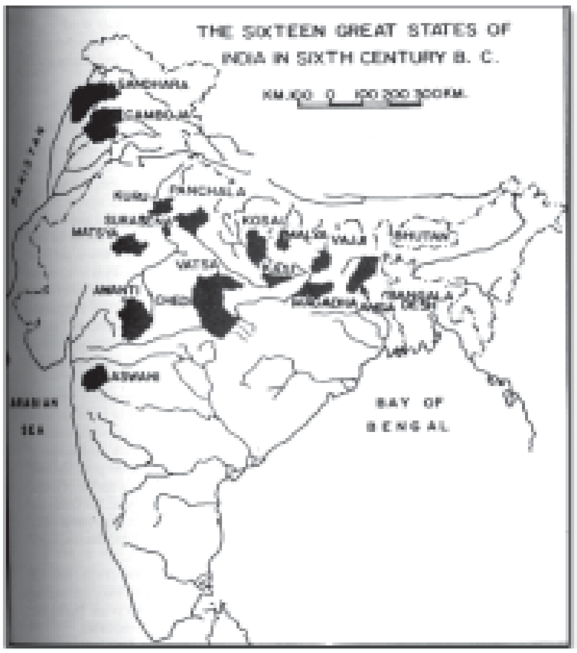
Mohenjo-Daro was initially developed as the only capital city. Harappa was built later to cope up with the expanding empire. Both the cities were highly organised and had a well structured system of drainage and water supply. They represented the epitome of the development of the empire both as a political and cultural symbol. However, the empire was short lived. The Harappan Cities were abandoned and it slowly disappeared by 1800 BC and with it disappeared all signs of urbanism from the Indian face (Misra, 1998; Ramachandran, 1992).

The Historical Period

After the disintegration of Indus Valley Civilisation, there was a major absence of urban development in the sub-continent. It was only *from 600 BC that urban centres were seen to develop. This second phase of urban development was associated with the Aryans in the north and the Dravidians in the south* (Ramachandran, 1992). After this second wave of urbanisation, the urban process became a pan-India phenomenon and a permanent characteristic of Indian landscape. It also proved to be a key turning point in the history of urbanisation in India bringing about a major social

Source: Misra, 1998, p. 45.

Map: 1. Location of India Valley Civilisation and Major Urban Centres



Source: R. Misra & Misra, 1998, p. 49

Map 2 Location of Mahajanpadas

Table 1
The Mahajanpadas and their Capital cities

MAHAJANPADAS	CAPITAL CITIES
Anga	Champa
Ashyaka	Pontana (or Pontali)
Avanti	Ujjaini
Cedi	Sotthivatnagara(orSukti or Suktimati)
Gandhara	Takshashila
Kamboja	Rajapur
Kashi	Varanasi
Koshala	Savatthi
Kuru	Indraprastha
Magadha	Rajagrigha then moved to Patliputra
Malla	Kusinara
Matsya	Viratnagar
Panchala	Adhichhatra(North Panchala),kampilya(south panchala)
Shurasena	Mathura
Vatsa	Kausambi
vrijji	Vaishali

and political change. It witnessed the rise of Janpadas and Mahajanpadas (Ahmad, 2013). These were politico-geographical territories which led to the start of urbanism, and territorial organisation with Capital City, the headquarter city as the centre. 'The Janpada was city-state and Mahajanpada was a conglomerate of many cities. Each Janpada was ruled by a king or a republican government located in a central city. Similarly, the Mahajanpada constituted empires centred on a metropolis of that time'(Ramachandran, 1992).

The arrival of Aryan in India also instigated territorial feud between Aryans and non-Aryan as well as among the Aryan which proceeded with the rise of kingdoms which in turn led to the establishment of capital cities which were usually a fortified city made to house the ruling class, the armies and the bureaucrats(M. Misra, 2009).

In the initial phase the Aryan territory was divided into eight Janpadas, later with territorial occupation and development, the number as well as the size of Janpadas rose to 230 which gave way to the organisation of Mahajanpadas and a total of 16 Mahajanpdas were recognised. They were namely: namely Gandhara, Kamboja, Kuru-Pancala, Matsya, Kashi, with Kashi, Koshala, Avanti, Ashvaka, Shurasena, Vatsa, Cedi, Malla, Vrijji, Magadha, and Anga(Ramachandran, 1992). These were mostly spread over the northern part of the subcontinent. The formation of Mahajanpadas provided a keystone in the rise of centralised empires. The cities and especially the capital cities lead to the rise of secular power of kings. This further boosted urbanisation and there was a rise in number as well as the size of cities(Ramachandran, 1992).

The historical phase of Indian urbanisation can be associated with three major developments. They are:

(a) Rise of Mauryan Dynasty

The rise of Mauryan Dynasty in 300 BC was again a significant turn in the urban history of India. They are credited for taking the urban processes in India to its culmination. By this period the lower Ganga Plain was fully inhabited and was under the urban influence (India - Encyclopedia Britannica, 2014). The smaller Janpadas gave way to Mahajanpadas (600BC) which ultimately led to the organisation of Mauryan Empire. The Mauryan Empire is credited for being the first pan India Empire with Patliputra as its capital. They brought almost the entire Indian subcontinent except for the area of South India present day named Kerala, Karnataka, and Tamil Nadu and parts of Afghanistan under a single political structure with an imperial system (Ramachandran, 1992).

The Maurya's are known for their organised urban structure with the capital city at the apex. According to the Buddhist literature, there were numerous types of cities in Mauryan urban system. They were namely Rajdhaniya Nagara (the Capital City), Sathaniya Nagara (the Capital of Janpada of 800 villages), Kharvata (local point of 200 villages), Kheta (small town in hostile territory), Putabhedana (a large commercial centre), Nigama (market centre), Pattana (coastal town) and Dronamukha (a port city at the

Source: Encyclopedia Britannica, 2011.

Map 3 : India in the Historical Period and Major Urban Centres

mouth of the river). Apart from these, there were numerous other types of cities like educational, commercial, etc. (Ghosh, 1990).

Patliputra emerged to be the most developed city in the empire. It became a centre of political, commercial, trade, cultural and educational prominence. The other cities of prominence belonging to Maurya dynasty are Nalanda, Kaunauj, Taxaashila, Mathura and so on. The Mauryan way of life started declining by the end of 5th century. Most of the major cities were abandoned and were in ruins like Nalanda, while some lost their significance (Misra, 2009). Even Patliputra lost its grandeur.

(b) Rise of Urbanisation in South India

Urbanisation and State formation in Southern India has a distinct structure and characteristics. They maintained a unique cultural identity owing to the fact that they always remained aloof from any foreign invasion and also from Muslim invasion. The Aryan impact was also very limited and was comparatively late compared to Northern India (Ghosh, 1990).

Urbanisation in southern India can be traced to in and around 5th century BC and is associated with the development of Mandalams. The region was divided into four Mandalam. Each Mandalam was further divided into Nadu's and Kottams (Ghosh, 1990). The kings ruled the Mandalam, while the chieftains ruled over the Nadus and Kottams. The capital city formed the centre of urban structure and was joined by numerous small cities. There were also numerous port cities specialising in international trade (Ramachandran, 1992).

The most distinctive feature of southern kingdoms was that they had two capitals, one coastal and other inland. The four Mandalams and their capital cities were: **The Chera Mandalam** with Vanji or Karu as inland capital and Chera port as coastal capital; **The Chola Mandalam** with Uraiyur as inland capital and Puhar as coastal capital; **The Pandya amandalam** with Madurai as inland capital and Korkai as coastal capital; **The Tondai Mandalam** with Kanchi (present Kancheepuram) as Inland capital of Tondai mandlam. The southern cities had flourishing trade with the Arabs, Greeks and the Romans. Most of the cities are in ruins only Kancheepuram and Madurai have withstood the odds (Ramachandran, 1992).

(c) The Rise of Gupta Dynasty

After the disintegration of Mauryan Empire in the north, the Gupta dynasty rose up in 300 BC, though this dynasty was not as extensive as the Mauryans, but it still incorporated the parts of Northern and Central Indian Subcontinent and was referred as more or less Imperialistic. Patliputra served as their Capital and regained its lost grandeur (Misra, 2009).

The Gupta dynasty started declining by mid of 6th century. It gave way to the rise of numerous small kingdoms like Hunas of central India, the Gurjaras and Patiharas in the west, the Tomar Rajputs and so on. Thus, Indian society transformed from centralised imperialism, under the Mauryan Empire to decentralised administration better known as a feudalistic system in the post-Gupta period (India-Encyclopedia Britannica, 2014).

The Medieval Period

The decline and disintegration of Gupta gave a major blow to the urban processes in Indian Subcontinent. The advent of muslin rule further intensified the

Source: Encyclopedia Britannica, 2011

Map: 4. India in the Medieval Period and Major Urban Centres

problem. However, the situation was quite the opposite in the Southern and Central India (Misra, 1998). Larger kingdoms with numerous cities flourished in these parts of the country. The major Kingdoms were the Chalukyas of Karnataka with their capital at Vatapi; the Ishvakus of Krishna-Godavari Region; The Pallavas of Kancheepuram; the Cholas of Tamil Region. 'The Chalukyas and Pallavas were preceded by the Rashtrakutas of Deccan with their capital at Malkhed; the Chalukyas with their capital at Kalyani; the Hoysalas of Belur; the Kakatiyas of Warangal' (Ramachandran, 1992, pp. 49–50).

The urban process again gained momentum in Northern India under the Mughals with their capital at Agra (later Delhi) and reached new heights. They revived the entire political structure of the country providing political stability, economic and cultural development. They not only established new cities but also revived the old cities and the urban spread ranged all the way from Srinagar in the north to Madurai in the south and Chittagong in the east to Badodara in the west. Delhi and Agra became the hub of political and cultural vibrancy. Along with them there were fourteen other large cities namely Fatehpursikri, Ahmadabad, Cambay, Ellichipur, Buharanpur, Ajmer, Ujjain, Mandu, Awadh, Lucknow, Varanasi, Jaunpur, Bihar and Cuttack. These cities dominated the entire Mughal urban system. They were invariably the largest and most impressive cities of their times (Ramachandran, 1992).

In the Southern end of Mauryan Empire, the Nizam of Hyderabad, the Marathas, Vijaynagar Empire and the Bahmani Kingdom gave a stimulus to urbanisation by establishing capital cities at Pune, Golconda, Hyderabad, Hampi, Bijapur and Aurangabad. Most of the medieval towns are still intact and are centres of political and cultural significance. While certain cities like Hampi, Golconda, Siri, etc. have been lost (Misra, 1998).

After the Maurya's, the Mughal rule in India took urbanisation to its epitome and contributed toward bringing political cohesion in the country to a larger extent.

The British Period

The European impact on Indian urban scene began in an almost 16th century when the Mughals were still dominant in the country. The Portugal traders were the first to arrive in India in 1510. They established the port cities of Panaji (1510) and Bombay (1532). Then came the Dutch and established the cities of Masulipatnam (1605) and Nagapattinam (1658). The French came to Pondicherry in 1673 and Chandranagar in 1690. The Britishers were the last to arrive at Madras in 1939 and Calcutta in 1690 (Misra, 2013).

In the initial phase, most of the Europeans just acted as traders extracting raw materials for their industries, without creating much of an impact on the political system and urban culture. However, after the Britishers consolidated their power and established as a colony in 1958, their impact on political system and urban landscape started unravelling. 'The entire Indian subcontinent along with about 500 Princely State came under one political umbrella. This was unprecedented in Indian history' (Ramachandran, 1992, p. 60).

British library: http://www.bl.uk/reshelp/findhelpregion/asia/india/indianindependence/map1/large14213.html

Map 5. India before Independence and Major Urban Centres

The territory of India was divided into two political units: the British India Province and the Princely States. There were 14 British India provinces which were under the direct rule of the Crown through representatives. The Princely States contained around 600 native States scattered all over the country. The Indian States were allowed to remain under the personal rule of their Chief and Princes under the 'Suzerainty of the Crown' popularly known as 'Paramountcy' (Hunter, 1885).

The urban processes, however, received a major setback as the Britishers did not take any interest in developing the Indian urban landscape. Their primary objective was the extraction of raw materials and to develop a market for their finished goods. Though, they developed railway network and port cities to strengthen the export and import of raw material and finished goods respectively. But after World War I and transfer of power from British East India Company to the crown, major steps were taken to transform the urban landscape and making it fit for the habitation of the British Officers. The princely States, however, did not develop at par with the British Provinces. Their major focus revolved around developing their capital cities (Misra, 1998).

The capital was shifted from Delhi to Calcutta. However, it was again moved back to Delhi in 1911. A new city called New Delhi was built with 'modern commercial areas, magnificent administrative complex'. They also established a network of hill station to escape the scorching heat like Shimla

(Summer Capital), Shillong, Dalhousie, Nainital, Mahabaleshwar, Kodaikanal, etc. Civil lines and cantonments further accentuated the urban landscape. The port cities were given great importance in the overall urban system. Calcutta, Madras, and Bombay emerged as the leading administrative, commercial and industrial cities (Crane, 1955).

The Post Independence Period

After independence and partition of India in 1947, India was disposed of with nine British Provinces and 562 princely States. The princely States were legally allowed to join India or Pakistan according to their free will. All the princely States situated within the political boundary of India conceded to India. However, the existence of independent political unity within the country was a hindrance to the political stability and economic development of India, as a whole. With the efforts of Sardar Vallabhabhai Patel, the majority of these princely States joined the Indian Union, while some were also beset to join. This political integration and consolidation which took almost 2 years led to the development of 27 States in 1950 and India was declared as a democratic republic with Delhi as the National Capital (Tiwari, 2005).

These 27 States were grouped into 4 (A, B, C, D) categories on the basis of the principle of federalism. The **'A category'** included all the former British India provinces namely Assam, Bihar, Bombay, Madhya Pradesh, Madras, Orissa, Punjab, Uttar Pradesh and West Bengal. Madras was further bifurcated into two States of Madras and Andhra Pradesh (in 1953). The **'B category'** included States formed by union of bigger princely States namely Hyderabad, Jammu and Kashmir, Mysore, Patiala and the East Punjab States Union (PEPSU), Rajasthan, Travancore-cochin and Central India. These were governed by Rajpramukhs. The **'C Category'** included provinces and small princely States administered by Chief Commissioner (a representative of central government). It included States like Ajmer, Bhopal, Coorg, Delhi, Himachal Pradesh, Kutch, Manipur, Tripura, and Vindhya Pradesh. The **'D category'** Union Territories of Andaman and Nicobar Islands directly governed by Union of India (Khullar, 2008).

However, it was believed that this system of organisation of States was not economical as well as political vibrant. 'The newly created system was unwieldy, expensive and inequitable'(Tiwari, 2005, p. 97). The State reorganisation commission was formed in 1953, which eventually led to the approval of two-tier system of Indian States. With 14 big States namely Andhra Pradesh, Bihar, West Bengal Orissa and so on with elected assemblies and governor as the Administrative Head and 6 Union Territories namely Delhi, Himachal Pradesh, Manipur and so on under the direct administration of Union Government through Lieutenant Governor.

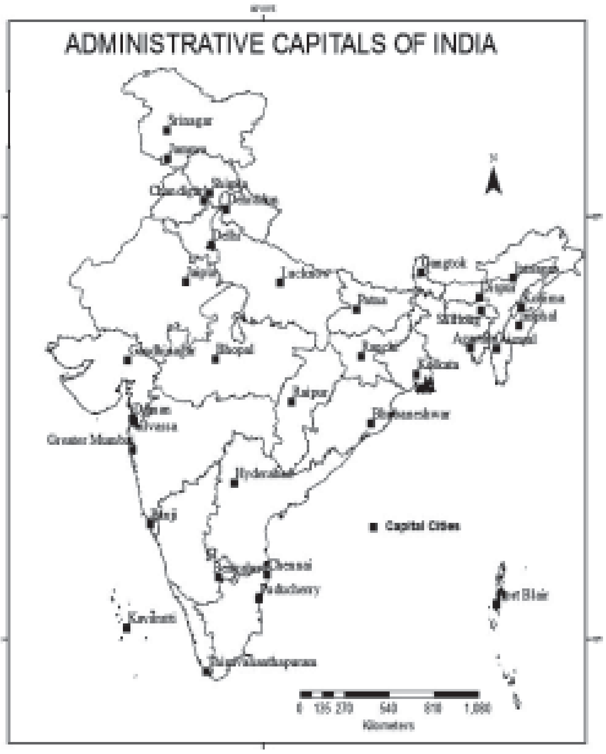
This reorganisation also did not satisfy all demands of Statehood. This led to further birth of Maharashtra and Gujarat which was carved out of Bombay (1960) on linguistic demands. Goa, Daman and Diu were given the status of Union Territories after their liberation from the Portuguese Colonial rule. Nagaland was carved out of Assam (1963). Punjab was divided two States of Haryana and Punjab. Chandigarh was made Union Territories (1966); Himachal Pradesh was given Statehood (1970). The new State of Meghalaya (1970) was formed out of the Garo, Khasi and Jaintia hill district of Assam (Tiwari, 2005).

In 1971 under the North East Reorganisation Act the region was divided into 5 States of Assam, Meghalaya, Nagaland, Manipur and Tripura and two Union Territories of Arunachal Pradesh and Mizoram, which were later given Statehood in 1986. Sikkim was integrated as a State into the Indian Union in 1975. Goa was also given Statehood in 1987. In the year 2000, Chhattisgarh and Uttaranchal were carved out of Madhya Pradesh and Uttar Pradesh respectively (Khullar, 2008). Delhi has also been accorded the status of Quazi-State. More recently the new State of Telangana was carved out of Andhra Pradesh in 2014. Henceforth, with all the reorganisation mathematics India at present has 29 States and 7 Union Territories.

ORGANISATION OF THE CAPITAL CITIES IN INDIAN SPACE

The early Indian society was divided into various small clans and tribes and the people were acknowledged by it. However, with time the clan identity transformed into territorial identity, and the State, with established political and administrative governments emerged to be the new form of organisation with the capital city at its centre.

The capital cities during the entire historical process, occupied a central position and maintained its position at the top of the hierarchy of cities. They were expressive of the wealth and grandeur of their kingdoms. Even the provincial and lower administrative capital always retained their significance as the centre of political and administrative power centralisation. Though, other cities like ports and commercial cities had their significance, but the 'capital cities dominated the urban scene both in terms of population and number' (Ramachandran, 2008). During the British regime as well, the capital cities (national and regional) maintained their dominance over other cities in development. The colonial rule also gave birth to



Map. 6

another set of capital cities called the 'Transient Capital' (Ramachnadran, 2008). These are commonly known as Summer Capital like Shimla, Darjeeling, Shillong, Ootamund etc.

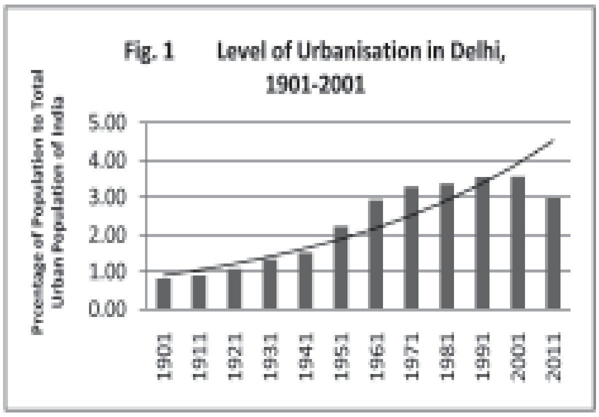
At present, the politico-geographical structure of Indian State is characterised by two set of capital cities: The National Capital and the Provincial capital more specifically the State Capitals. New Delhi is invariably the National Capital of the Indian Union. Along with it there are 27 State capital cities. The Union Territories also have administrative capital cities.

The National Capital of Delhi

Delhi is invariably the National Capital of Indian Federation since 1911. Prior to it, Kolkata was the capital of India for almost three decades. Being the national capital, the political nerve centre of an enormous country like India Delhi is expected to be the largest and the most dynamic city in the nation. However, this is not the case. Indian politico-administrative system with its quasi-federal system and a decentralised power structure discourages the development of the National Capital as a primate city.

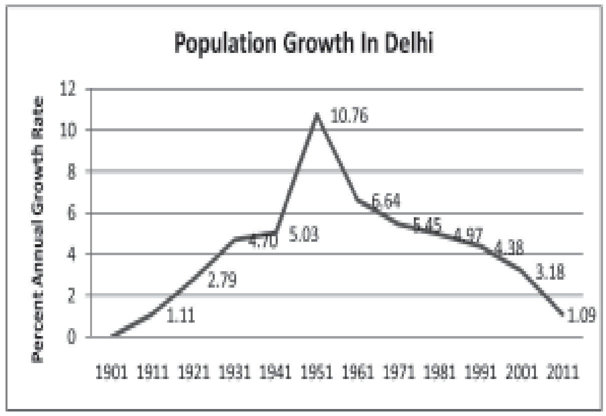
The lack of political organisation before independence is also one of the important reasons for lack of primate city at the national level (Mehta, 1964). In the historical times, the country was divided into numerous clans and kingdoms, each with their own centre of political and economic centralisation which in most cases was served by their capital city. So there were numerous sites of political, cultural and economic importance but never a centre which could traverse all this regional heterogeneity and emerge as a primate city (Ramachandran, 1992).

After Independence even though Delhi was named as the National Capital and made the centre of all political and administrative function, but it was nowhere close to the three port cities of Kolkata, Mumbai, Chennai cities that gained prominence during the British Era. These port cities were flourishing centres of trade and commerce whereas Delhi, a newly built city was no match for them. It was only a small city with a population of 0.2 million in 1911 (Sarkar & Maji, 2013). However, the grant of



Source: Computed from Census of India.

capital city status greatly changed the population dynamics. Since then the city is growing by leaps and bound. It has emerged to be a dynamic centre of trade and commerce. It has also emerged to be the favourite destination for the migrants for the entire north Indian. The share of the urban population has been continuously increasing over the decades, however, there has been a decline in the urban share in the 2001-2011 Census decade.



Source: Computed from Census of India.

Fig. 2

In the words of Ramachandran (2008, p.193) the development of Delhi as a primate city is still in process. Delhi, is now the second most populated city in India with a population of almost 11 million. The population of the city has been growing quite rapidly since 1911. The growth rate was highest in 191-51, basically due to huge settlement of migrants from Pakistan on account of partition. Since then the population growth rates are declining slowly but steadily.

The State Capitals

Most of the capital cities of the Indian State's were given the capital status owing to their economic status or rich cultural heritage while some were chosen on political whims. Some of the cities have historically evolved to acquire the capital status like Patna, Ranchi, and Thiruvananthapuram while some were completely new cities designed specially to serve as a capital.

Jammu and Kashmir is the only State in India which has two capital cities. Jammu serves as a winter capital while Kashmir as the summer capital. The extreme winter condition in Srinagar is the possible cause for such a choice. Srinagar by far is the largest city in the State both in terms of population as well as economic and cultural dominance.

When Andhra State (Telugu speaking areas) was formed out of Madras in 1953 Kurnool was the capital. However, when the State was reorganised by merging it with the Telugu speaking areas of Hyderabad State, Hyderabad was made the capital of this new State which was named as Andhra Pradesh. Very recently (Andhra Pradesh Reorganisation Act 2014) the State of Telangana has been carved out of Andhra Pradesh as the 29th State of India. Hyderabad will serve as a joint capital for both the State for the coming 10 years.

Shillong was the Capital of Arunachal Pradesh when it was given the Union Territories status in 1972. The capital was shifted to Itanagar in April 1974. Shillong also served as the Capital of Assam. However, when Meghalaya was created out of Assam with Shillong as its capital, the capital of Assam was shifted to Dispur. Dispur is only the symbolic capital of the State housing the administrative and political machinery. The city is a small locality which comes under Guwahati Metropolitan Corporation area.

When Gujarat was carved out of Madras State, Ahmadabad was chosen to be its capital. It serves as a capital of Gujarat for a period from 1960-1970. However, it was later decided to shift the capital city to the planned city of Gandhinagar. However, the significance of Gandhinagar as a capital city is limited to only administrative function only. Ahmadabad is far the largest and the economically most important city of the Gujarat.

Before Independence, the capital of Punjab province was at Lahore. After independence and partition when the western part of Punjab went to Pakistan with the capital city, a need for a capital city for was required. Chandigarh was planned to be the capital of the Indian Punjab. Shimla served as a temporary capital for the State until Chandigarh was completed in 1960. However, when the State of Punjab was reorganised in 1966 as three distinct States namely Punjab, Haryana and Himachal Pradesh, Chandigarh came at the borders of Punjab and Haryana. Hence, it was made a Union Territories and served as a joint capital for both Punjab and Haryana. And Shimla was made the Capital of Himachal Pradesh.

In 1956 the State of Madhya Bharat was created with Nagpur as the capital. However, when the State was reorganised as Madhya Pradesh, Bhopal was made the capital city as Nagpur lying in the Marathi speaking Vidarbha area was ceded to Bombay State. In 2000 Chhattisgarh was carved out of Madhya Pradesh with Raigarh as its Capital, which used to serve a capital city of Princely State of Raigarh.

Cuttack has long been the capital of Orissa, however, after independence, the planned city of Bhuwaneshwar was given the status because Cuttack was quite vulnerable to flood and was also experiencing major space issues.

Hence the present system of State and capital cities was acquired. After the States reorganisation each State is given the right to choose their capital cities. For States with the lack of suitable city for capital, they are assisted centrally to build new capitals for example Chandigarh (Punjab and Harayana), Bhubaneshwar (Orissa), Gandhinagar (Gujarat) and Dispur (Assam). However, time and again with the frequent demands for creation of new States, a new capital city is also required with shift of location of certain capital cities, for example: Vidharbha, Karbi-Anlong, Harit Pradesh/Pachimanchal, Purvanchal, Bundelkhand, Gorkhaland, Bodoland, Ladakh and so on.

There has been demand for shifting the capital of Uttranchal from Dehradun to Garisen. The State of Andhra Pradesh in also on a look out for a new capital city as the Hyderabad city (joint capital for Andhra Pradesh and Telangana) in most probability will be transferred to Telangana. Hence the status of a capital city is though significant but is susceptible to change and hence not a permanent phenomenon.

Structure of the Indian Capital Cities

The Indian Federation is composed of the union of 29 States and seven Union Territories. These States and union territories though formed after Independence after much political contestation but have deep historical roots. The assertiveness of the

States, since 1956, has created an environment and had favoured the development of primate city (Denis and MARIUS-GNANOU, 2011), which in most cases is the capital city.

Out of 29 States of India, 25 States have the capital city as the largest city of the State. Infact, in the North Eastern States, except for Nagaland, the capital city is by far the largest city of the State. But there are States like Gujarat, Assam, Jharkhand, Madhya Pradesh where the capital city is a mere centre of political and administrative function The table 3.2 and 3.3 gives the city-size distribution of the capital cities of India for the Census decade 2001- 2011.

Table: 2

Distribution of Capital Cities According to City Size, 2011						
class	Population Size	Capital Cities				
I	One Million and More	Greater Mumbai	Delhi	Lucknow	Jaipur	Srinagar
		Bangalore	Kolkata	Bhopal	Ranchi	
		Hyderabad	Chennai	Patna	Raipur	
	1,00,000-9,99,999	Bhubaneshwar	Chandigarh	Port Blair	Shimla	Imphal
		Thiruvananthapur	Aizwal	Jammu	Shillong	Guwahati
		Puducherry	Gandhinagar	Gangtok	Agartala	
II	50,000-99,999	Kohima	Silvassa	Itnagar	Dehradun	
III	20,000-49,000	Daman	Panaji			
IV	10,000-19,000	Kavaratti				

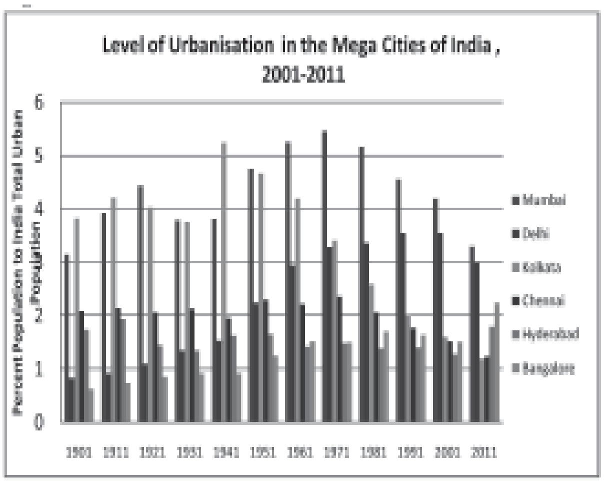
Source: Computed from Census of India

It is not surprising to notice that most of the capital cities (27 out of 34 in 2011) belong to the Class I category of city size. Out of 27, thirteen of the cities are million plus cities. Even in this category Delhi and Mumbai stand separately of the group with their Mega city (more than 10 million population) status. However, according to Indian standards the cities with a population more than 4 million are considered Mega Cities as such India has 6 mega cities namely Mumbai, Delhi, Chennai, Hyderabad, Bangalore and Kolkata.

Greater Mumbai, the capital of Maharashtra and the financial capital of India is by far the largest city in India in terms of population. It is followed by the National Capital, Delhi, Bangalore, Hyderabad, Chennai and Kolkata. Kolkata, the capital of West Bengal and the Imperial Capital of India was the leading city of India through the 19th and half of 20th century for almost seven decades both in terms of population as well as commerce and trade (Sarkar & Maji, 2013). It was the first metropolitan city of India. Later it was joined by Mumbai, Delhi, Chennai and Hyderabad and Bangalore.

These six cities have not only the leading cities infact, the primate cities in each of their State but have also overcome their regional identity and are becoming vibrant and dynamic centres of trade and commerce. Their structure and dynamism resemble the form of global cities. They are in a true sense the growth engines of the country.

Fig: 3



Source: Computed from Census of India

These cities in the regional context hold a supreme importance. Mumbai city alone accounts for almost 24 percent of the total State's urban population. The increasing importance of Bangalore and Hyderabad can be determined from the fact that they contain over 35 over percent and 24 percent of the State's total urban population respectively.

The most striking observation is that most of the capital cities of smaller States, as well as the Backward States, accounts for major share of the State's urban population for example Agartala, Aizwal, Gangtok, Imphal, Srinagar, etc. Among this group, the most noteworthy is Aizawl, the capital of Mizoram which contains almost 50 percent of the total State's urban population. There are also some State capitals which, contain only a meagre share of the State's urban population. These are the States where the capital city performs just the symbolic function for example Gandhinagar, Lucknow. Both of Kerala and Gujarat are leading the Urbanised States of India. However, in the case of Gujarat the meagre share of urban population is because Gandhinagar is not a major urban centre of Gujarat. Most of the urban population are concentrated in the city of Ahmadabad and Surat. In the case of Kerala, the urban population is again distributed over a large number of cities. The Capital Cities of Madhya Pradesh and Uttar Pradesh also contain a relatively low share of state's urban population.

CONCLUSION

This chapter focused on understanding the organisation as well as the structure of capital cities in the Indian context. Tracing through the historical roots of urbanisation the process of organisation of India as a State with a quasi-federal structure is observed. The first seed of State formation with capital city as a counterpart is believed to be laid in the Indus Valley. However, in its history of over 5000 years, India was never under a single political domain. The Britishers were the first to bring together the entire Indian Sub-Continent under their imperialist ambitions. After independence and partition, the country went through a lot of deliberations to acquire the present political structure.

With a quasi federal structure, which is federal in form and unitary in functioning India opted for a decentralised power structure. Delhi, as the National Capital is the centre of Indian Union. While each of the 29 States and the Union Territories centralised their political power in their respective capitals. Owing to the decentralised political system and a long history of colonialism the National Capital has failed to emerge as the largest and the most vibrant city in the country. It has limited itself only to the role of a political symbol. However, over the years the city is moving rapidly to acquire its true form. While speaking of the State capitals, there are certain cities namely Kolkata, Chennai, Mumbai which have emerged to be the leading city not only for the State to which they belong rather to the national interests. They have traversed much of the regional embeddedness to acquire the role of growth engines. The other capital cites also exercise dominant status in the state,surban system.

REFERENCES

1. Ahmad, A (1999)Social Geography. *Rawat Publication.* Jaipur.
2. Campbell, S. (2003). *The Enduring Importance Of National Capital Cities In The Global Era* (No. 03). *Urban And Regional Planning Program* (pp. 1–32). Michigan. Retrieved
3. Crane, R. I. (1955). Urbanism In India. *American Journal Of Sociology*, *60*(5), 463–470.
4. Daum, A. (2005). Capitals In Modern History: Inventing Urban Spaces For The Nation. In A. W. Daum & C. Mauch (Eds.), *Berlin–Washington 1800-2000: Capital Cities, Cultural Representation, And National Identities* (pp. 3–28). NEW YORK: Cambridge University Press.
5. Dikshit, R. D. (1999). *Political Geography 3E*. Tata Mcgraw-Hill Education
6. Ghosh,A. The City In Early Historical India, Indian Institute Of Advanced Study, Shimla, Munshiram Manoharlal Publishers Pvt.Ltd, New Delhi 1973(1990)
7. Hunter, W.W. (1885). The Imperial Gazetteer of India, http://dsal.uchicago.edu/reference/gazetteer/
8. India. (2014).In *Encyclopædia Britannica*.
9. Khullar. D.R.(2008) India: a Comprehensive Geography. *Kalyani Publishers.*New Delhi
10. Misra.M (1999) The Britannica Guide to India: A Comprehensive Introduction to the World's Fastest Growing Country (Britannica Guides) Encyclopaedia Britannica, Inc. London
11. R.P.Misra. (2013). *Urbanisation In South Asia Focus On Mega Cities*. New Delhi: Cambridge University Press India Pvt. Ltd.
12. Ramachandran, R. (1992). Urbanization And Urban Systems In India. *Oxford University Press.*
13. Sarkar, S., & Maji, S. (2013). An Analysis Of Urban Primacy/ : The Case Of Kolkata*, Indian Journal Of Applier Research, 3(3),* 158–162
14. Slack, E., & Chattopadhyay, R. (2009). *Finance And Governance Of Capital Cities In Federal Systems* (Vol. 1). Mcgill-Queen's Press-MQUP.
15. Tiwari,R.C. (2007)Geography of India. *Prayag Pustak Bhawan*, Allahabad.

APPENDIX 1

Level of Urbanisation in the Mega cities of India, 1901-2011 (in percentages)

Year	Mumbai	Delhi	Kolkata	Chennai	Hyderabad	Bangalore
1901	3.14	0.83	3.82	2.09	1.73	0.62
1911	3.92	0.92	4.21	2.14	1.94	0.73
1921	4.43	1.08	4.03	2.06	1.44	0.85
1931	3.79	1.34	3.77	2.13	1.34	0.92
1941	3.82	1.52	5.24	1.96	1.63	0.92
1951	4.75	2.24	4.66	2.29	1.65	1.25
1961	5.26	2.94	4.19	2.22	1.42	1.52
1971	5.47	3.29	3.41	2.36	1.49	1.50
1981	5.17	3.37	2.59	2.05	1.38	1.70
1991	4.56	3.55	2.02	1.77	1.41	1.64
2001	4.19	3.56	1.60	1.52	1.28	1.51
2011	3.30	2.99	1.19	1.23	1.79	2.24

Source: Computed from Census of India

APPENDIX 2

Population Growth Rates in the Mega Cities of India, 1901- 2011 (in percentages)

Source: Computed from Census of India

Year	Mumbai	Delhi	Kolkata	Chennai	Hyderabad	Bangalore
1901-1911	2.53	1.11	1.06	0.27	1.20	1.91
1911-1921	2.22	2.79	0.36	0.41	-1.92	2.53
1921-1931	0.19	4.70	1.13	2.33	1.03	2.90
1931-1941	3.29	5.03	8.37	2.13	6.09	3.27
1941-1951	7.60	10.76	2.57	6.50	4.29	9.15
1951-1961	3.99	6.64	1.36	2.26	0.91	5.35
1961-1971	4.38	5.45	1.24	4.71	4.47	3.64
1971-1981	3.81	4.97	1.10	2.73	3.52	6.61
1981-1991	2.04	4.38	0.66	1.72	3.93	3.17
1991-2001	2.07	3.18	0.41	1.31	1.96	2.09
2001-2011	0.39	1.09	-0.18	0.70	8.40	9.58

Appendix 3

Distribution of Population and Level of Urbanisation, 2011 (in percentages)

NAME	Population	Urbanisation	NAME	Population	Urbanisation*
Greater Mumbai	12442373	24.5	Agartala	400004	41.6
Delhi	11292358	69.0	Jammu	369959	14.6
Bangalore	8443675	35.7	Aizwal	293416	51.3
Hyderabad	6731790	23.9	Imphal	268243	32.2
Chennai	4646732	13.3	Puducherry	244377	28.7
Kolkata	4496694	15.5	Gandhinagar	202776	0.8
Jaipur	3046163	17.9	Shimla	169578	24.6
Lucknow	2817105	6.3	Shillong	143229	24.1
Bhopal	1798218	9.0	Port Blair	108058	75.3
Patna	1684222	14.3	Gangtok	100286	65.3
Srinagar	1180570	34.4	Kohima	99039	17.3
Ranchi	1073427	13.5	Silvassa	98265	61.2
Raipur	1010433	17.0	Itnagar	59490	18.7
Chandigarh	961587	93.7	Dehradun	52716	1.7
Guwahati	957352	21.8	Daman	44282	24.2
Bhubaneshwar	840834	12.0	Panaji	40017	4.4
Thiruvananthapur	743691	4.7	Kavaratti	11210	22.3

* Percentage of urban population to State's total urban Population

Source: Computed from Census of India

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AVAILABILITY OF HEALTH FACILITY AND USE OF MATERNALHEALTH SERVICES IN RURAL MANIPUR

P. THONGKHANTHANG[1]

ABSTRACT

The objectives that guided the paper were to observe whether the availability of health facility has any relationship with maternal health care use and examine the reasons for not receiving maternal health services among the women in rural Manipur. The study also examines the levels of maternal health service use in rural expanses, and a cross-sectional survey was adopted with a convenience sampling technique to select 390 currently married women having a live birth preceding three years before the survey. Findings revealed a wide variation between PHC and other remote villages in maternity coverage. Results also indicated that rural women in Manipur underutilized maternity care despite free provisions of maternal health care services were initiated under NRHM programme. Mothers' education and transportation problem are the prominent reasons that influence health service use. Effective interventions to promote maternal health service utilization should target the underlying individual, household and community factors. It is recommended that special attention be given to prenatal care and place of delivery where rates of utilization are reasonably low.

Keyword(s): *Antenatal Care, Place of Delivery, Assistant during Delivery*

INTRODUCTION

Utilization of health service is often problematic in rural areas. One common problem frequently observed in rural areas is poor road network, and the absence of regular means of suitable transport leaves rural areas inaccessible. Physical accessibility becomes a significant hindrance for accessing health care in rural areas which significantly and adversely affects the achievement of maternal and child health outcomes in developing countries (Galaa & Daare 2008). In addition, availability of medical facilities has a significant impact on health-seeking behavior of women (Chakraborty et al. 2003). However, availability of service alone is not enough for increased utilization of health care¯high quality along with culturally appropriate and responsive to women's needs is a must as well(Naveneethan and Dharmalingam 2002).Shortages of skilled workers and unequal distribution of health resources create problem for receiving servicein rural areas and service use is generally restricted by individual, household, community and policy-level factors.

Several studies at the individual level have demonstrated that poorer and less educated women and those living in rural areas are far less likely to give birth in the presence of a skilled health worker than better-educated women who live in wealthier households or urban areas. Moreover, health-related knowledge and attitudes, women's autonomy within the household, and the economic status of households influence utilization of maternal health services. A growing number of studies document perceptions of quality in health care influence health service utilization (Abouzahr et al. 1996; Morgan, 2003; Roberts et al. 1999; Sutherns et al. 2004). Studies also explore that poor, ethnic minorities and women, are particularly at risk for poor access to care (Vissandjee et al. 2001). A few studies go further to address the connections between various dimensions of social inequality, in most cases revealing cumulative disadvantage.

The choice of the State (Manipur) for this study is the fact that Manipur has the best infant mortality rate (IMR 10, SRS 2014) in India, just next only to Goa (IMR 8) but it failed in maternal health (MMR 374, SRS 2001-03), which is among the highest in India. Correspondingly rural women typically registered low compared to their urban counterparts in all dimensions of healthcare indicators(NFHS-3, 2005-06). Thus maternal health status of women is a major problem for the overall development of women in the State.

OBJECTIVES

(1) To examine the levels of maternal health service utilization.

(2) To observe the reasons for not receiving maternal health services.

(3) To examine the relationship between availability of health facility and utilization of maternal health services.

MATERIALS AND METHODS

The present study was carried out in Churachandpur district, Manipur which is the largest district of the State (Fig. 1). Two TD Blocks namely Churachandpur and Singngat were selected for the study based on development indicators (table not shown). Random

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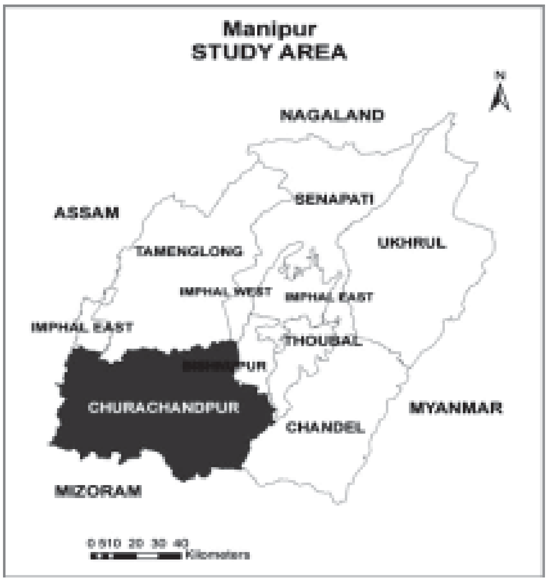

Fig. 1 : Study Area

sampling technique was used to select the sample villages and respondents.

In order to observe whether availability of health facility has any association with maternal health service use the sample villages were selection on the basis of availability of health facility. The basic assumption in this study is that if service use is significantly higher in one particular villages group than the others, apart from other factors, it is viewed as the impact of availability of health facility altogether. The fact is that 90 per cent of the geographical areas are covered by hills where transportation is a major problem in rural areas of Manipur. Hence, two PHC villages, six SC villages and eight other villages without any health facility were selected and 390 mothers were interviewed from the three village groups. The field survey was undertaken from January-March 2014. Participants were women with at least one child under 18 months old who lived in the study villages regardless of where they actually gave birth. Their age ranged from 15-49. Although the sample of mothers was diverse in terms of birth experiences, income, education levels, number of children and age, it was strikingly homogeneous in terms of ethnicity (Kuki-Zomi).

FINDINGS

Maternal health refers to the health of women during pregnancy, childbirth and postpartum period (World Health Organization 2012). Prenatal care ensures that the health of the expectant mother, more specifically her nutritional status, is periodically supervised, and avoidable complications of pregnancy are prevented or treated. Intranatal services provide skilled care and attention by trained health personnel during child birth. Postnatal care includes checks on the mother's health after delivery that makes it possible for a gynecologist to diagnose and prevent some of the chronic and disabling conditions common in women (Shivakami 2008).

Relationship between availability of health facility and maternal health service use has been observed by the differences in receiving antenatal care, natal care and postnatal care in the study area. With respect to natal care, a wide gap between the PHC villages and other villages has been observed in receiving delivery assistance and institutional delivery. Apart from availability of health facility, these variations in receiving maternal health services between village groups might be due to other certain socio-economic and cultural reasons.

Antenatal Check-up

Ante-natal care (ANC) or check-up is defined as pregnancy-related health care provided by a doctor or a health worker in a medical facility or at home. The safe motherhood initiative proclaims that all pregnant women must receive basic professional ante-natal care. In this context, the mothers were asked whether they saw anyone for antenatal care for their most recent birth. Table 1 show that58.2per cent women had received any antenatal check-up while 69.2per cent from PHC villages group had received ANC, 56.9 and 48.5per cent from SC and other village groups received the same, respectively. While 58per cent pregnant women received ANC, institutional delivery ended only with43.2per cent. The availability of health facility in association with higher educational attainment of mothers in PHC villages could be the factors in explaining the higher number of antenatal care visits in PHC villages compared with SC and other village groups. The chi square value is significant at 1 per cent.

Table1
Women according to Receiving Antenatal Check-up

Response	*Overall*	*PHC villages*	*SC villages*	*Other villages*	
Yes	58.2	69.2	56.9	48.5	$\chi^2 = 11.7$
No	41.8	30.8	43.1	51.5	significant
N	100.0	100.0	100.0	100.0	at 1%

Source: Field Survey.

Frequency of ANC

The number and timing of the first antenatal visit are important for the health of the mother and the outcome of the pregnancy. The World Health Organization recommends that all pregnant women should have at least four antenatal care (ANC) assessments by or under the supervision of a skilled attendant. These assessments should be spaced at regular intervals throughout pregnancy, commencing as early as possible in the first trimester (NFHS-3). As such, women respondents who received antenatal care during their last pregnancy were asked about the total number of antenatal care visits they had.

It is found from Table 2 that antenatal care received by mothers in sample villages varied significantly with regard to the number of times such as care was received. Generally, less than four times antenatal care during pregnancy is more common in other villages compared to PHC and SC village groups. Further it is evident that majority of women received more than four antenatal cares in their last pregnancy across the sample PHC villages. Mothers who received four or more antenatal cares during pregnancy in the sample villages is encouraging, especially in PHC (57.8 per cent). On the contrary, four or more antenatal care in the sample villages are comparatively less since about 39.2 per cent and 31.7per cent women received four or more antenatal care, respectively in SC and other villages. This presents that number of antenatal care visits is more among the PHC villages' women, followed by SC villages' women and less among other villages' women. The availability of health facility in shorter distance and the lesser cost of travel in PHC villages, as well as the higher educational attainment of mothers in PHC villages could be the factors in explaining the higher number of antenatal care visits in PHC villages. The chi square value is significant at 1 per cent.

Table 2
Antenatal Mothers According to Frequency of ANC

Response	*Overall*	*PHC villages*	*SC villages*	*Other villages*	
< 4	55.5	42.2	60.8	68.3	$\chi^2 = 11.7$
> 4	44.5	57.8	39.2	31.7	significant
N	100.0	100.0	100.0	100.0	at 1%

Source: Field Survey.

Timing of First Antenatal Check-up

The first antenatal check-up should take place at the latest during the second trimester of pregnancy (NFHS-3). In this context, women respondents who received antenatal care for their last pregnancy were asked about the month in which they had their first ANC visit. Table 3 shows that there is a slight variation between the three village groups. Accordingly 44.1per cent of mothers out of 227 in the study area reported that their first visit for antenatal check-up occurred within three months of their pregnancy. It is interesting that in all the three village groups, majority of the mothers received antenatal care before 6 months, and the proportion is 88.9per cent in PHC villages, 86.5per cent in SC villages and 84.1per cent in other villages. A little over 15per cent from other villages received antenatal care for the first time as late as 6 months into their pregnancy while only 11.1 per cent and 13.5per cent of SC and PHC villages' mothers performed the same, respectively. It suggests that mothers from other villages group are more likely to receive their first antenatal check-up at a late stage compared to the mothers from PHC villages and SC villages where the proportion are only 11.1 per cent and 13.5per cent, respectively.

Table 3
Timing of Pregnancy Who Received Antenatal Check-ups

Month	*Overall*	*PHC villages*	*SC villages*	*Other villages*	
Up to 3	44.1	50.0	44.6	34.9	$\chi^2 = 4.6$
4 to 6	42.7	38.9	41.9	49.2	
7 to 9	13.2	11.1	13.5	15.9	
N	100.0	100.0	100.0	100.0	

Source: Field Survey.

Test Performed

The effectiveness of antenatal care in ensuring safe motherhood depends on the test and measurement done and the advice given as part of antenatal package. The women who received antenatal care services were asked whether they got tests like weight/blood pressure/blood test/urine test/height measurement during their last pregnancy. The results of the antenatal components during last pregnancy are presented in Table 4.

The figures shown in the table is somehow encouraging with the respondents who reported that they had their weight measured. However, other tests received by the respondents are discouraging and unsatisfactory. Overall, one-third (37.8 per cent) of the respondents (who received antenatal check-ups) reported that they had their blood tested during antenatal check-ups. It is learned that there is lack of physical and laboratory facilities and qualified medico personnel at local level of sub-centres and primary health centers. Moreover, the proportions of the respondents who had blood pressure checked (45.8 per cent), urine tested (46.8 per cent) and height measured (6.3 per cent) are low. Height measured is quite distressing since only 6.3 per cent pregnant women have got their height measured. This might be due to lack of instrument for measuring height or negligence of the health providers as rural women are generally short stature.

Due to availability of health facility it is observed that the tests and measurement were performed 14.4 times more often during antenatal check-ups in PHC villages in other villages. Similarly, 9.5 times more for the same from PHC villages than from SC villages.

The difference among the respondents of PHC, SC and other village groups for getting blood tested is higher. In PHC villages, the proportion of the respondents who had their blood tested is 51.5 per cent, followed by 33 per cent and 28.7 per cent in SC and other villages, respectively. The chi-square value is significant at 5 per cent level in the study area.

Table 4
Antenatal Mothers According to Test Performed during Last Pregnancy

Response	*Overall villages*	*PHC villages*	*SC villages*	*Other*
<Weight measured	56.3	61.4	56.0	51.3
Height measured	6.3	5.9	8.4	4.6
B.P. Checked	45.8	58.9	39.2	34.9
Blood tested	37.8	51.5	33.0	28.7
Urine tested	46.8	53.8	47.0	39.6

χ^2 = 2.12 significant at 5%

Source: Field Survey

Reasons for Not Receiving Antenatal Care

Figure 2 presents that in PHC villages, 25per cent pregnant women who did not receive any antenatal check-ups thought 'not necessary to check-up' with other reasons mentioned being "long queue (22.5per cent)", "economic constraints (20per cent)", "required for household work (15per cent)" and "lack of knowledge (10per cent)." In case of SC villages group, 25 per cent women stated that it is "not necessary to check-up" with other reasons being "economic constraints (20.9 per cent)", "transportation problem (17.9per cent)","required household work (14.9per cent)","lack of knowledge (14.3 per cent)" and "long queue (7.1 per cent)." Similarly, in Other villages, 24.4 per cent women felt that it is "not necessary to check-up", 22.4 per cent reasoned to "economic constraints",21.9 per cent thought "transport problem" as a burden for not seeking ANC, 20.3 per cent reasoned to "lack of knowledge", 9.4 per cent felt of "required for household work", and only 1.6 per cent thought of "long queue." This shows that antenatal care services are not taken seriously by women during their pregnancy due to negligence, poverty and lack of awareness in the rural areas of Manipur. Thus there is a need to educate mothers and families about the availability and benefits of antenatal check-ups to help to overcome traditional attitudes and other hurdles that prevent mothers from seeking antenatal care. The chi-square value is significant at 1 percent level in the study area.

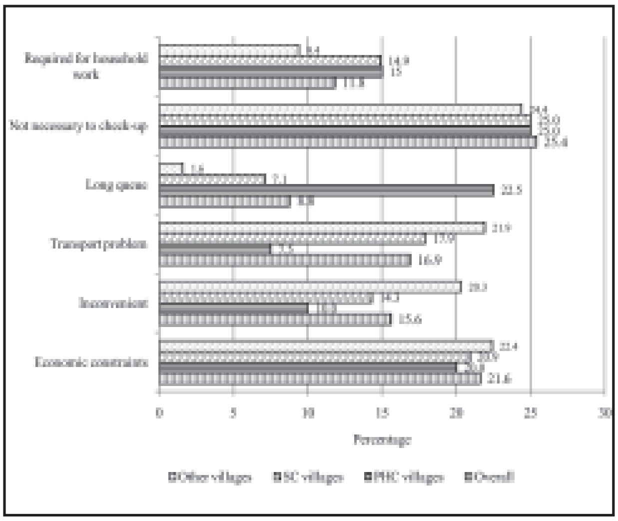

Fig. 2: Reasons for Not Receiving Antenatal Care in Rural Manipur (n=163)

Person Who Assisted Delivery

Obstetric care from a trained provider during delivery is recognized as central for the reduction of maternal and neonatal mortality. Births delivered at home without the assistance of trained health professionals are more risky than those carried out with the assistance of trained health professionals. Results from Table 5showsabout5.8 per cent women reported that their last delivery was assisted by health personnel, 38.8 per cent mentioned traditional birth attendant (TBA) and 55.4 per cent got assistance of relatives/friends. The proportion of women whose last delivery was assisted by health personnel

Table 5
Women according to Assistance at Home Delivery

Type of village	*Health personnel**	*TBA/ Dai*	*Friends/ relatives*
PHC villages	15.7	31.4	52.9
SC villages	2.3	25.4	36.2
Other villages	0.0	43.7	56.3
N	5.8	38.8	55.4

χ^2 = 19.15 significant at 1%
*Includes assistance ANM/nurse/midwife/LHV etc.

TBA=Traditional birth attendant.

Source: Field Survey.

constitutes 15.7 per cent in PHC villages, 2.3 per cent in SC villages and there is none in other villages group. The percentage of women who got assistance from TBA/dai is 31.4, 25.4 and 43.7 per cent in PHC villages, SC villages and other villages, respectively. The proportion of women whose deliveries were assisted by friends/relatives is 52.9, 36.2 and 56.3 per cent in PHC villages, SC villages and other villages, respectively. Thus getting delivery assistance from health personnel is highest in PHC villages, followed by SC villages and other villages in the study area and this might be due to easier availability of health services in PHC villages than in SC or other village groups.

Place of Delivery

Another important thrust of the Reproductive and Child Health Programme is to encourage deliveries in proper hygienic conditions under the supervision of trained health professionals. For this purpose, women respondents were asked about the place of delivery during their last pregnancy. Table 6 and Fig. 3 show that institutional delivery was very low. Of all the surveyed participants, only 43.2per cent gave birth at a health facility, 20.7per cent of them at government hospital, 12.6per cent at primary health centre and 12.4per cent at a private hospital/clinic. The table also shows that the highest proportion of birth took place at home (56.9per cent).There are variations in utilization of health services with regard to delivery at type of village levels. In PHC villages, the higher proportion of birth took place at health institution (53.8 per cent), followed by government hospital (23.5per cent), PHC (14.6 per cent) and private sectors (15.7per cent). However, in other villages the proportion of birth that took place at home is higher (61.5 per cent) and the proportion of births that took place in government hospital, primary health centre and private sectors are lower when compared with PHC villages. The same pattern occurs in SC villages where 55.4 per cent of women gave birth at home and less than half were delivered in health institutions. Thus, institutional deliveries, particularly from the government (government hospitals) are the common place for delivery for those who had institutional delivery. One factor contributing to these patterns may be due to economic constraints that people approached government facilities over private facilities where they charge high cost during both pregnancy and delivery. The chi square is significant at 1 per cent in the study area.

Table 6
Place of Delivery During Last Pregnancy

Type of Village	Institution Delivery	Delivery at Home	% of Institutional Delivery		
			PHC	Govt.	Private
villages	53.8	46.2	14.6	23.5	15.7
SC villages	44.6	55.4	12.3	19.4	12.9
Other villages	38.5	61.5	10.8	19.2	8.5
N	43.1	56.9	12.6	20.7	12.4

Chi square = 20.9
significan at 1%

Source: Field Survey.

Fig. 3: Place of Delivery in Rural Manipur

Reasons for Non-Institutional Delivery

Respondents who did not utilize health facilities for delivery were asked about the reason for not doing so. The main reasons for non-institutional delivery, reported by the mothers in the study area have been given in Figure 4. Proportion of women (26.2 per cent from PHC villages, 25.2 per cent from SC villages, and 26.6per cent from other villages) who have reported that it was ''easy birth'' that health facilities were not utilized for delivery care. The second most frequently mentioned reason was ''high cost (23.2 per cent from PHC, 22.6 per cent from SC and 24.3 per cent from other villages).'' The third reason expressed by the women was ''too far/no transport (9.6 per cent from PHC villages, 27.1 per cent from SC villages and 30 per cent from other villages).'' Other factors contributing for not visiting a health institution for delivery were ''sudden onset of labor (20.2 per cent from PHC villages, 14.5 per cent from SC villages, 7per cent from other villages)'', ''not aware of service (4.5 per cent from PHC villages, 8.5 per cent from SC villages, 11.1 per cent from other villages)'' and ''poor quality of service (16.3 per cent from PHC, 2.1 per

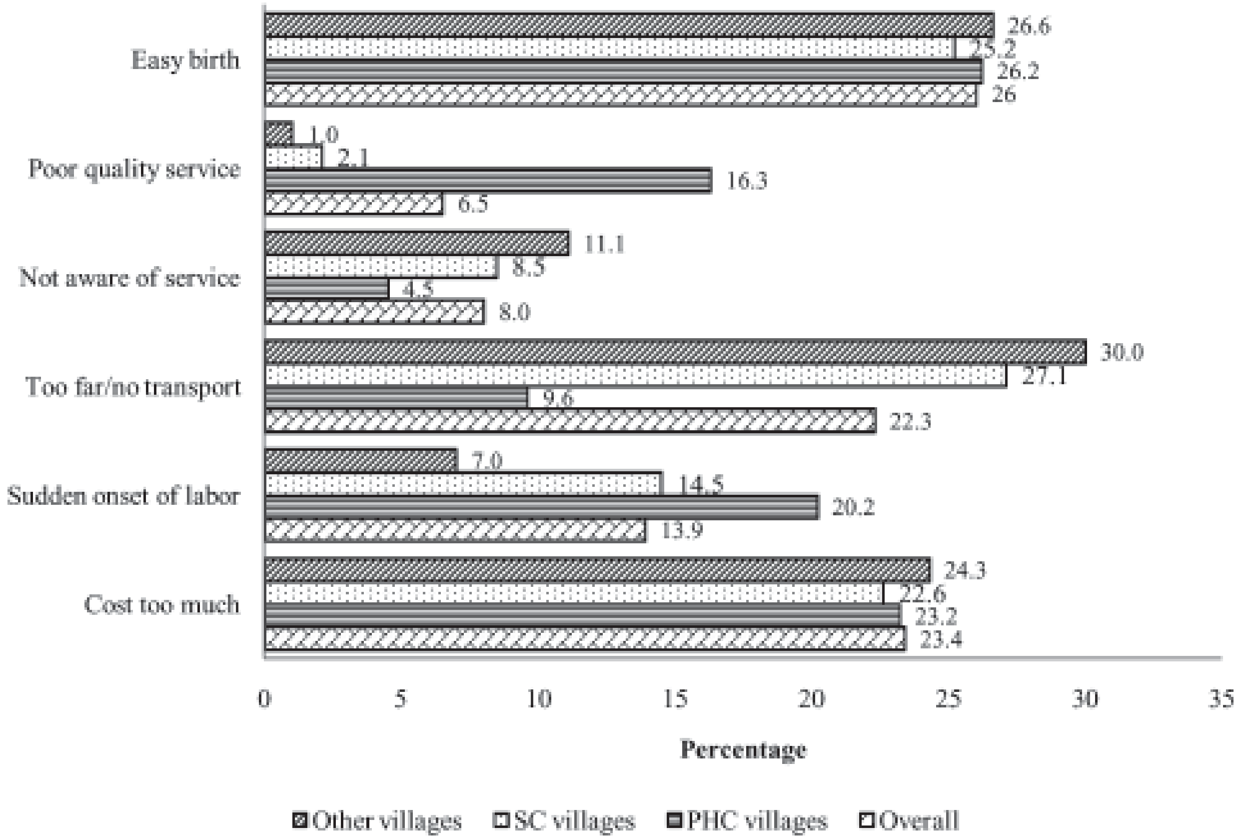

Fig. 4: Reasons for Non-Institutional Delivery in Rural Manipur (n=222)

cent SC villages, 1per cent from other villages).'' The pattern was almost similar in all the villages groups.

Postnatal Check-up

Postnatal care (PNC) refers to the assistance given to a mother and the baby for a period of six weeks from the time of delivery. Postnatal services are primarily comprised of physical examination, immunization, health education, and family planning services. In this regard women were asked whether they received postnatal check-up after their delivery at health institution. Many women have not received these essential health services though they need these services after delivery. The Millennium Development Goals 5 focused to improve maternal health (MDG 5 WHO), with targets to reduce maternal mortality by three quarters between 1990 and 2015, and to achieve universal access to reproductive health by 2015 (WHO 2009). Postnatal care is essential to save the life of the mother and newborn. Our survey data reveals a very low proportion of mothers have received postnatal check-up within two weeks of delivery who had delivered birth at health institutions in the three years preceding the survey. Out of 99 mothers who delivered birth at health institution, 71.2 per cent of them in PHC villages group out of 73, 52 per cent from SC villages group and out of 50, only 46.7 per cent of them in other villages out of 45 have received postnatal check-up within 2 weeks of delivery for their last birth. Overall, out 168 mothers, only 58.9 per cent have received postnatal check-up within two weeks of delivery (Table 7).

CONCLUSION AND SUGGESTIONS

This study is based on the primary survey data on maternal health services utilization in rural Manipur. The study covers the three dimensions of pregnancy-related care—antenatal, delivery and postnatal services. The study attempts to understand the

Table 7
Postnatal Check-up within Two Weeks
(among institutional delivery)

Response	*Overall*	*PHC villages*	*SC villages*	*Other villages*	
Yes	58.9	71.2	52.0	46.7	$\chi^2 = 8.36$
No	41.1	28.8	48.0	53.3	significant
N	100.0	100.0	100.0	100.0	5%

Source:Field Survey.

association between availability of health facility and utilization of maternal health services in rural Manipur. In order to understand its association, villages were categorized into three groups: PHC villages, SC villages and other villages without any health facility. Based on the availability of health facility a significant differential has occurred in utilization of maternal health services in the study area. Results of this study show that the utilization level of maternal health care services is lower in other villages group than in PHC and SC village groups. A wide gap has been observed in receiving antenatal care visit and frequency of ANC between village groups with the exception of timing of ANC visits and receiving test performed. Similar is the case with utilization of natal care where there are considerable differences between institutional delivery and delivery assistance between the village groups where women living in PHC villages have more institutional delivery and delivery assistance than women living in SC and other village groups.

One of the most important reasons for not receiving maternal health services is economic problem. Majority of the respondent women stated that utilization of both antenatal care and natal care are hindered by poverty. Despite many women wanted to utilize maternal health services, they could not able to visit health centre because of economic problem. Since 90 per cent of the State is hills, transportation problem is the common problem in rural areas. Result from field survey indicates that too far/no transportation is the second major problem in utilization of maternal health services. This has been indicated by the fact that there is a significant variation between PHC villages and other villages group in receiving antenatal visit, frequency of ANC, delivery assistance and delivery at health facility. Other important factor that influence women's health-seeking behavior of maternal health services is lack of knowledge/awareness since many women stated that they felt it unnecessary to visit medical facility unless they face complication during their pregnancy. In fact, lack of awareness is related with low level of education since 39 per cent of the studied women had no education. It is obvious that because of higher level of education in PHC villages that utilization of maternal health services is better than other remote villages. The study also found that there is poor quality of health service in the rural Manipur and that caused for lack of interest to the women to utilize health care. It was reported during the survey that many sub-centres in rural areas have no building infrastructure and some health SC remain without any health providers. Considering institutional delivery, there is large difference between PHC villages and other villages, while 53.8per cent have delivered in health institutions in PHC villages, only 38.5per cent of mothers have given birth at health facilities.

It is due to non-availability of drugs and staff at primary health centres and sub-centres that many women could not receive complete course of maternal health services (table not shown).As rural women help in any possible way to support their family's income that many could not spare enough time for medical care unless they perceived as a serious issue. This indicates that women pay more attention on curative measure than preventive ones which indeed influence their utilization level of maternal health service. Another prominent reason for not receiving antenatal care is inconvenient which indirectly mean their in-laws or husbands or family has not agreed them to meet doctors for pregnancy-related issue. In short, women's literacy is an important predictor for the use of maternal health care services in the study area since illiterate women are less likely to use maternal health care services for delivery assistance and place of delivery compared to literate women. Literature provides many reasons for higher utilization of maternal health care services by educated mothers than uneducated mothers. Educated women may have a greater decision making power on health related matters and also attach a higher value to the welfare and their health. Further, educated mothers will have more confidence in handling the officials and have the ability and willingness to travel alone outside the home to seek health services.

In order to address the differentials and increase the level of maternity health services use in the study area, there is a need to increase availability of health facility. Since PHC villages' women use more health care than SC and other villages' women demonstrated the fact that availability of health facility has influence women's health-seeking behavior in the study area. As educated women are more likely to use maternal health care services, women education needs to be emphasis in a policy implication. The local health workers such as health activists (ASHAs) and aganwadi workers (AAWs)in the rural areas have to give more awareness to the public which is essential for increased utilization of health service in rural Manipur. The urgent need therefore is to develop innovative strategies that will help upscale intervention especially for improvement in the use of these services by rural women. In this direction it is recommended that special attention be given to pre-natal care and place of delivery where rates of utilization are reasonably low.

REFERENCES

1. Archana, L.B. and Cleland J. (2000): "Maternal and Child Health Services in Rural Nepal: Does Access

or Quality Matter More?", *Health Policy and Planning,* Vol. 15, No.2, pp. 223-229.

2. Abouzahr, C., Vlassoff, C., & Kumar, A. (1996):"Quality Health Care for Women: A Global Challenge," *Health Care for Women International*, Vol. 17, No. 5, pp. 449-467.
3. *Government of India* (2005-06) : "National Family Health Survey (II & III)," International Institute for Population Sciences, Mumbai.
4. Haynes, R. (2003) : "Geographical Access to Health Care". In M. Gulliford & Morgan (ed.), *Access to HealthCare* (pp. 15-35). London: Routledge.
5. *Internal Institute for Population Sciences (IIPS)* (2010) : "District Level Household and Facility Survey (DLHS-3), 2007-08: India". Mumbai: IIPS.
6. Morgan, M. (2003) : "Patient's Help-seeking and Access to Health Care". In M. Gulliford& M. Morgan (eds.), *Access to healthcare*, pp 61-83. London: Routledge.
7. Chakraborty, N., Islam MA, chowdhury RI, Bari W., Akhter HH (2003): "Determinants of the use of Maternal Health Services in Rural Bangladesh", *Health Promot Int*. Dec.; Vol. 18, No. 4, pp. 327-37.
8. Galaa S, Daare K (2008): "Understanding barriers to Maternal Child Health Services Utilization in Northern Ghana", *J SocDev Afr*. Vol. 23, No. 2, pp.127-155.
9. Naveneetham K. and Dharmalingam A. (2002):"*Utilization of Maternal Health Care Services in South India*," *SocSci Med*, Nov. Vol. 55, No. 10, pp.1849-69.
10. Roberts, L. W., Battaglia, J., &Smithpeter, M. (1999):"Office on Main Street: Health care dilemmas in Small Communities," *The Hastings Center Report*, Vol.29, No.4, pp.28-37.
11. Sivakami, M. (2008):"*Determinants of Maternal Health Care Service Use: A Regional analysis in Karnataka*," Institute for Social and Economic Change, Bangalore.
12. Sutherns, R. (2005):"So Close Yet so far: Rurality as a Determinant of Women's Health," *Canadian Woman Studies*, Vol. 24, No. 4,pp.117-922.
13. Vissandjee, B., Weinfeld, M., Dupere, S., &Abdool, S. (2001):"Sex, Gender, Ethnicity and Access to Health Care Services: Research and Policy Challenges for Immigrant Women in Canada," *International Journal of Migration and Integration*, Vol. 2, No.1, pp. 55-75.
14. *World Health Organization (WHO)*, (2009) : "Accelerating Progress Towards Achieving Maternal and Child Health Millennium Development Goals (MDGs) 4 and 5 in South-East Asia: Report to high-level consultation."

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CLIMATE CHANGE : AN IMPACT ON HEALTH

Prisilla JAYANTHI G[1] & Chandra Sekaran SUBRAMANIAN[2]

ABSTRACT

Climate change is not just an environmental issue but an issue related to socio-economic that reaches the core areas. Climate change is all about future progress of the earth's climate. It is very clear that these changes are major caused by humans. Climate change changes everything, even the developed nations are suffering from extreme weather events. The preventing measures adapted before a disaster occurs would be more sensible and effective than to provide relief to its victims. The change in climate plays a major role on the impact of the health where children are affected the more. A deeper understanding of how climate change and hazardous weather events can affect societies will enable civil community and governments to develop stronger risk reduction programs where even the children are trained.

Keywords: *Climate, Impact, Predictability, Hazards*

INTRODUCTION

It is not enough for the engineering, scientific and organizational solutions, but the society in broad sense the public people should be motivated and encouraged to adopt the needed changes. The threat posed by the growing ozone hole has been effectively and extensively covered by scientists and the media, resulting in international political achievement to phase out the main sponsor, chlorofluoro-carbons (CFCs).[1]

Several uncertainties exist in climate change prediction. The lack of complete knowledge of how the climate works is one and other uncertainty is due to natural variability in the climate system and a supplementary uncertainty is due to the inability to predict human behavior and its cumulative effect on the earth's climate.[1]

The predictability leaves a great relief for humans while uncertainty may be uncomfortable. The people feel safe, secure and confident with predictability, whereas uncertainty leads to anxiety. Predictability provides control, helps people avoid threats to their physical and material well-being, and frees them from fear and anxiety.[1]

The Cross edge concerning over the disabled people, women, children and older persons for the helpless conditions in disaster situations and stand the heaviest load of disasters' impact. The disaster management ought to design the better tools for people with disabilities to anticipate hazards and to react to disasters. This human movement and migration due to the undesirable impacts of slow and sudden-onset disasters have vast impacts on local, national and global vulnerabilities.

Following are the principles of climate change communications

1. Know the audience
2. Get the audience attention
3. Translate scientific data into concrete experience
4. Be careful of the emotional appeals
5. Address scientific and climate uncertainties
6. Encourage group participation
7. Make behavior change easier

Climate Forecast

The future evolution of the climate system including both forced and internally generated components is the climate prediction. Climate predictions does not forecast the daily progression of the system but rather the evolution of some climate statistic such as seasonal, annual or decadal extremes, which may be for a particular location, or a regional. Climate predictions are made with models that are the same or similar to one used to produce climate simulations and projections. A climate prediction proceeds by integrating the governing equations forward in time from observation-based initial conditions.[2]

The prediction quality measures the success of a prediction against observation-based information. Forecasts made for preceding cases, may be analyzed to give a warning of the better quality that may be probably for future forecasts for a particular variable at a particular location. Since the long data records are needed, multi-annual diagnostic to decadal predictability studies based on observational data are comparatively few.

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Results vary significantly across models but do offer some areas of commonality. Climate prediction is probabilistic by nature. Probabilistic predictions are expected to be skillful and reliable. Decadal predictions should be evaluated on an accurate estimation of the relative frequency of the predicted outcome. The forecast probabilities of an event correspond to the mean probability of observing the event.[2]

Six components of good climate risk management

1. Climate risk assessment : priorities and follow-up planning
2. Integrating climate change in various programmes and activities
3. Raising public awareness
4. Establishing and enhancing partnership
5. Shaping the global response to climate change
6. Documenting and sharing experiencing and information

The association between hazards (cyclones, storms or droughts) and the vulnerability of societies is disaster risk. Both of these elements are constantly changing. Climate change causes the frequency, intensity and location of hazards to change. Occurrences such as urbanization, poverty, population growth and disease continuously alter the nature of vulnerability.

IMPACT OF CLIMATE CHANGE ON HEALTH

The health impacts may happen by heat stress and death or injury in floods and storms directly. The most common cause of weather related deaths are a heat wave which leads to heat stroke and dehydration. In northern latitudes the people are less prepared to cope with excessive temperatures. The children, older adults, people with medical illnesses, and the poor are more vulnerable than others to heat-related illness. In the summer the climate change will lead more frequent, more severe, and longer heat waves as well as less severe cold spells in the winter.

Other threats will arise through changes in the range of disease and decreases in water quality, air quality and food security. The impacts of climate change will vary from developed countries to undeveloped countries. The growing concerns about climate change become a disturbing rise in the vulnerability to natural disasters. The number of people killed in natural disasters has been reduced in few decades, whereas dramatic increase in the number of people affected and socio-economic losses is found. This rise in losses and people affected reveals a growing defenselessness to natural hazards, and in particular to weather and climate-related threats, which lead the disaster statistics. Extreme weather events may become more frequent and long-lasting – which may lead to more disasters. At the higher altitudes the malaria outbreak is high with rising temperature.

The scientists project an increase in the risk of flooding for hundreds of billions of people due to heavier rainfall and sea level rise. Heavy floods will increase the risk of waterborne diseases and moreover countries suffering from health and sanitation problems will be knockout hardest by these changes. Heatwaves will result in additional heat stress mortality, and increases in droughts and extreme events would add to stresses on water resources and flood security.

It will be important to learn from each other's experiences of assessing and responding to climate-related risks. Instructions in disaster preparedness and risk reduction should be documented and shared between the different national societies and with other organizations involved in adapting to climate change. It cannot be said that the disasters are caused by the climate change but as the world warms up, disasters (drought, floods and soon) becomes more severe, more frequent and more vulnerable to the people living on the earth. The disaster effect that can be seen from the extreme events affects the poorest people of the world.[4]

There is an increasing awareness programs being adapted to bring the necessary changes in the nations for the impacts of climate change and extreme weather events. The various structures are being set up, and studies are made about the vulnerabilities of the particular regions and zone. By improving the disaster preparedness efforts of managements, the societies and other organizations integrates disaster risk reduction into development strategies.

Early Action

A timely action makes a lot of difference with an early warning. For illustration if a huge flood is expected, with the early warning the local community can protect its main water well from contamination and at the national level the country can update its contingency plan. If the warning is given within few days, an instant disaster preparedness action like identifying evacuation routes, evacuation cores and protecting assets for immediate response can be taken. However, a longer tenure warning (years in advance) allows expanding the disaster risk reduction actions by organizing to respond in better way to warnings including helping society's plant trees to stabilize hillsides, building storm-resistant houses.[5]

First and foremost issue is that the information has to be effectively communicated to the societies, and necessary actions have to respond and react to it. Proper communication is main mechanism of having the ability to use the information. It is essential to train and educate local leaders in what the possible impact of climate change might be and ways to prepare and training the locals in assisting first aid in damage/need assessment, shelter management, risk mapping, community health, water and sanitation.

The Model for RCP 4.5 and RCP 8.5

RCP (Representative Concentration Pathway) the RCP which defines a specific emissions trajectory and subsequent radiative forcing. Radiative forcing is referred as a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system, measured in watts per square meters.

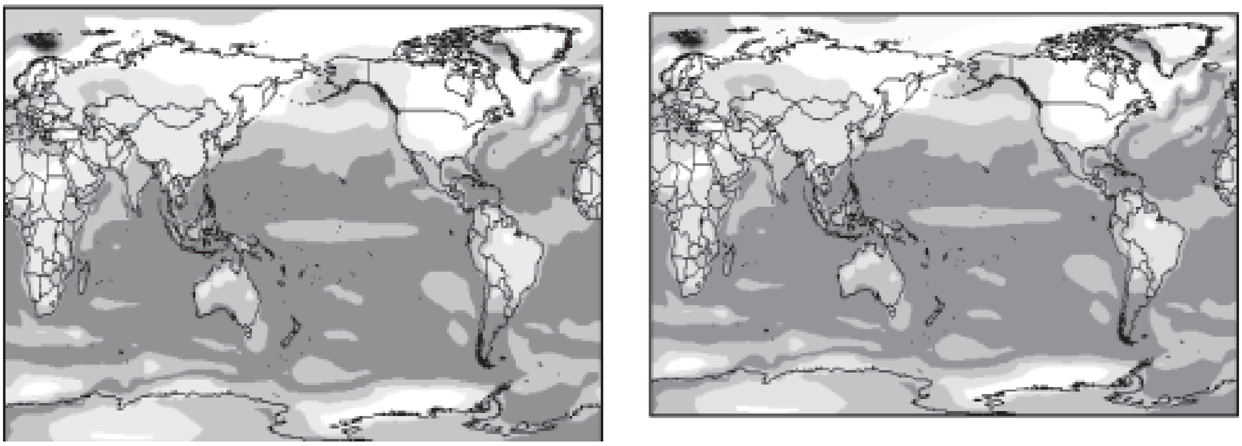


Figure 1a, 1b shows RCP 4.5 to the left and to right RCP 8.5

The study reveals that the atmospheric concentrations of carbon dioxide, nitrous oxide and methane have increased to extraordinary levels since 1750 but for human activity. The 40% rise in Carbon dioxide concentrations major from fossil fuel emissions and then from net land use change emissions since pre-industrial times. The 30% of the emitted anthropogenic carbon dioxide is absorbed by ocean causing ocean acidification.

Using Sim CLIM 2013 version 3.5.1.0 a product of CLIM systems at New Zealand , the climate modelling is indicated for the mean temperature for the longitude of 8.000 with the latitude 31.000 of RCP 4.5 and RCP 8.5 in figure 1a and figure 1b respectively.

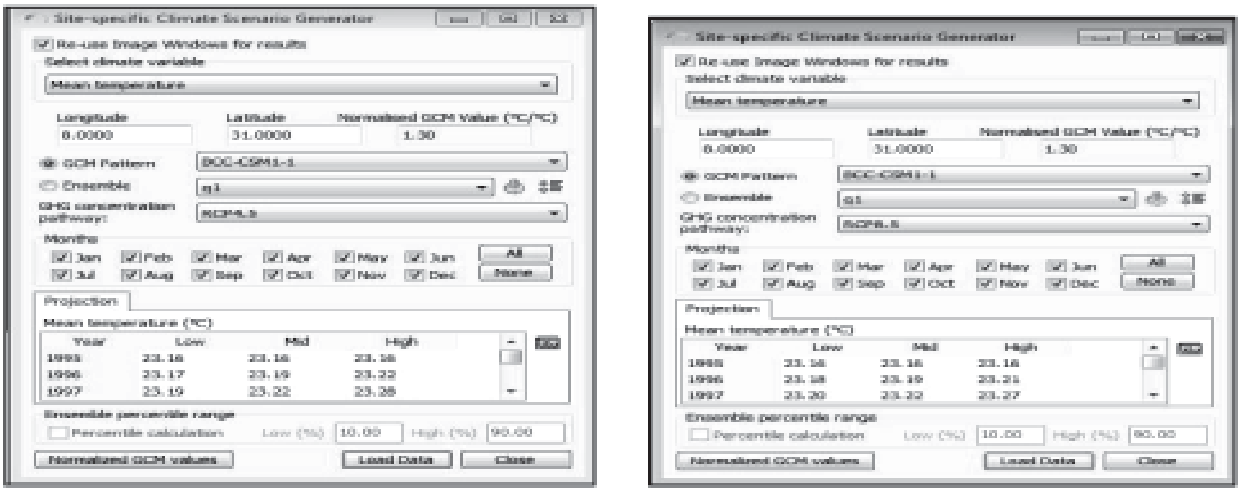


Figure 2a, 2b Shows Climate Scenoria Generator from the Year 1995 to 2100 for RCP4.5 and RCP8.5

With the changes in temperature or precipitation do cause change in the seasonality of some allergenic species, some disease vectors and changes in the seasonal distribution of malaria, dengue, tick-borne diseases, cholera and soon. Extreme weather events and changes in maximum temperatures can increase the incidence of mortality and illness. Epidemiological studies on climate and disease transmissions show that the main killers of children are highly sensitive to climate variability.

Research and case studies states that climate change offers a challenge to children and youth to be strong supporters by helping their families, schools and communities to adapt climate change. The children are often more knowledgeable about climate change impacts than adults, by gaining information learned at school or from accessing environmental resources through other media and communication sources. The children can make positive contributions as

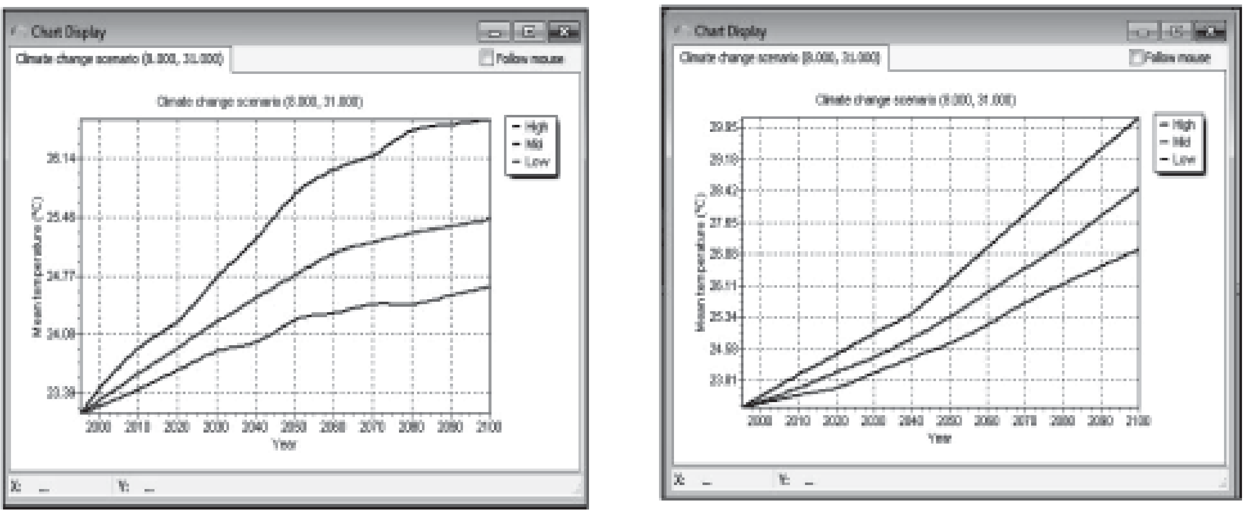
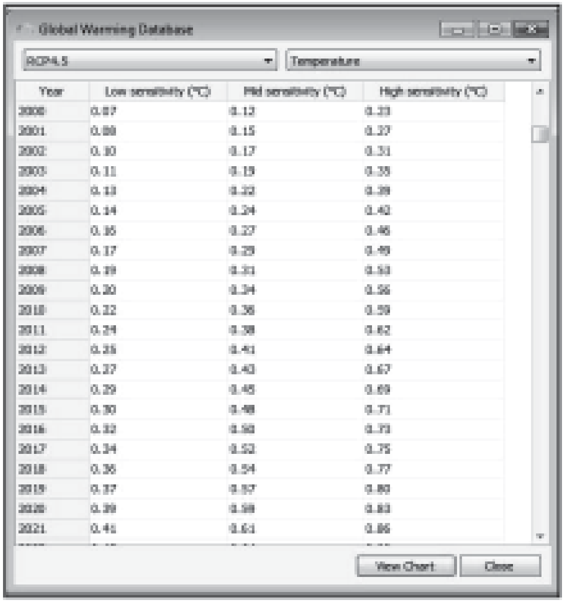


Figure 3a,3b displays the graph chart for the climate change for the mean temperature and the year (2000 – 2100) where blue line indicates high sensitivity , red –middle sensitivity and green -low sensitivity.



Global Warming Database

RCP4.5 | Temperature

Year	Low sensitivity (°C)	Mid sensitivity (°C)	High sensitivity (°C)
2000	0.07	0.12	0.23
2001	0.08	0.15	0.27
2002	0.10	0.17	0.31
2003	0.11	0.19	0.35
2004	0.13	0.22	0.39
2005	0.14	0.24	0.42
2006	0.16	0.27	0.46
2007	0.17	0.29	0.49
2008	0.19	0.31	0.53
2009	0.20	0.34	0.56
2010	0.22	0.36	0.59
2011	0.24	0.38	0.62
2012	0.25	0.41	0.64
2013	0.27	0.43	0.67
2014	0.29	0.45	0.69
2015	0.30	0.48	0.71
2016	0.32	0.50	0.73
2017	0.34	0.52	0.75
2018	0.36	0.54	0.77
2019	0.37	0.57	0.80
2020	0.39	0.59	0.83
2021	0.41	0.61	0.86

View Chart | Close

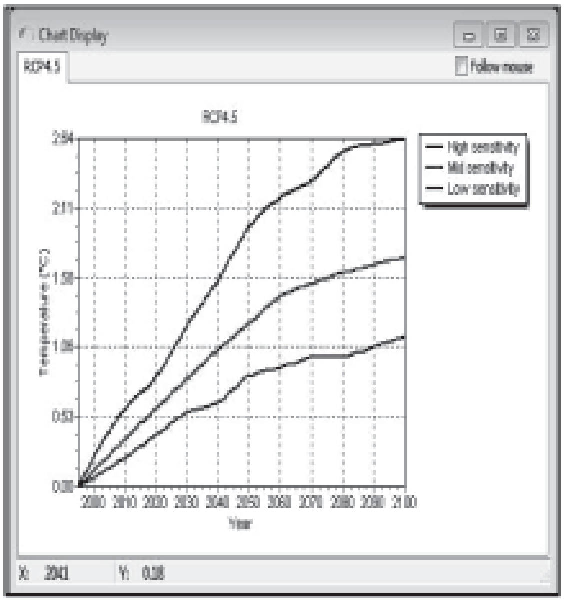
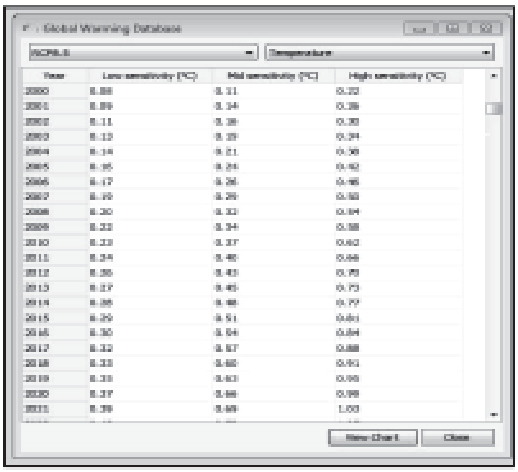


Figure 4a shows the global warming data of RCP4.5 and its corresponding graph to the right in fig 4b



Global Warming Database

RCP8.5 | Temperature

Year	Low sensitivity (°C)	Mid sensitivity (°C)	High sensitivity (°C)
2000	0.08	0.11	0.22
2001	0.09	0.14	0.26
2002	0.11	0.16	0.30
2003	0.13	0.19	0.34
2004	0.14	0.21	0.38
2005	0.16	0.24	0.42
2006	0.17	0.26	0.46
2007	0.19	0.29	0.50
2008	0.20	0.32	0.54
2009	0.22	0.34	0.58
2010	0.23	0.37	0.62
2011	0.24	0.40	0.66
2012	0.26	0.43	0.70
2013	0.27	0.45	0.73
2014	0.28	0.48	0.77
2015	0.29	0.51	0.81
2016	0.30	0.54	0.84
2017	0.32	0.57	0.88
2018	0.33	0.60	0.91
2019	0.35	0.63	0.95
2020	0.37	0.66	0.98
2021	0.39	0.69	1.03

View Chart | Close

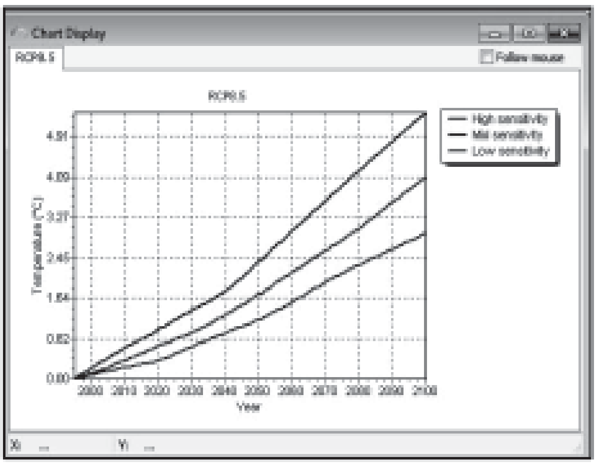


Figure 5a shows the global warming of RCP 8.5 with the chart to the right in the figure 5b with the temperature and year, the gradual rise in the temperature which touches 5p c for the year 2100.

analyzers of risk and risk-reduction activities, as implementers of climate change and disaster risk reduction.

The survey reveals that Climate change presents an opportunity for children to learn about their environment and community and helps them to identify them as role citizens. Both formal and informal education activities help many children to be aware of climate change through the media. The child-sensitive climate change education and disaster risk reduction resources are being developed that care children as dynamic learners and trainers. Presently, the governments have issued climate change adaptation and disaster risk reduction into the education system.

CONCLUSION

The societies with the technical knowledge have well addressed Climate change in the sectors of most concerned**.** The National Societies should prepare to adapt the risk reduction program to climate change. As we are racing against time, the sooner we act the better. The better understanding of the vulnerability of climate-influenced decisions will benefit the society to large irreducible uncertainties than for concerning to increase the accuracy and precision of the next generation of climate models.

REFERENCES

1. Early warning -early action, International Federation of Red Cross and Red Crescent Societies.
2. http://www.epa.gov/climatechange/impacts-adaptation/health.html
3. Kirtman, Ben. Power, Scott B., "Near-term Climate Change: Projections and Predictability".
4. Lawler, Jill. "Children's Vulnerability to Climate Change and Disaster Impacts in East Asia and the Pacific , UNICEF".
5. PB Urich, P Kouwenhoven, Y Li, K Freas, J Poon , "How climate change will impact on the water industry key findings of the UN Intergovernmental Panel on Climate Change Fifth Assessment Report".
6. Rode, Kruis. "Preparedness for climate change, Implications for the International Federation of Red Cross and Red Crescent Societies".
7. Shome, Debika., Marx Sabine., "The Psychology of Climate Change Communication, CRED".

   Topfer, Klaus. (2001), "Climate change information kit UN Framework Convention on Climate Change UNFCCC".

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DEMOGRAPHIC CHARACTERISTICS AND CHANGING LAND USE PATTERN IN GANGTOK, SIKKIM (1975-2011)

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ABSTRACT

Gangtok, the capital and the largest town of the state of Sikkim lies at 27.33°N latitude and 88.62°E longitudes, located in the eastern Himalayan range at an elevation of 1,650 m (5,410 ft). It is among the fast growing town of Sikkim. Increase in population has led to drastic change in land use pattern especially conversion of green cover areas into built up area. During the decades of 1991 and 2001, the population growth rate was only 17.30 percent, but the population of Gangtok town has increased to 100286 in 2011 from 29354 in 2001 which is around 241percent increase (census of India). The land use pattern of the town has been categorized in six categories i.e. residential, commercial, public and semi-public, transportation, industrial and recreational. In post-merger period, public and semi area has also been expanded from merely 0.55 percent in 1975 to 23 percent in 2014. In the last three decades, the highest growth rate has been seen in the industrial sector, which shows a growth rate of 363.41percent from 1985 to 1995. There has been 6percent and 16.40 percent increase in the transport and recreational sectors respectively during the time span of 1975 to 2006. This paper focuses on demographic growth and land use changes of Gangtok since 1971 using integration of remote sensing with GIS technology to identify various types of changing land use pattern. In this paper LANDSAT-TM (Bands 1, 2, 3,4,5,6 and 7, imagery year of 2001 and 2011, Path and Row =139/41) data has been used for land use/Land cover mapping. The Supervised Classification Method has been applied for delineating the study area into different land use land cover classes by using ERDAS 13.0 and Arc GIS 10.1 was used for mapping Population Density and Urban Growth.

Keywords: *Population Characteristics, Land use pattern, Gangtok Town, Geospatial & Demographic Techniques*

INTRODUCTION

A population characteristic is the major phenomena of the any geographical region or states. Heterogeneity population become is indicated that few physical obstacles are there. However, the silent features of population parameter to determined the land utilization of an area (Dyson & Moore, 1983). The structure of the paper is mainly twofold. The first is to explain the population distributon and its growth in decadal scale characteristics of population and another is utilisation of land use of Gangtok town from 1975-2011 Land is one of the main important natural resources, and the Land use refers to the purpose the land serves, for e.g. recreation, wildlife habitat, agriculture, Industrial etc. . In others words, it can be described as the multifaceted use of the land, which includes both use and misuse of land. Land use indicates the activity to which an area of land is devoted. The Land-use and land-cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space Land use/ Land cover change has become a vital component for natural resources management and monitoring of environmental change, also for various developmental, resource planning activities at global and regional scale (Kandrika and Roy, 2008; Roth et al. 2016). In developing countries, the population growth is mainly rapid in the urban areas. Population explosion escorts to faster rate of urbanization, which cause an increased pressure on land and water resources. Rapid urban expansion brings new opportunities for urban development; however, consequently it has brought a serious losses of arable land, forest land and productive soil into build up area (Lambin and Geist, 2006; Huang et al. 2009; Arsanjani, 2012; Meshesha,et al. ,2012; Shristava, et al. 2012; Rawat et al. 2013; Ariti et al. 2015) Gangtok Town of Sikkim is one of the fastest growing towns of India. Since, last three decades Gangtok is experiencing with widespread conversion of natural forest and farmland into built up, commercial and industrial land. This unsystematic land use changes seriously affects on the biodiversity of local habitat. Additionally, urban population has increased in faster than any other towns of Sikkim. It indicates a significant propensity to the outward quick extension of urban areas at their fringes. The detection and monitoring of urban settlements via multi-temporal

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remote sensing imagery has increasingly become a topic of research interest with greater attention in recent years Gallego, 2004; Mayunga et al. 2007; Peijun et al. 2010) . Such studies have helped in understanding the dynamics of human activities in space and time (Sharma et al. 2001). The temporal repetivity of Remote Sensing data enables us to measure and monitor dynamics of land use/land cover properties of the same region and GIS provides us tools for quantification of the spatial data, thus integration of Remote Sensing and GIS can provide, better, accurate, real and up to date information about spatio-temporal dynamics of natural and cultural landscapes.

The modeling and projecting of land cover change is essential to the assessment of consequent environmental impacts. Land use and land cover change is scalar dynamic. In Sikkim, rapidity of urban process took place in the last few decades due to population growth. This speedy growth of population changed the internal structure/ landscape of Gangtok town. In Gangtok the land use has been changing, every year new development (residential, industrial, commercial, etc.) are emerging. Only three major land use classes (built-up area and bare land, step cultivated area and forest) were considered as the most dynamic land use practice of Gangtok. LULC in any urban area is changing rapidly due to the increasing population and pressure of urbanization (Voogt and Oke, 2003; Mukhopadhyay et al., 2014).

Location of Gaangtok Municipal Corporation

Mixed land use pattern is the prominent features of Gangtok town. The land use pattern of Gangtok town has been categorized into six categories i.e. residential, commercial, public and semi-public, transportation, industrial and recreational. In post-merger period, public and semi area has also been expanded from merely 0.55 percent in 1975 to 21percent in 2011; this is because of building more infrastructures in public sector. As per NERDUP Report, 2012 (the total size of the town in 1975 was 240.5 hectares which has expanded to 79 sq.km in 2011 (including surrounding colonies). In the last three decades, it is observed that the total development area has been increasing. The highest growth rate has been seen in the industrial sector, which shows a growth rate of 363.41percent from 1985 to 1995. There has also been considerable increase in the transport (6percent) and recreational (1percent) sectors in between 1975 to 2011.

The aim of the paper is to explore the role of population characteristics to utilization of land use pattern of Gangtok town. In that contextual, paper also describe the level trends and pattern of the land use through geospatial and demographic techniques.

STUDY AREA

Gangtok is the capital and largest city in the state of Sikkim. It is located in the East District of Sikkim, lies between 27.33° N latitude and 88.62°E longitude. The city is flanked on east and west by two streams, namely Rorochu and Ranikhola. It is a small town that displays rapid development in the last few decades It has a geographical area of 25 (sq km) and located at an altitude of 5,800 feet (1,800 m). Due to the favorable climatic condition now, it has been marked in the attractive tourist destination map of India (Casado-Diaz, 1999). In Gangtok temperature remain as below as 30^0C in summer to above 4^0C in winter. It is the largest town in Sikkim and serves as administrative hub. National Highway 10 connects the town with other parts of the country.

OBJECTIVES AND METHODOLOGY

This paper focuses mainly on the demographic scenario and its consequent land use/land cover changes of the Gangtok town since 1971 using Integration of remote sensing with GIS technology to identify various types of changing land use pattern.

In this paper Satellite based Remote Sensing data i.e. LANDSAT-TM (Bands 1,2,3,4,5,6 and 7, imagery year of 2001 and 2011, Path and Row =139/41) has been used for preparing land use map and to document the land use change. At first, Administrative map of Gangtok was scanned and then, it was Geo-referenced in UTM projection (Zone 45), and WGS 84 Datum. Seven Bands of LANDSAT images of 2001 and 2011 were stacked into one layer into .img format in ERDAS 13.0. After Layer Stacking, subsetting was performed in order to cut the portion of Sikkim Administrative Area. We applied Supervised Digital Image Classification approach for delineating the study area into different land use category.

Supervised classification involved the selection of several training sets on the image, which represent specific land use classes (Kashagili and Majaliwa, 2010). The training sets were selected according to following criteria: carefully investigating the Google Earth Images of the study area; analyzing spectral characteristics of the objects into the Feature Space; performing Image Alarm (it is a visual tool that provides quick pre-classification of the image also indicates the potential confusion of classes) iteratively; and field knowledge. After providing training sets on the image, we applied Maximum Likelihood Classificaion technique which is widely used for Supervised Classification. It considers both the variences and covariences of the class signatures. By giving these parameters, statistical probability is computed of each pixel value to determine membership to a particular class (Lillesand et al., 2004). The final Land use map produced by Supervised Classification is in a raster form. We converted Raster Land use map into Vector format in ArcGIS 10.1 by performing Feature to Polygon. Then, the areas of each considering class computed for both images through Calculate Geometry command in Arc GIS 10.1. To traced earlier settlement pattern and their expansion, toposheet published in 1996 by the Swiss Foundation for Alpine Research Project has been used. Ward wise population density maps were prepared by using the population data published in Town Directory of Census, 2011 in Arc GIS 10.1.

RESULT AND DISCUSSION

Population Characteristics of Sikkim

Sikkim is the least populous state in India with population of 6, 07,688 of which 1, 53,578 (25.15percent) is urban as per Census 2011. The total population of Sikkim has grown from 5,40,851 in 2001 to 6,10,577 in 2011 implying a decadal growth rate of 12.89percent, which is way below the national average of around 17 percent. However, what is phenomenal about the population growth of Sikkim is that, while the rural population growth rate registered a negative figure of (-) 5.20percent in 2001-11, the urban population growth rate for the same period is 153.43percent. Gangtok is not just the largest city but can be described as the primate city of Sikkim accounting for more than 65percent of the total urban population of Sikkim.

Table 1

Top Ten in and out Migration Patterns of Sikkim, 1991-2001

Rank	*In-migration toward Sikkim* 1991		2001		*Out-migration from Sikkim* 1991		2001	
1	Andhra Pradesh	25470	West Bengal	29,698	West Bengal	17150	West Bengal	4,778
2	Uttar Pradesh	10950	Bihar	12,666	Bihar	7734	NCT of Delhi	1,390
3	Tamil Nadu	6880	Uttar Pradesh	2,449	Uttar Pradesh	2145	Assam	1,223
4	West Bengal	5810	Assam	1,648	Assam	679	Karnataka	953
5	Karnataka	3500	Haryana	841	Haryana	635	Bihar	668
6	Assam	1820	Rajasthan	835	Rajasthan	603	Maharashtra	509
7	Maharashtra	1440	Uttarnchal	519	Kerala	517	Arunachal Pradesh	465
8	NCT of Delhi	1242	Manipur	498	Punjab	380	Uttarnchal	253
9	Rajasthan	1230	Kerala	486	Andhra Pradesh	306	Rajasthan	230
10	Madhya Pradesh	1170	Jharkhand	400	Tamil Nadu	229	Uttar Pradesh	226
	India	**66050**	**India**	**52985**	**India**	**31992**	**India**	**12752**

Source: Census D Series 1991, 2001 *Excluding unclassified area

From table 1, it is to be noted that in 1991, with the supply of in-migrants from Andhra Pradesh dominated towards Sikkim, the state was ranked top at 25.47 thousand, followed by the adjoining state of Uttar Pradesh (10.95 thousand) and southern state of Tamil Nadu (6.88 thousand). But, the scenario has changed opposite in Census 2001. In the next decades, first single-largest volume of migration is from West Bengal (29.69 thousand), followed by Bihar (12.66 thousand). But, flow of out migrants was concentrated to West Bengal, Delhi, Maharashtra and southern states like Karnataka, Kerala (Census of India, 2001). Unskilled labour migration, seeking for employment is the main attraction of crowd. The contribution of Indian in-migrants and out-migration, generally the unskilled, semiskilled, professional jobs and others types of workers. The dilemma of development issues of north-east namely Sikkim has been fairly debated and documented (Bhagwati 1979; Khadria 2009), but the systematic understanding about the contribution in and out migration in Sikkim (Specially Gangtak) is rather scarce (Nandy 2005; Joseph and Narendran 2013).

Population Characteristics of Gangtok

In 2001, Gangtok shares 49 percent of Sikkims urban population. Gangtok accounted for over 77 percent of the total urban growth. Below the table has been showed that the trend in the urban population and changing index of Gangtak town of Sikkim from 1971-2011. It is evident that total urban population has risen considerably from 13 thousand in 1971 to around 1 million in 2011. According to the table the growth of urban population increased approximately four times from the base year of 1971(Table 2).

Table 2
Change in Index of Gangtok Town, (1971-2011)

Year	*Urban Population*	*Change in Index*
1971	13308	100
1981	36747	276.1
1991	25024	188
2001	29359	220.6
2011	98658	741.3

Sources: Census of India, 1971-2011

Table 3
Population Growth in Gangtok (1951-2011)

Year	*Town Population*	*Growth Rate Town*	*Sex Ratio*
1991	25024	-31.9	764
2001	29354	17.3	845
2011	100286	241.6	912

Source: Census of India 2011, Town directory 2011.

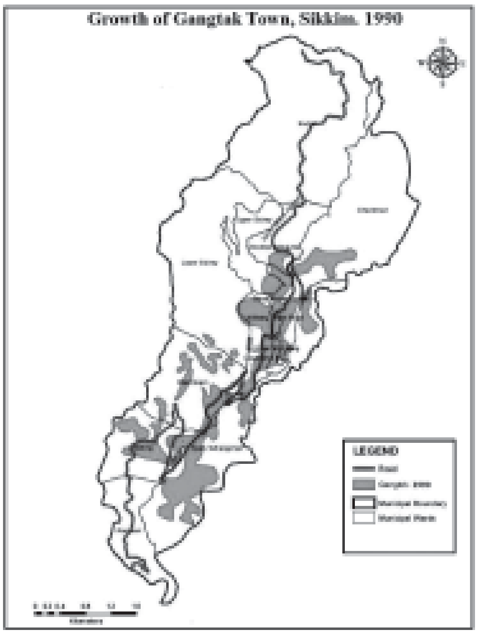
The growth rate of overall population is much lower than the urban population of Gangtak much lower is counterpart of Sikkim towns. The last decade has shown the most phenomenal growth rate of 241.64 percent which is fourteen time fold from the previous year of 2001. At the same time, highest sex ratio is found in 2011 and it has gradually improved in the last three decades (Table 3).

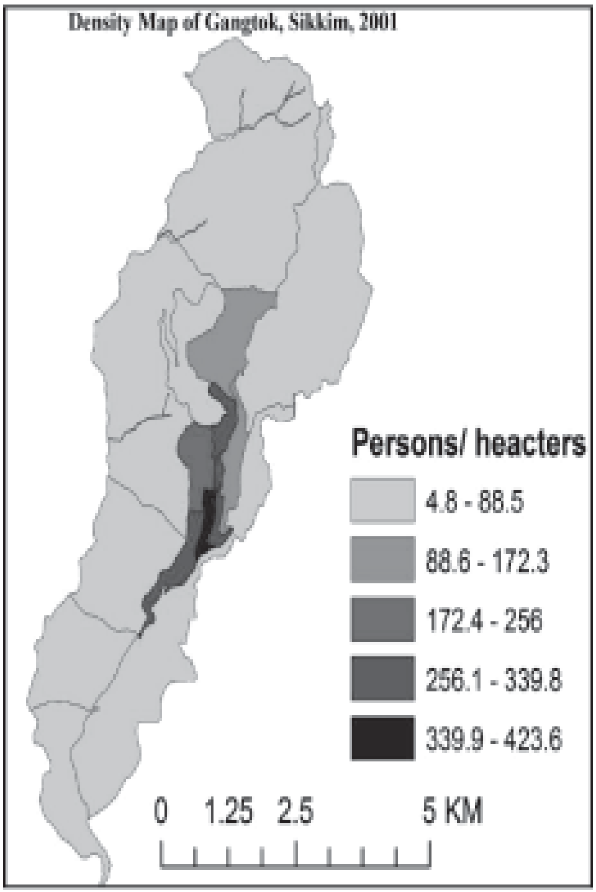
Table 4
Ward wise Population Distribution and Density: Gangtok 2011

Sl. no	*Name of the ward*	*population*	*Area (in ha)*	*Density (person per Km^2)*
1.	Burtuk	9957	433.2	23
2.	Lower Sichey	5873	303.67	19
3.	Upper Sichey	7979	72.54	110
4.	Chandmari	6177	288.63	21
5.	Development Area	6723	73.06	92
6.	Diesel Power House	3987	17.38	229
7.	Arithang	8212	34.32	236
8.	Lower MG Marg	4032	12.2	330
9.	Upper MG Marg	2664	12.98	205
10.	Tibet Road	3266	28.66	114
11.	Deorali	6938	29.8	233
12.	Dara Goan	9605	157.92	61
13.	Tadong	9325	124.28	75
14.	Ramipool	4520	101.61	45
15.	Syari-Tathangchen	11028	238.64	46

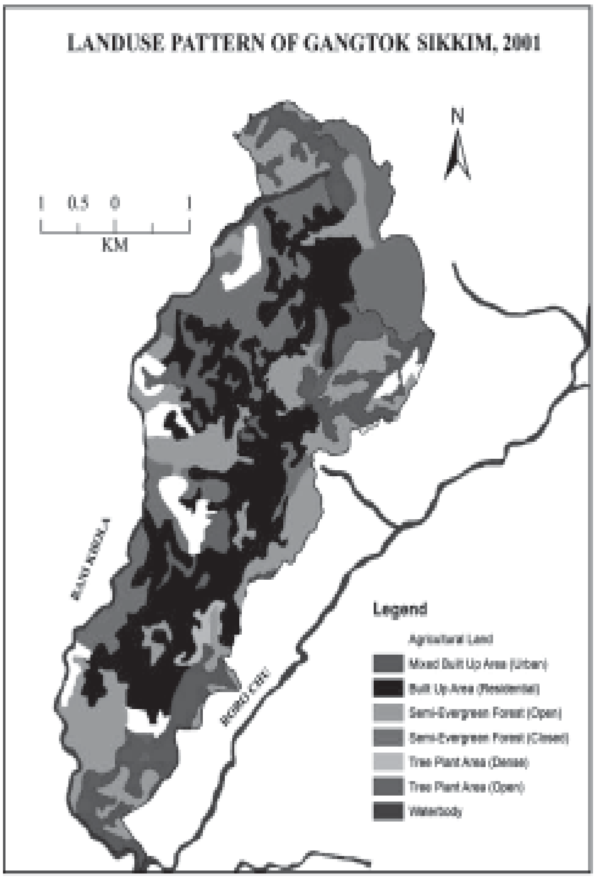
Source: Town Directory of Census, 2011.

Due to tough terrains and others, natural obstacles, population of Gangtok is uneven. Gangtok Municipal Council has been subdivided into 15 wards. Highest population is recorded in Syari-Tathangchen ward (11,028) followed by Burtuk (9957). The average density of the city is 52 persons per Km^2. It shows wide variation ranging from 330 persons per Km^2 in Lower M.G. Marg to 19 persons per Km^2 in Lower Sichey. The areas that show maximum density are M.G. Marg., Deorali, Arithang and Diesel Power House area of Gangtok (Table 4).

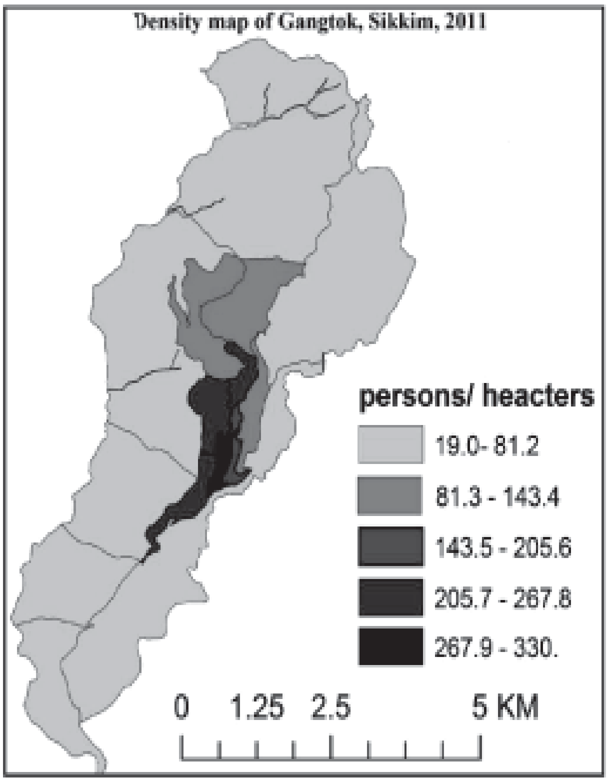




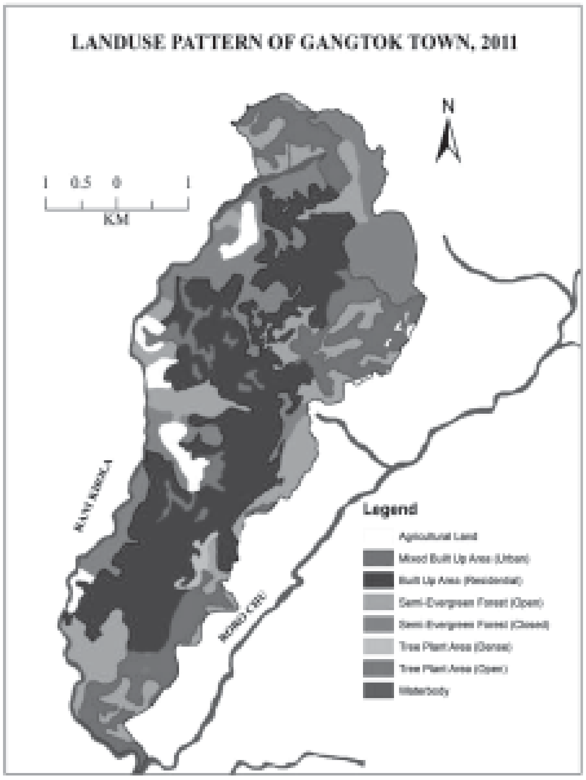
Density Map of Gangtok, Sikkim, 2001



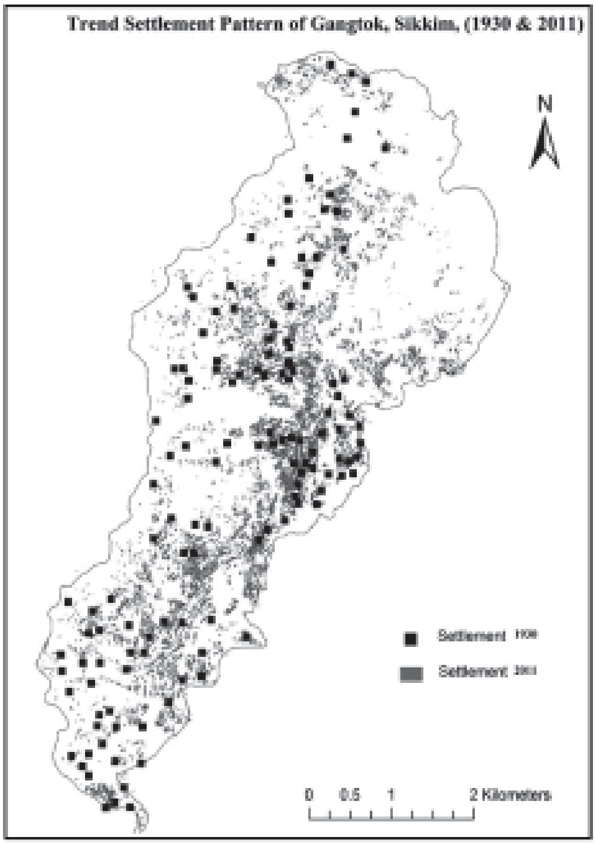
LANDUSE PATTERN OF GANGTOK SIKKIM, 2001



Density map of Gangtok, Sikkim, 2011



LANDUSE PATTERN OF GANGTOK TOWN, 2011



LAND USE PATTERN

The land use pattern of Gangtok town has been categorized in six categories i.e. residential, commercial, public and semi-public, transportation, industrial and recreational. In the post-merger period, public and semi public area had also been expanded from 0.6 percent in 1975 to 21.4 percent in 2011. Residential area has declined from 65.5 percent (1975) to 36.0 percent in 2011. There has been 7 percent and 1.7 percent increase in the transport and recreational sectors respectively from 1975 to 2011.However, the land use pattern of industry drastically declined from the previous of 2006 (Table 5).

Table 5
Different Types of Land Use Categories of Gangtak Town, 1975-2011

Sl. No.	*Land Use Categories*	*Percentage to Total Land Area*				
		1975	*1985*	*1995*	*2006*	*2011*
1.	Residential	65.5	54.8	49.6	43.0	36.0
2.	Commercial	6.9	6.4	4.6	4.0	3.5
3.	Public & Semi-Public	0.6	1.7	4.2	15.0	21.4
4.	Transportation	13.4	12.2	10.6	19.0	20.1
5.	Recreational	12.6	17.7	22.0	13.5	14.1
6.	Industrial	1.1	7.3	9.0	5.5	4.9

Source: DST, Gangtok-Sikkim.

Table 6
Different types of Land Use categories of Gangtak Town, 2001-2011

Land Use Categories	*Area in (Hectares)*		*Area in percent*	
	2001	*2011*	*2001*	*2011*
Agricultural crop land (Kharif Crops)	109.48	79.79	5.92	4.32
Mixed Build up area (Urban)	231.74	274.42	12.54	14.85
Build up area (Residential)	551.77	702.57	29.86	38.02
Forest Semi-evergreen (Dense/closed)	393.62	348.84	21.30	18.88
Forest Semi-evergreen (open)	449.09	349.13	24.30	18.89
Tree Plant Area (open)	96.38	79.23	5.22	4.29
Tree plant area (Dense)	14.75	13.04	0.80	0.71
Water bodies (perennial)	1.17	0.98	0.06	0.05
Total	1848	1848	100	100

Sources: Calculated by Authors

(Table 6) In the post-merger period, Gangtok has experienced an unparalleled spatial expansion. Because of problems like existence of slopes, vulnerability of landslide and inaccessibility most of the areas have been diverted for settlement. According to Land Use and Land Cover data 2011, more than 38 percent of land use is under residential build up area. The area of open tree plantation has rapidly fallen and opposite semi-evergreen dense closed forest has raised in 2011. However, the area of agricultural cropland has been improved over a period of time. The figure is expected to increase further since the conversion of other land use categories into build up area is continuous in the future. As a response to increasing economic opportunities land is being diverted for developmental purposes. During 1930s, Gangtok was known for a colony of few houses. However, now urban fringe areas facing increasing pressure on land. In this 18.48-sq.km area, almost more than 75 percent of land is under build up (table 6). The city falls in ecologically susceptible and seismological vulnerable zone. Considering the fact, this kind of rapid land conversion may pose an enormous risk to the people and society.

CONCLUSION

Urbanization is one of the major processes of the 21st century which has affected the nature of land cover in hill areas. The rapid growth of urbanization combined with the explosive population growth in Gangtok has made a dynamic change in the urban areas and its surrounding regions due to which the available limited land resources in the city are exhausted. The characteristics of demography and pattern of land use are entirely negative. This paper has explored that variables of population like sex ratio, growth rate and change index portray that volume of mobility from rural-urban has been rapidly increased. But, concentration of growth rate population is more like a monopoly in the centre. This huge increase in population of Gangtok can partially be attributed to the reorganization of the Gangtok Municipal Corporation boundary. However, it also implies that the phenomenon of urbanization in Sikkim is Gangtok centric which reinforces the imbalanced urban structure and primacy of Gangtok City. The pressure mounted on the surrounding environs of fertile and vulnerable lands is causing faster rate of land conversion from non-urban to urban. This results in uncontrolled aerial expansion of the city as well as problem of providing basic public services and facilities.

Analysis of the changing land use pattern of Gangtok, clearly shows that the built-up area has been growing at a fast rate, especially after 1990. The density of the existing built-up area is increasing and more area is constantly being added to the built-up area. On the other hand, the percentage of area under cultivation is decreasing every year. These types of urban expansion at the expense of fertile cultivated land is not a symptom for the good health of a city like Gangtok where population is increasing and the city is extremely congested (APPENDIX-A).

In order to have a systematic urban growth of Gangtok town, it is necessary to understand the limitation imposed by its physiography on its pattern. Existence of the number of seasonal streams, dissected topography, hills and other undulation has resulted on radial growth. A dearth of open spaces poses growing challenges for traffic and its management in the city. Therefore, policy need to be strengthened and update to provide sufficient open spaces by erecting buildings in a planned and proper manner. Town out centric development may reduce the growing pressure by improving road connectivity in the adjoining areas.

The most important anthropogenic influence of urbanization on climate is the emission of greenhouse gases and changes in land use, such as urbanization and agriculture. But it has been difficult to separate these two influences because both tend to increase the daily mean surface temperature. The impact of urbanization has been estimated by comparing observations in cities with those in surrounding rural areas, but the results differ significantly depending on whether population data or satellite measurements of night light are used to classify urban and rural areas.

REFERENCES

1. Ariti, A.T., Vliet, P. and Verburg, H. (2015). Land-Use and Land Cover Changes in the Central Rift Valley of Ethiopia: Assessment of Perception and Adaptation of Stakeholders. *Applied Geography,* 65, 28–37.
2. Arsanjani, Jamal Jokar (2012). *Dynamic Land-Use/Cover Change Simulation: Geosimulation and Multi Agent-Based Modelling.* Springer-Verlag, Berlin.
3. Asoka, W.N, Gilbert Thuo Aggrey D.M. Bunyasi, Martin M. (2013). "Effects of Population Growth on Urban Infrastructure and Services": A Case of Eastleigh
4. Bhagwati, J (1979). "International Migration of the Highly Skilled: Economics, Ethics and Taxes", *Third World Quarterly*, 1(3): 17–30.
5. Casado-Diaz, M. A. (1999). Socio-demographic Impacts of Residential Tourism: A Case Study of Torrevieja, Spain. *The International Journal of Tourism Research*, *1*(4), 223.
6. Census of India (1981). Series 19 Sikkim, Part XIII-A & B
7. Census of India (1991). Series 22 Sikkim, Town Dictionary, Part XII A & B, District Census Handbook.
8. Census of India (2001) Town Dictionary, Part XII A & B, District Census Handbook
9. Census of India (2011). General Population Tables, A-series, Registrar General of India, New Delhi, India.
10. Census of India, (1971). Series 21 Sikkim, part XII-A&B
11. Central Statistical Organisation (1998). 'Statistical Abstract of India 1998', Government of India.
12. City Development Plan-Gangtok City, Urban Development and Housing Department, Government of Sikkim
13. Dyson, T., & Moore, M. (1983). On Kinship Structure, Female Autonomy, and Demographic Behavior in India. *Population and Development Review*, 35-60.
14. Gallego F J. (2004). Remote Sensing and Land Cover Area Estimation. *International Journal of Remote Sensing*, 25(15), 3019-3047
15. Gangtok. (1997). 'Sikkim State: Annual Plan 1996–7', Bureau of Economic and Statistics, Planning and Development Department, Gangtok.
16. Geymen, A., & Baz, I. (2008). Monitoring Urban Growth and Detecting Land-cover Changes on the Istanbul Metropolitan Area. *Environmental monitoring and assessment*, *136*(1-3), 449-459.
17. Government of India. (2013). Rapid Baseline

Assessment Gangtok City-Draft Report. Ministry of Urban Development, Capacity Building for Urban Development.

18. Government of India. (2013). Rapid Baseline Assessment Gangtok City-Draft Report. Ministry of Urban Development, Capacity Building for Urban Development.

19. Government of Sikkim (2001). 'Sikkim State Annual Plan 2000–2001', Planning and Development Department, Gangtok. Google Map (2011):https://www.google.co.in/search?q=sikkim+map&biw=1366&bih=643&tbm=isch&tbo=u&source=univ&s a=X&ved=0ahUKEwi45oqThb_JAhVGkI4KHSLFDNYQsAQIHA&dpr=1

20. Herold, M., Couclelis, H., & Clarke, K. C. (2005). The Role of Spatial Metrics in the Analysis and Modeling of Urban Land Use Change. *Computers, Environment and Urban Systems*, *29*(4), 369-399.

21. Huang B., Zhang L., and Wu, B. (2009). Spatiotemporal Analysis of Rural-Urban Land Conversion. *Information Science,* 23(3), 379–398.

22. Joseph, Jolin and Vishnu Narendran (2013): "Neither Here nor There**:** An Overview of South-South Migration from Both Ends of the Bangladesh-India Migration Corridor", Working Paper No 569, The Hague: International Institute of Social Studies.

23. Kandrika, S. and Roy, P.S. (2008). Land Use Land Cover Classification of Orissa using Multi-Temporal IRS-P6 AWiFS Data: A Decision Tree Approach. *International Journal of Applied Earth Observation and Geoinformation.* 10, 186–193.

24. Kashaigili, J.J., Majaliwa, A.M. (2010). Integrated Assessment of Land Use and Cover Changes in the Malagarasi River Catchment in Tanzania. *Physics and Chemistry of the Earth,* 35,730–741.

25. Khadria, B. (2009). Adversary Analysis and the Quest for Global Development: Optimizing the Dynamic Conflict of Interest in Transnational Migration. 53(3), 106-122.

26. Lama, M. P. (Ed.). (1994). *Sikkim: Society, Polity, Economy, Environment*. Indus Publishing.

27. Lama, M.P (2001) 'Sikkim Human Development Report, 2001, Social Science Press, New Delhi

28. Lambin E.F., and Geist H.J. (2006). *Land-use and Land-cover Change: Local Processes and Global Impacts.* Springer-Verlag, Berlin.

29. Lavalle, C. (2002). *Towards an Urban Atlas: Assessment of Spatial Data on 25 European Cities and Urban Areas* (Vol. 30). European Environment Agency.

30. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. (2004)Remote Sensing and Image Interpretation. John Wiley & Sons Ltd, NY.

31. Mayunga S D, Coleman D J, and Zhang Y. A. (2007). Semi-automated Approach for Extracting Buildings from Quick Bird Imagery Applied to Informal Settlement Mapping. *International Journal of Remote Sensing*, 28(10), 2343-2357.

32. Meshesha, D., Tsunekawa, A., and Tsubo, M. (2012). Continued Land Degradation: Cause-effect in Ethiopia's CRV. *Land Degradation Development,23*, 130–143.

33. Nandy, Chandan (2005):"Illegal Immigration from Bangladesh to India: The Emerging Conflicts", Mellon-MIT Foundation on NGOs and Forced Migration, SLIFKA Program in Inter-Communal Coexistence, Brandeis University, available at http://web.mit.edu/CIS/www/migration/

34. Peijun, D., Xingli, LI., Wen,C., Yan, L., Huapeng, Z. (2010). Monitoring Urban Land Cover and Vegetation Change by Multi-temporal Remote Sensing Information. *Mining Science and Technology* 20, 0922–0932

35. Provisional Population Totals, (2011), 'Sikkim State District Profile, Census of India, New Delhi.

36. Rawat, J.S., Biswas, Vivekanand., Kumar, Manish (2013). Changes in Land Use/Cover Using Geospatial Techniques: A Case Study of Ramnagar Town area, District Nainital, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Sciences,* 16, 111–117

37. Roth, D. Moreno-Sanchez, R., Torres-Rojo, J. M. and Moreno-Sanchez, F. (2016). Estimation of Human Induced Disturbance of the Environment Associated with 2002, 2008 and 2013 Land Use/Cover Patterns in Mexico. Applied Geography, 66, 22-34.

38. Sarma, V. V. L. N., Murali Krishna, G., Hema Malini, B., and Nageswara Rao, K. (2001). Landuse/Landcover Change Detection through Remote Sensing and its Climatic Implications in the Godavari Delta Region. *Journal of the Indian Society of Remote Sensing*, 29,1 & 2, 86-91.

Appendix A: Fact & Figures of Gangtok Town, 2011

Existing Fact and Facilities	GANGTOK
Total Households	23773
Total Population of Town	100286
Total Male Population of Town	52459
Total Female Population of Town	47827
Total Scheduled Castes Population of Town	4793
Total Scheduled Castes Male Population of Town	2422
Total Scheduled Castes Female Population of Town	2371
Total Scheduled Tribes Population of Town	28514
Total Scheduled Tribes Male Population of Town	13954
Total Scheduled Tribes Female Population of Town	14560
Scheduled Castes Population (2011 Census)	4793
Scheduled Tribes Population (2011 Census)	28514
Rainfall (cm.)	359
Maximum Temperature (in centigrade)	18.8
Minimum Temperature (in centigrade)	12.7
Nearest Ciity Name with Population of 1 Lakh and more	SILIGURI
Nearest Ciity with Population of 1 Lakh and more Road Distance (in kms.)	114
Nearest Ciity Name with Population of 5 Lakh and more	KOLKATA
Nearest Ciity with Population of 5 Lakh and more Road Distance (in kms.)	697
Railway Station Name	SILIGURI
Railway Station Road Distance (in kms)	114
Bus Route Name	GANGTOK
Pucca Road Length (in kms.)	19
Drainage System (Open-1/Closed-2/ Both-3/No-4 ?)	3
Latrines-Pit (Numbers)	807
Latrines-Flush/Pour Flush (Numbers)	21716
Latrines-Others (Numbers)	1250
Electricity-Domestic Connection (Numbers)	11313
Electricity-Industrial Connection (Numbers)	39
Electricity-Commercial Connection (Numbers)	2983
Electricity-Road Lighting Connection (Numbers)	630
Govt. Primary School (Numbers)	12
Private Primary School (Numbers)	35
Govt. Middle School (Numbers)	10
Private Middle School (Numbers)	21
Govt. Secondary School (Numbers)	8
Private Secondary School (Numbers)	8
Govt. Senior Secondary School (Numbers)	5
Private Senior Secondary School (Numbers)	3
Hospital Allopathic (Numbers)	2
Hospital Allopathic Doctors-Total Strength (Numbers)	124
Hospital Allopathic Para Medical Staff-Total Strength (Numbers)	91
Hospital Alternative Medicine Nearest facility Distance (in kms.)	55
Dispensary/Health Centre (Numbers)	1
Dispensary/Health Centre Para Medical Staff-Total Strength (Numbers)	3
Family Welfare Centre (Numbers)	1
Family Welfare Centre Doctors-Total Strength (Numbers)	1
Family Welfare Centre Doctors Para Medical Staff-Total Strength (Numbers)	9
Maternity and Child Welfare Centre (Numbers)	1
Maternity and Child Welfare Centre Doctors-Total Strength (Numbers)	6
Maternity and Child Welfare Centre Para Medical Staff-Total Strength (Numbers)	33
Maternity Home (Numbers)	1
Maternity Home Doctors-Total Strength (Numbers)	6
Maternity Home Para Medical Staff-Total Strength (Numbers)	33
T.B. Hospital/ Clinic Doctors-Total Strength (Numbers)	2
T.B. Hospital/Clinic Para Medical Staff-Total Strength (Numbers)	3
Nursing Home Nearest facility Distance (in kms.)	113
Veterinary Hospital (Numbers)	1
Veterinary Hospital Doctors-Total Strength (Numbers)	2
Non-Government Medicine Shop (Numbers)	101

Sources: Town Directory of Census, 2011

MAPPING OF INFORMAL WORKERS IN INDIA: AN EXPLORATORY ANALYSIS FROM NSSO DATA

Sarmistha SINGH[1]

ABSTRACT:

The recent estimation by NSSO shows more than 90 percent of workforce derive their livelihood from the 'Informal sector' and 60 percent share to the Net Domestic Product (NDP) accounted for by the informal economy. The major challenge for Indian workforce is the larger involvement of low skilled labour in economy. A high proportion of socially and economically underprivileged sections of society are concentrated in this sector. Informal employment is becoming the major source for working poor with low skill and semi-skilled labour. The Informal sector is a pervasive and persistent economic feature of most developing countries. It significantly contributing to employment creation, production, and income generation (ILO, 2002,)

With NSSO 68th round data assessing the relative size and composition of the informal sector with delineates the recent changes in agricultural and non-agricultural sector. The present paper has two objectives. Firstly, analyze the proportion of informal employment in labour force in India that is examine the informal employment scenarios in the formal and informal sectors Secondly, assess the share of unorganized workers in different kind of non-agricultural activity in respect to urban and rural areas with gender wise. With the help of ARC GIS map software analysing the share of informal workers in Agriculture and non-agriculture industry at state level.

Keyword(s): *Informalisation , Underprivileged, Labour Force.*

INTRODUCTION

The use of the term 'organised' and 'unorganised' as used in India is internationally known as 'formal' and 'informal'(NCEUS,2007). The term "Informal sector" was first introduced in the report of International Labour Oorganisation (ILO) in year 1972 while studying the urban labour markets in Africa (Hart, 1973). Since then role of informal sector in economic development has been vigorously debated. Some view the informal economy in positive term as a "pool" of entrepreneurial talent or a "cushion" during economic crises. While other see the informal economy as a source of livelihood for the working poor. However, some other argue that informal entrepreneurs willfully avoid registration and taxation (Chen, 2012).

The terms "unorganized" and "informal" sectors are often used interchangeably (Committee on Unorganised Sector Statistics, 2012). As per the National Commission for Enterprises in the Unorganized Sector (NCEUS) report 2007, unorganised sector consists of all unincorporated private enterprises owned by individuals or households engaged in the sale and production of goods and services operated on a proprietary or partnership basis and with less than ten total workers. Whereas, Organised workers consist of those working in the unorganized/informal sector, who are regular workers with social security benefits provided by the employers and the workers in the formal sector with any employment and social security benefits provided by the employers (NCEUS,2007).

While addressing the issues of employment in informal sectors, the NCEUS report 2007 noted that: employment in India can be meaningfully grouped into four categories to reflect quality and its sectoral association. These are (a) formal employment in the formal or organised sector, (b) informal employment in the formal sector, (c) formal employment in the informal sector, and (d) informal employment in the informal sector. Thus, organized/formal sector consist of formal as well as informal worker. Similarly, unorganized/informal sector also consists of formal as well as informal worker.

It is important to understand that the employment in "***Informal Sector***" and "***Informal Employment"*** is two distinct concepts. Informal sector is an *enterprise-based concept* which includes both own-account enterprises and informal employees. Usually, informal enterprises are mostly identified by registration status and size criteria, typically firms with fewer that of five to ten employees. ***"Informal employment"*** refers to a *job-based concept of informal activities*. It comprised of workers in the informal sector including the workers in informal jobs in formal sectors enterprises and the paid domestic workers in household. Informal employment also identified by the set of social protections. Such indicators as paid leave, an employer-provided pension etc. Other identification of job is formal or

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informal nature through the existence of a written, or enforceable, contract (Vanek, 2007).

Informal workers consist of those working in the unorganised enterprises or households, excluding regular workers with social security benefits, and the workers in the formal sector without any employment/ social security benefits provided by the employers. Whereas, formal workers consist of those working in the unorganized/informal sector, who are regular workers with social security benefits provided by the employers and the workers in the formal sector with any employment and social security benefits provided by the employers (NCEUS,2007).

OBJECTIVE

The importance of unorganized sector in the Indian Economy is widely recognized in the literature of Economics. NSSO report indicates that approx 90 percent of employment is generated in unorganized sector in India. This sector provides cheaper input to formal sector which in turn helps Indian Economy to remain competitive in International market. However, work condition and social security of unorganized worker is pathetic. The work condition and social security also affect the productivity of workers of unorganized workers which in turn affects the productivity of overall economy. Keeping this view in mind, present paper tries to study the unorganized sector of India under following objectives:

(i) To analyze the proportion of informal employment in labour force in India.

(ii) To assess the share of unorganized workers in different kind of non-agricultural activity in respect to urban and rural areas with gender wise.

DATABASES & METHODOLOGY

The paper is based on the systematic analysis of secondary data and information collected from the various sources. The secondary database is as from National sample survey organization (NSSO) various rounds such as 55th, 61st,66th, and 68th employment and unemployment report. . It is also necessary to mention that some of data are cited from the other journals, annals and other published reports.

The study is based on the secondary data analysis of formal –Informal sector with different industry of Informal sector. Here, the spatial analysis refers to urban and rural employment in informal sector in Non-agriculture industry. The state level analysis of the of Informal workers in AGEGC or agricultural, Non-Agriculture carried out with the help of map.

DISCUSSION & ANALYSIS

After liberalization, the economy had grown at more than 6 percent on the average during the period 1990-2014. India's overall employment has been increased from 372.1 million in the year 1993-94 to 472.9 million in the year 2011-12. The compound annual growth rate (CAG) of employment between the period 2009-10 to 2001-12 is 1.50. The detailed data on employment growth is given in following two tables:

Table 1
All India employment data: Usual Status (PS + SS) Basis, in million

	1993-94	*1999-00*	*2004-05*	*2009-10*	*2011-12*
Labour Force[1]	378.7	405.9	469.0	468.8	483.7
Work Force[2]	372.1	396.8	457.9	459.0	472.9
Number of unemployed	7.5	8.0	11.3	9.8	10.8
Unemployed (%)	2.5	2.0	2.3	2.0	2.2

Source: Trends in Employment in India,EPW Statistics, 2015

The matter of concerned is that the above-mentioned rise in employment has been mostly within the unorganised and unregulated informal sector particularly in the period after liberalisation. In case of organised sector, annual employment growth has decreased from 3.44 per cent per annum during 1990-91 to 1996-97 and -0.63 percent in 1997-98 to 2004-05(Rani and Unni, 2004). The increase in employment during the last decade can be shown through following table.

Table 2
Employment Trends, Usual Status, 1999-2000 to 2011-12 (millions)

	1999-2000	*2004-05*	*2009-10*	*2011-12*
Total	397.9	457.9	459.0	472.9
Male	274.0	309.3	331.7	343.8
Female	123.9	148.6	127.3	129.1

Source: NSSO Report of Various Rounds 55th ,61st ,66th and 68th.

As per the latest round of the NSS (68th Round), the total workforce in the country increased from 459 million in 2009-10 to 472.9 million in 2011-12. In comparison, the increase in employment from 2004-05 to 2009-10 was just 1.1 million. This indicates that there is increasing trend in employment generation. Now the next question arises whether this increasing trend is lead by formal employment or informal employment. The growth of formal and informal worker can be seen in following table:

Table 3
Formal and Informal Employment in Years 2009-10 and 2011-12 (in million)

Year	*Informal Employment*	*Formal Employment*	*Total Employment*
2009-10	424.00 (92.35)	35.00 (7.65)	459.0
2011-12	436.1 (92.22)	36.8 (7.78)	472.9

Source: NSSO 66th and 68th report
Note: Numbers in bracket are in percent

The above table clearly indicates that during the period of 2009-10 to 2011-12, formal employment increased by only 1.68 million whereas informal employment increased by approx 12 million. In terms of percentage, formal employment shows declining trend whereas informal employment shows increasing trend.

Literature suggests that growth of formal employment in the country has always been less than that of total employment which suggests a faster growth of employment in the informal sector. Available data indicates that within the formal sector also the proportions of informal workers are on the increase. This process is called informalisation of workforce. As regards reason of informalsation, India Labour Market Report (2008) indicates that capitalistic development as an important factor of growth of the informal sector. The report mentions that high growth in the informal sector is the result of unchecked growth in capital led production mechanism. Further, it argues that informal sector growth is also attributed to policies of deregulation and withdrawal of the state. It has also been pointed out that the growth in the informal workforce in recent years is also due to subcontracting arrangements of production.

In order to know the status of informalisation of workforce in India, segregation of informal workers into agriculture and non agriculture sector is necessary. Because, agriculture sector continues to be largest sector in terms of employment since long back and it is predominated by informal workers since. Thus the clear picture of informalisation of workforce can be seen through the segregation employment into agriculture and non agriculture sectors.

Table 4 presents the share of workers employed in the informal sector among workers in AGEGC sector and non-agriculture sectors as obtained from NSS 61st (2004-05), 66th (2009-10) and 68th (2011-12) rounds. The table indicates that, there is a decline in the share of informal sector employment among workers in AGEGC and non agriculture sector for both males and females in rural and urban areas during 2004-05 and 2011-12. The highest decline is 14 percentage points for rural females.

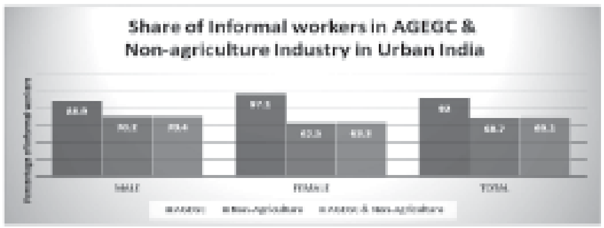
Table 4
Workers in the informal sector (P & P) among workers (ps+ss) in Agriculture and Non-agriculture sectors during 2004-05, 2009-10 and 2011-12 (in percent)

	Agriculture		*Non-Agriculture*		*Total*	
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
NSSO 61st Round (2004-05)						
Male	90.4	86.8	78.1	73.7	79.2	73.9
Female	97.2	94.9	77.1	63.5	86.4	65.4
NSSO 66th Round (2009-10)						
Male	90.6	88.3	73.0	68.3	74.2	68.5
Female	95.0	97.7	64.1	60.1	74.4	61.6
NSSO 68th Round (2011-12)						
Male	88.9	88.9	75.5	70.2	76.2	70.4
Female	94.0	97.1	64.0	62.5	72.7	63.6

Source: NSSO Rounds 61st 66th & 68th Reports.

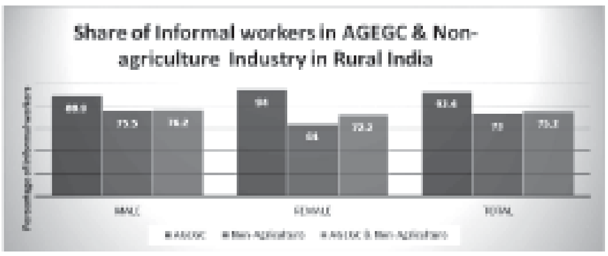
The Spatial Analysis of Informal Workers in Agriculture and Non-agricultural Activities

Because the agriculture is the backbone of Indian economy, it is necessary to depict the picture of employment scenarios in this industry. The share of informal workers in agriculture and non-agriculture sector can be depicted through following diagrams.



Source: NSSO Report 68th Round, 2011-12

Diagram1: Informal Workers in AGEGC and Non-agriculture Activities in Urban India



Source: NSSO Report 68th Round,2011-12.

Diagram 2: Informal workers in Agriculture and Non-agriculture activities in Rural India

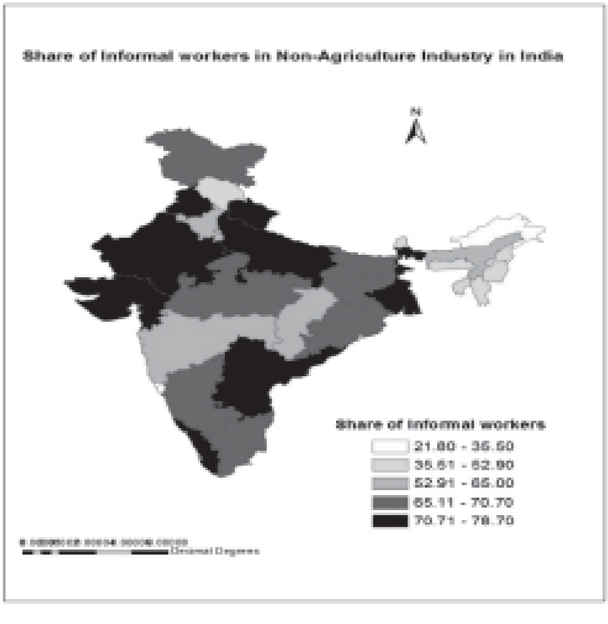
Employment Trend by Sector-wise

In order to analyses the relationship of employment between the sectors i.e., Formal & Informal, employment by various sectors is necessary, as some sectors have relatively high growth rate of employment like manufacturing, non-manufacturing and services. Sectoral composition of employment trend can be shown through following table:

Table 5
Share of Formal -Informal Workers by Different Sectors, 61st and 68th Round (in Percent)

Sector	*Organised/ formal Sector*		*Unorganised/ formal Sector*		*Total*
	For-mal	*Infor-mal*	*Formal*	*Informal*	
NSSO 61st Round (2004-05)					
Agriculture	0.76	0.99	0.00	56.75	58.50
Manufacturing	1.21	2.10	0.10	8.33	11.73
Non-manufac-turing	0.53	1.45	0.00	4.42	6.41
Services	4.48	1.89	0.19	16.80	23.36
Total	6.98	6.43	0.29	86.30	100.00
NSSO 68th Round (2011-12)					
Agriculture	0.60	0.16	0.00	48.69	48.90
Manufac-turing	1.48	2.79	0.06	8.28	12.80
Non Manu-facturing	0.69	3.77	0.01	7.18	11.85
Services	5.62	2.72	0.22	18.29	26.84
Total	7.84	9.43	0.29	82.43	100.00

Source: Adopted from Srija & Shirke (2014).



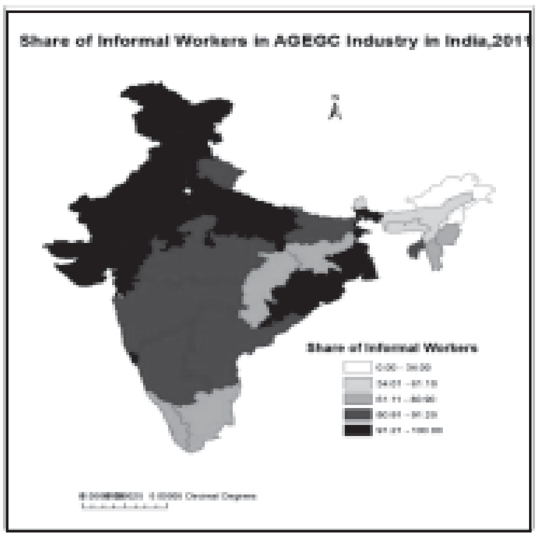
Source: NSSO Report 68th Round, 2011-12.

Map-1 Share of Informal workers in Non-agriculture Sector in India

As per the 68th round NSSO survey report, 48.91 percent of total employment is working in griculture sector and approximately 97 per cent of the agriculture workers are informal workers. The above table indicates that percentage share of agriculture in total employment has declined from 58.50 per cent in 2004-05 to 48.90 per cent in 2011-12. During the same period, share of employment in non agriculture sector has shown the increasing trend. For example, share of services sector has increased from 23.36 percent to 26.84 percent and share on non manufacturing sector has increased from 6.41 percent to 11.85 percent which indicates that structural transformation in Indian Economy is taking place.

The above table also states that manufacturing and non-manufacturing sectors show some expansion in employment; however, a large part of the same falls under informal employment. The remaining sector mentioned in above table and graph represent service sector. For example, in non-manufacturing sector, formal employment under organised has increased from 0.53 percent to 0.69 during 2004-05 to 2010-11 where as informal employment has increased from 1.45 to 3.77 percent. Similarly, in unorganized sector, formal employment has increased by 0.01 percent whereas informal sector has increased by nearly 3 percent. Same trend is followed in other on agriculture sectors also.

The labour market is also characterized by gendered segmentation. Women are predominantly into certain sections and occupations, which are considered as well as suited to women's 'natural' skills. These occupations are low paying and often marked by a very low degree of unionization.



Source: NSSO Round 68th Round

Map-2 Share of Informal workers in Agriculture Sector in India

Informal Workers in Agricultural and Non-Agriculture Industry in India: State Level Analysis

India's informal labour force scenario can be understood through the various industry groups of nonagricultural activities. The gender difference in informal employment found in manufacturing, which accounting for female higher share of employment with 92.5 percent and male with 75.7 percent.

From Map-1 it is analysed that share of informal worker in Non-agriculture sector is highest found in north and north western staes such as Gujurat, Rajasthan, Punjab, Uttar Pradesh, Uttarakhand, west Bengal, Andhra Pradesh, kerela and Sikkim. Whereas the lowest proportion of informal employment found in Arunachal Pradesh.

From Map-2 depicting the share of informal workers in Agriculture sector. More than 91 percent of informal workers are in the state J&K, Himachal Pradesh, Punjab, Punjab, Uttarakhand, Haryana, Rajasthan, Gujurat, U.P, West Bengal, Odisha and Goa.

CONCLUSION

The economic reform started after 1991 intensely impacted upon the organised and the unorganised sector of the Indian economy. The new economic policies promoted casualisation of workforce in terms of irregular, casual and non-permanent employment. Workers in general and women workers in particular were severely affected by these measures. These measures are adopted by the employers because it reduces labour cost in tight completion. It clearly indicates that these flexible workers in the new informal economy are extremely vulnerable in terms of job security and social protection.

The existing literature on unorganized sector indicates that more than 90 percent of workforce and approx 50 percent of the national product are accounted by the unorganized/informal sector in India. It is well recognized that unorganized sector meets the requirements of organised sector as a supplier of inputs and services at lower cost.

The growth of formal employment in the country has always been less than that of total employment which suggests a faster growth of employment in the informal sector. Available data indicates that within the formal sector also the proportions of informal workers are on the increase. Labour Market Report (2008) sees capitalistic development as an important factor of growth of the informal sector. The report mentions that high growth in the informal sector is the result of unchecked growth in capital led production mechanism. Further, it writes that Informal sector growth is also attributed to policies of deregulation and withdrawal of the State.

Since, informal workers do not have any type any social and job security, this increasing informalisation of workforce raise an important social concern. Social security has several socio-economic goals like redistribution of income in order to reduce disparities between rich and poor, maintenance of income to a reasonable extent during certain contingencies or unforeseen in future of vulnerable masses. Social security offers to the humanity the dignity, self-confidence, and new means for moral and material improvement. On the other hand, at the macro level, social security serves as an instrument of economic development, equitable income distribution, industrial peace, securing a contended as well as committed labour force, socio-economic justice and finally a stable socio-economic order.

Therefore, the Government should adopt a holistic approach to addressing the issue of informalisation specially in the formal sector. As per the WTO Report (2009) on "Globalisation and Informal Jobs in Developing Countries the approach should focus on providing: (a) support for employees to transit out of informality; (b) investment in infrastructure so as to promote productivity of informal firms and facilitate formalisation; and (c) a basic network of social protection for those who continue to be employed informally". One of such initiatives is NPS – Swavalamban scheme. Any citizen working in the unorganized/informal sector, can open NPS - Swavalamban account under which Government will contribute Rs. 1000 per year to each NPS[3].

Notes

1. As per NSSO report, Labour force constitutes all the persons who are working, seeking work and unemployed or available for work.
2. Workforce constitutes the employed labour force. The difference between the labour force and the workforce is the unemployed labour force.
3. http://www.financialservices.gov.in/Swavalamban%20Operational%20Guidelines.pdf

REFERENCES

1. Arnold, D., & Bongiovi, J. R. (2012). Precarious, Informalizing, and Flexible Work/ : Transforming Concepts and Understandings. *American Behavioral Scientist*, *57*(3), 289.
2. Chen, Martha Alter (2012), "The Informal Economy: Definitions, Theories and Policies", *WIEGO Working Paper No 1.*
3. Chandrasekhar, C.P. and Ghosh, Jayati (2007) Growth and Employment in Organised Industry Business Daily, *THE HINDU Group of Publications*, Tuesday, Jan 09, 2007.

4. Kannan, K.P. and Jan Breman (2013) The Long Road to Social Security. *Oxford University Press*, New Delhi.
5. Kannan, K.P(2014) Interrogating Inclusive Growth Poverty and Inequality in India, *Routlege Publication*, New Delhi.
6. Harriss-White, Brbara.Anushtee Sinha. (eds) (2007) Trade Liberalisation and India's Informal Economy, *Oxford University Press*, New Delhi.
7. India Labour and Employment Report (2014), Workers in the Era of Globalisation, *Academic Foundation,* New Delhi.
8. Bino Paul, Bhirdikar.K, Shani ,Mukharjee. P, krshna .M, Bhardwaj.R, (2011), India Labour Market Report 2009-10. *Adecc TISS Labour Market Research Initiatives*. Mumbai.
9. India Labour and Employment Report (2014), Academic Foundation and Institute for Human Development, New Delhi.
10. International Labour Organisation (2002). *Women and Men in the Informal Economy: A Stastical Picture*, ILO Employment Sector, Geneva.
11. National Commission for Enterprises in the Unorganized Sector (2006) Report, *Social Security for Unorganized Workers Government of India*. New Delhi.
12. Papola, T. S. (2013). Role of labour regulation and reforms in India Country case study on labour market segmentation. *ILO Working Paper*, (147).
13. Srivastava,Ravi (2011).Recent Trends and Patterans in Labour Migration. *The Indian Journal of Labour Economic*s, Vol.54, No.3.
14. Srija and Shirke (2014), "An Analysis of the Informal Labour Market in India" Confederation *of Indian Industry.*
15. Unni, Jeemol and Rani, Uma (2004), "Unorganised and Organised Manufacturing in India – Potential for Employment Generating Growth", *Economic and Political Weekly*, Vol. 39, No.41, October 9Srija, A., & Shirke, S. V. (2012). An Analysis of the Informal Labour Market in India, 40–46.
16. Vanek, J. H. and J. (2007). Employment, the informal sector, and Poverty: Data and Analytical Challenges. *Research Design Conference*, (1), 1–22.

MAPPING CHRONIC DISEASES IN INDIA: EVIDENCE FROM NSS 71TH ROUND

Sunita CHOUBEY[1]

ABSTRACT

The chronic disease in India is not only one of the leading causes of disabilities and deaths in the country but also the loss of household incomes. In such conditions, understanding the spatial distribution of chronic diseases is essential for disease management and prevention. The latest National Sample Survey data on health 'Key Indicators of Social Consumption in India on Health' (71st round) in 2014 shows the nature of the chronic disease in India. According to the report, every 10, 00 populations 48 persons are suffering from chronic diseases in India. The injuries share the utmost proportion of chronic diseases followed by infectious diseases, gastrointestinal, genitourinary, cardiovascular, psychiatric, neurological and other diseases. The findings of the study reveal the sharp deviation from general epidemiological theory, which propagates that the non-communicable diseases more confine to the richer economic classes and urban area, now it is also spreading its root in the rural areas and among poor people of the country. It is an early warning. Thus, there is not only need to spread awareness about chronic diseases in the rural areas and among poor but also require a sufficient supply of preventive and curative health services in the countryside so that, the loss of life and income can be minimised due to this menace.

Keywords: *Chronic Disease, loss of income, Inequality, Burden of Diseases*

INTRODUCTION

The United States National Center for Health Statistics defined a chronic disease as it last three months or more. Another characteristic of chronic illness is, it cannot be prevented by vaccines or cured by medication, nor do they just disappear. That is why, it is taking a form of the epidemic across the world while due to poverty and inadequacy of health care services, its burden is very high in low and middle-income countries. According to World Health Organisation (WHO), around 80% deaths occurred in these countries in 2015 due to chronic illness and the major chronic diseases were heart disease, stroke, cancer, chronic respiratory disease, and diabetes. In India, the chronic diseases is also a primary cause of the deaths. According to an estimation around 53% deaths occurred in India in 2005 because of chronic illness and it is projected that 66.7 % all deaths would have happened by 2020 due the chronic diseases (KS Reddy; 2005).

Often, chronic diseases are caused the long-standing disabilities which lead to loss of household incomes in both the terms of uptake of health care services and loss of income or labour productivity due to disease (Abegunde et al. 2007; WHO, 2005). With the increasing trend of non-communicable disease among the poor people of the country, it has observed that they suffer from both non-communicable as well as communicable diseases. Consequently, they bear the double burden of diseases (Barik; 2012).

The paper has organised into six sections. The first section is an introduction. In the second section database and research methodology of the paper has given. In the third section, the pattern of chronic diseases in India across the major Indian states, demographic and socioeconomic characteristics of the patient of chronic diseases have analysed. The fourth section brings out the nature of chronic diseases in India. In the fifth section, the health seeking behaviour of the patient of the chronic diseases has discussed. The last section presents a summary and conclusion of the study.

DATA BASE AND METHODOLOGY

For the analysis of chronic diseases 'Key Indicators of Social Consumption in India: Health' (January to June 2014), carried out by National Sample Survey (NSS) Organisation is the main data source of this paper. In this round, NSS conducted a large-scale sample survey regarding social consumption related to health. This round is the primary source of basic quantitative information on the health sector, including morbidity, hospitalisation, the extent of the receipt of pre-natal and post-natal care by women, expenditure incurred on treatment received from public and private sectors, use and cost of AYUSH treatment. In the survey a stratified multi-stage sampling design adopted for both rural and urban areas. The survey collected information using household as well as individual schedules. The household and individual response rates were >95%. All these details have mentioned in the NSS 71st round. In this round, data collected from 3, 6480 households in the rural areas and 2, 9452 households from the urban areas. The total numbers of

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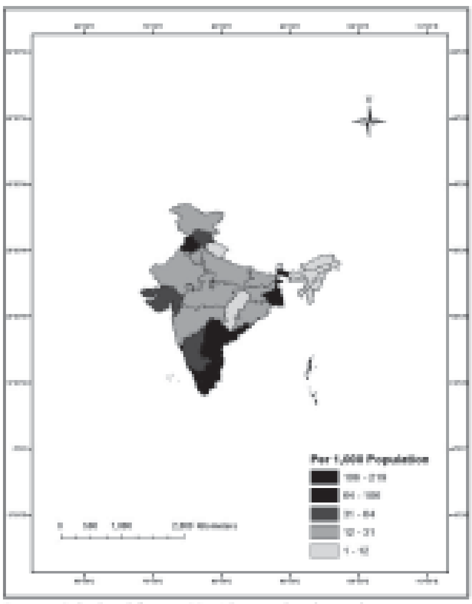
individuals were 333,104out of which 169,095 were females and remaining 164,947 were males. In this round, the data regarding the prevalence of chronic diseases in India collected by asking a question whether individual are suffering from any chronic ailments. Though, it is a self -reported morbidity, however, an absence of large-scale clinical data about the chronic disease in India, this self- reported morbidity is main data for the study of chronic disease in India. The Arc GIS 10.2 has used for the data displaying maps. Furthermore, for cross tabulation, STATA 12.0 has applied in this study.

PATTERN OF CHRONIC DISEASES

The Pattern of chronic disease in India shows that its prevalence rate is the highest in Kerala and higher in the state of Tamil Nadu, Andhra Pradesh, Goa, Punjab and West Bengal. The occurannnce of the chronic disease is medium in Karnataka, Gujarat and Himachal Pradesh whereas its prevalence rate is lower in Maharashtra, Madhya Pradesh, Rajasthan, Haryana, Uttar Pradesh, Bihar, Jharkhand, Jammu and Kashmir, Odisha and the seven states of northeast regions and its reporting is the lowest in Chhattisgarh, Uttarakhand, and Delhi (map-1).

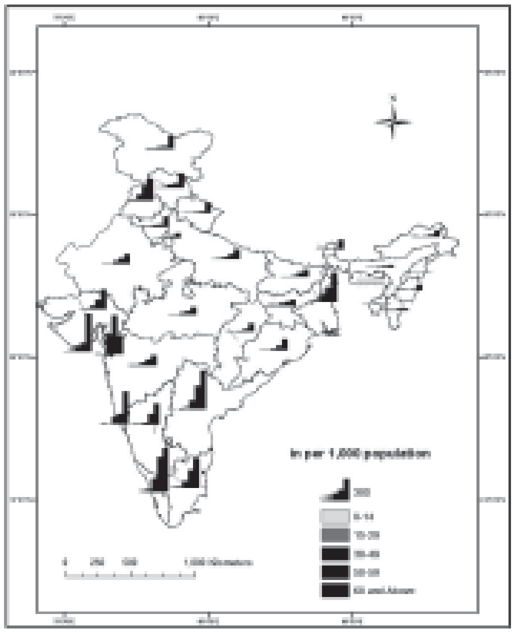
According to gender, the prevalence of chronic diseases is higher among females than the males. Out of every 1,000 females, 55 reported that they were suffering from chronic illnesses during the survey, while the equivalent figure for the male was 42 whereas out of every 1,000 people almost 48 persons in India reported chronic diseases. The similar pattern emerges in other Indian states, excluding Arunachal Pradesh where males had reported the highest number of chronic diseases than females (Map-3)



Source: Calculated from NSS 71th Round Unit Level Data

Map 1: State-wise Prevalence of Chronic Diseases in India, 2014

According to age group the occurrence of chronic diseases in India shows that its prevalence rate is the highest in the older population than the younger one, for instance, its reporting was the highest in the 60 and above age group. Although it is lower in younger age groups, such as out of per 1,000 people, 237 reported that they were suffering from chronic disease, whereas the corresponding number in 50-59 age group is 123 for per 1000 population followed by 50 in 30-49 age group. At last 12 in 15-29 and 6 in 0-14 years age groups. State wise distribution of chronic diseases shows the similar pattern except for a few exceptions. Most of the Indian states show similar trends except few exceptions, such as the prevalence of the chronic illnesses in Dadar Nagar Haveli is higher in the 50-59 age group compared to 60 and above that is a matter to further investigation (Map-2).



Source: Calculated from NSS 71th Round Unit Level Data

Map 2 Age Group Wise Prevalence of Chronic Diseases in India, 2014

The incidence of chronic diseases in India is higher in the urban areas compared to its counterpart. In urban areas out of per 1,000 populations, 67 persons reported chronic diseases while in the rural areas, it was 40 and these many numbers are quite alarming. The pattern of Indian states is not alike, but it reflects homogenise results. The people of Jammu and Kashmir, Himachal Pradesh, Punjab, and Maharashtra, were reported the higher number of morbidity in the rural areas, whereas it is higher in urban areas of remaining Indian states than its counterpart (Map-4).

The social group wise morbidity because of chronic diseases is the highest among Other group (64 per

Table 1
Profile of Chronic Diseases for per 1,000 Populations in India, 2014

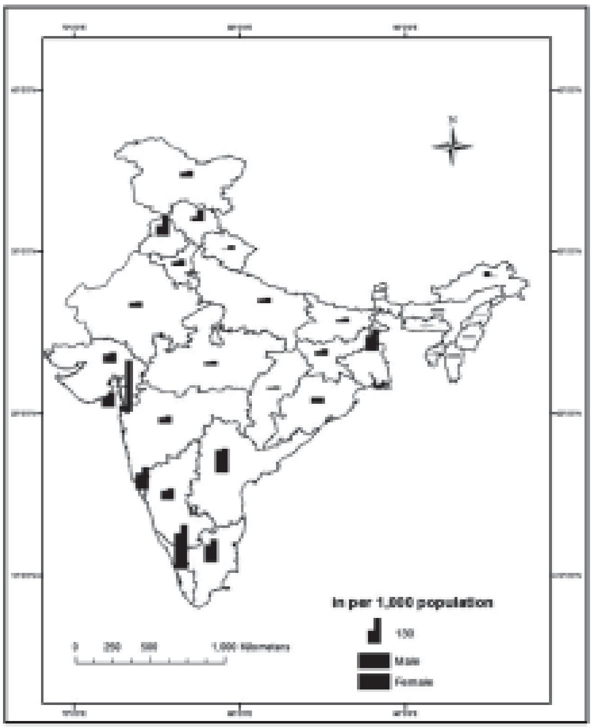
Social Indicators	*Chronic Disease*	*Percentage (n=18,779)*
Sex	Male	42
	Female	55
	Total	48
Age	0-14	6
	15-29	12
	30-49	50
	50-59	123
	60 & above	237
Social Groups	Scheduled Tribes	20
	Scheduled Castes	40
	Other Backward Classes	48
	Others	64
Quintiles	First Quintile	38
	Second Quintile	46
	Third Quintile	46
	Fourth Quintile	60
	Fifth Quintile	69
Sector	Rural	40
	Urban	67
Nature of Disease (for per 1,00000 Population)	Infections	2092
	Cancer	208
	Blood Disease	126
	Endocrine, Metabolic, Nutritional	112
	Psychiatric & Neurological	527
	Eye	334
	Ear	47
	Cardiovascular	596
	Respiratory	423
	Gastrointestinal	989
	Skin	98
	Musculoskeletal	426
	Genitourinary	616
	Obstetric	291
	Injuries	93112

Source: Calculated from NSS 71th Round Unit Level Data.

1000 population) followed by Other Backward Castes (48), Scheduled Castes (40) and Tribes (12). According to quintile classes, the reporting of the chronic diseases is the highest in the upper quintile followed by medium and lower quintile classes.

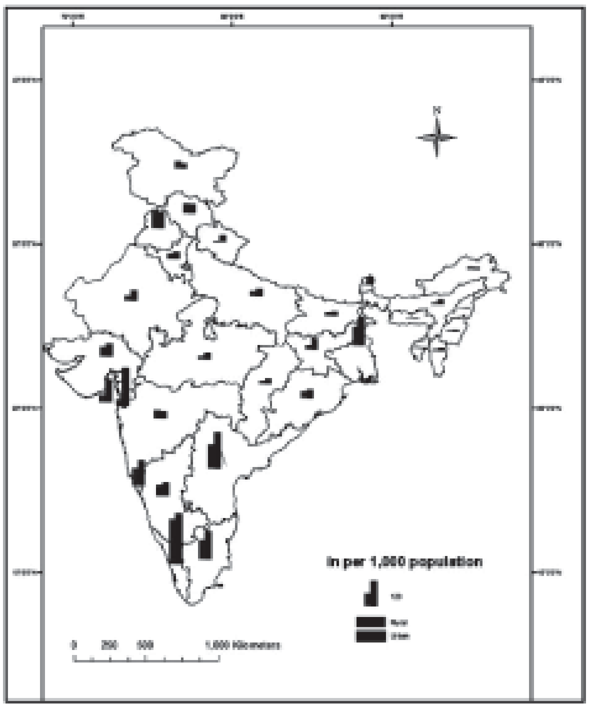
NATURE OF CHRONIC DISEASES

The nature of chronic diseases shows that the proportion of injuries is the highest among the other chronic diseases. Out of per 1, 00000 people 9, 3112 were reported chronic diseases because of long-term disabilities. After injuries, the second most prevalent chronic illnesses is a communicable disease



Source: Calculated from NSS 71th Round Unit Level Data .

Map 3: Prevalence of Chronic Diseases by Gender in India, 2014



Source: Calculated from NSS 71th Round Unit Level Data .

Map 4: Prevalence of Chronic Diseases by Sectors

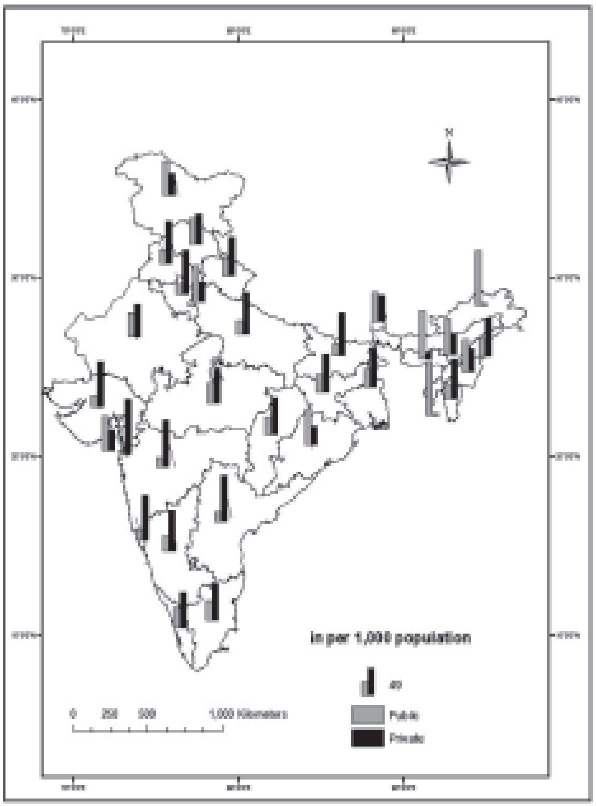
(infections) such as HIV/ AIDS, Tuberculosis, Measles, Sexually Transmitted Diseases. In a case of non-communicable disease, gastrointestinal (989), genitourinary (616), Cardiovascular (596), Psychiatric & Neurological (527), Musculoskeletal (426) diseases are most widespread diseases in the country.

HEALTH SEEKING BEHAVIOUR

The health seeking behaviour among the patients of the chronic diseases shows that most of the patients utilise private health care facilities rather than a public one. The patients have reported various reasons for not utilising government health care facilities. Nearly 46% patient of chronic diseases stated that they did not avail government facilities because available facilities in the government hospitals were not satisfactory. Around 37% patient stated that they did not take treatment because of financial constraints while 26 % of them reported that the quality of the government health care facilities was satisfactory but involves long waiting. Around 11% patient stated that required specific facilities were not available in the government hospitals, while 9% reported that the qualities of government facilities were satisfactory, but the facility is too far. The state-wise analysis shows a mixed pattern for not utilising government health care facilities. The persons of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Bihar, Sikkim, West Bengal, Meghalaya, Assam, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Tamil Nadu reported that the non-satisfactory government health care facilities were main reasons for not accessing it. The persons of Delhi, Arunachal Pradesh, Mizoram, Tripura, Goa, Kerala stated the main difficulties in the government health cares were long waiting. Most of the people of Manipur reported behind not availing government health care facilities were the unavailability of required specific medical facilities

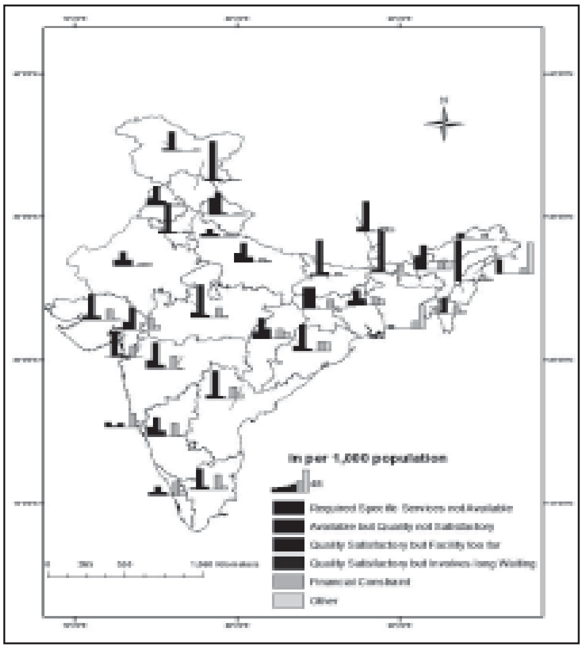
CONCLUSIONS

A mixed pattern of chronic diseases emerges across the Indian states, for instance, in the south; the reporting of the chronic diseases is the highest in Kerala, Andhra Pradesh, Tamil Nadu and Goa except for Karnataka. The demographic characteristics of the individual have an impact on the rate of prevalence of chronic diseases. The result shows that it appears higher among the females than the males, and the similar pattern appears in other Indian states except for Arunachal Pradesh where a large number of males reported chronic morbidity than the females. The association between prevalence of chronic diseases and age of the patient shows the positive relationship. The reporting of the chronic diseases is more in the urban areas than the countryside. The occurrence of the chronic diseases is the highest among other social



Source: Calculated from NSS 71th Round Unit Level Data

Map 5: Utilisation of Health Care Facilities by Chronic Diseases Patient in India, 2014



Source: Calculated from NSS 71th Round Unit Level Data

Map 6: Reasons for not utilising Public Health Care Facilities by Patient of Chronic Diseases in India, 2014

groups followed by other backwards castes, scheduled castes and tribes. By quintile classes, it is greater among the upper quintile classes compared to the lower quintile classes. The nature of chronic diseases shows that injuries led disabilities are a single most cause of chronic diseases in India followed by the infectious diseases such as Tuberculosis, HIV/AIDS. Further, Gastro-Intestinal and Genitourinary, Cardiovascular Disease, Musculoskeletal, Cancer are leading causes of chronic diseases in India.

The health seeking behaviour among the patients reveals that they more dependent on private healthcare facilities for the treatment than the public one. The main reasons for less utilisation of the public health care facilities are non-satisfactory public health care facilities followed by financial constraints and long waiting in the government hospitals. Here, it is clear that the government medical facilities are not adequate for the tackling chronic disease in India. Thus, the dependency of private healthcare facilities is increasing day by day. However, a country like India, where poverty and inequalities in every sphere of life are protuberant in such conditions needs to deliver a satisfactory quality of health care service at an affordable price in the government hospitals. Further, the extension of universal health coverage among the poor is a dire need of the time, so that every citizen of the country, irrespective of their locations, incomes, gender and castes, can lead a healthy and a long life with equity.

REFERENCES

1. Reddy KS, Shah B, and Varghese C, Ramadoss (2005): "A: Responding to the Threat of Chronic Diseases in India", *Lancet*, Vol. 366, Issue 9498, pp.1744–1749.

2. "Living Arrangements and Treatment Seeking Behaviour of the Elderly from Different Economic Segments in India", *Middle East Journal of Age and Ageing*, Vol.9, Issue 2, March-April, 2012: pp. 13-18.

3. Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K (2007), "The Burden and Costs of Chronic Diseases in Low-income and Middle-income Countries" Lancet, Vol. 370, Issue 9590, pp. 1929–1938. [PubMed: 18063029].

4. World Health Organisation, Non-communicable Disease 2015 .

PATTERNS OF LAND USE IN AND AROUND KOLKATA CITY: A SPATIO - TEMPORAL ANALYSIS

Sushobhan MAJUMDAR[1] & Lakshmi SIVARAMAKRISHNAN[2]

ABSTRACT

Urbanization refers to the increase in the proportion of people living in urban areas and it leads to the urban expansion. Urban expansion is the indications of urbanization and it greatly affects socio-economic growth and the decision making process for urban development policies. Therefore analyzing the patterns of land use change is an essential issue and it is needed for land use planning and future land management. Kolkata is one of the major metropolitan cities in India. The percentage of land use change in the 'City of Joy' is less in city core areas and it is much high in city peripheral areas. The physical expansion of the city grew linearly in south-easterly and south-westerly direction beside the eastern side of the river Hooghly as we have seen in the recent satellite imageries. Kolkata Metropolitan Area (KMA) is spread over 1875.04 Sq.km (Kolkata Metropolitan Development Authority, 2006). To analyse the expansion of the Kolkata city Remote Sensing and Geographical Information System (GIS) tool has been applied because it is very useful tool for analyzing land use changes on spatio- temporal scale.

The main purpose of this paper is to analyze the spatial expansion of Kolkata city and to study the growth rate in the municipalities around Kolkata city within Kolkata Metropolitan Area. Side by side an effort has been done to find out the spatial patterns of land use change and vegetation cover change and lastly to identify the patterns of recent land use change within Kolkata Metropolitan Area (KMA).

Keyword(s)*: Urban Expansion, Spatio-temporal Scale, Land use change, Vegetation cover change, Land management.*

INTRODUCTION

Land use and land cover are used to analyse the geographical features on land. Land use is a series of activities on land carried out by man with an intension to obtain product or benefit through the use of land (Nayak, 2014). According to Mc Cloy, (1995) land use describes the use to which the land is put, while land cover describes the surface characteristics. The spatial patterns and dynamic mechanisms of urban land use growth in the western industrialized countries have been well explored and documented in multi-disciplinary schools such as human ecology, spatial economics, social behaviour and political economies (Liu et al.,2001)

Land use expansion is mainly driven by population growth, social and economic development. It has always been the focus of academic research as well as social and economic debates because land use growth entails high profitability and risk in economic aspect, huge consumption of cultivated land with serious negative externalities on environmental sustainability (Bourne, 1996; Fischel, 1982; Peiser, 1989). Land use and land cover change is a consequence of human interference which aimed at satisfying human needs, either material or spiritual or both from the complex of natural and artificial resource (Vink, 1975)

STUDY AREA

Kolkata is one of the major metropolitan city in India. The rate of land use change in the 'City of Joy' is less in city core areas and high in city peripheral areas. The physical expansion of the city grew linearly in south-easterly and south-westerly direction beside the eastern side of the river Hooghly as we have seen in the recent satellite imageries .The concept of Calcutta Metropolitan Area is introduced by the Town and Country Planning Act of 1979 when its area was nearly 1300 sq.km. According to the 2011 census data, the total population of Kolkata Metropolitan Area is 14,112,536. It is under the control of KMDA (Kolkata Metropolitan Development Authority) which is established in 1970 under presidential ordinance and later sanctified under the KMDA Act of 1972.It is mainly a developmental agency with the purpose of carrying out major infrastructure development within KMA. After the journey of nearly 43 years of KMDA has still the authorization for urban planning and development within Kolkata Metropolitan Area.

The KMA extends from Kalyani to Budge Budge in the east bank and from Bansberia (Fig. 1) to Uluberia in the west bank of river Hooghly. It covers an area of 1875.04 km² (KMDA, 2006) that includes three municipal corporations, 38 municipalities, 70 non municipal urban units, 14 out growths, 422 rural areas (KMDA, 2005). It covers six districts of West Bengal i.e. South 24 Parganas, North 24 Parganas, Kolkata, Howrah, Hooghly and Nadia. KMA is one of the biggest urban agglomerations in India. It is located

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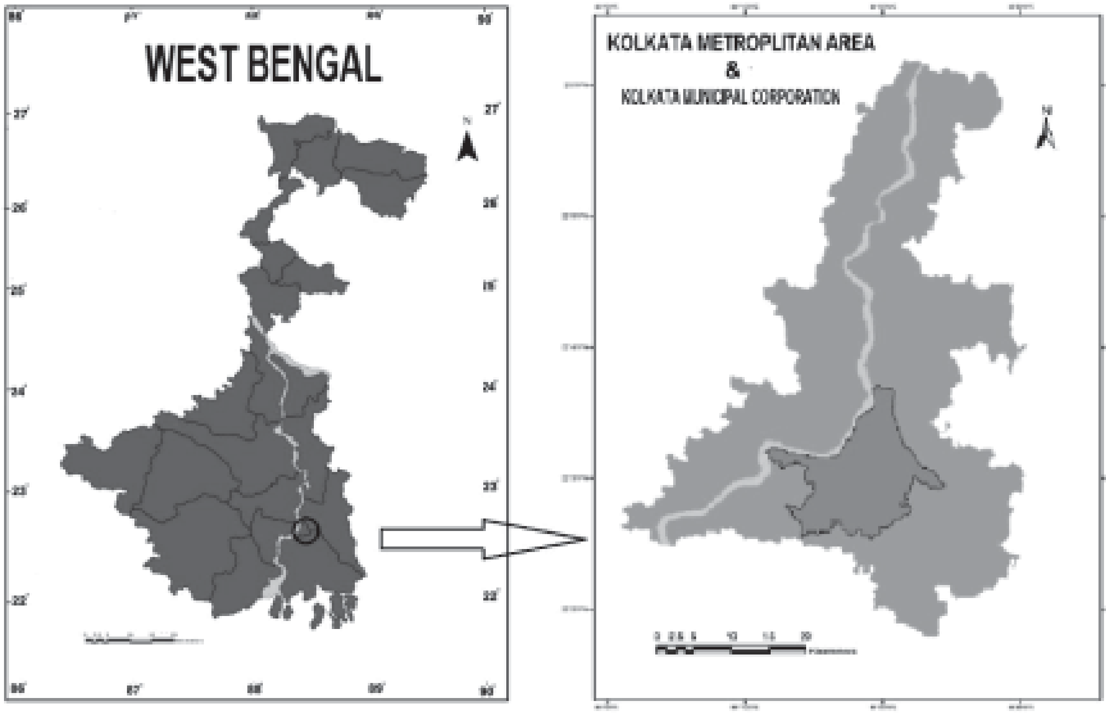

Fig. 1 : The Study Area

in the eastern India at 22. 34⁰N, 88. 20⁰E beside the Ganges River at an elevation ranging from 1.5 to 9 m (SRTM image, NASA, Feb 2000).

OBJECTIVES

The main objectives of the study area

- To analyse the growth rate of Kolkata city and its surrounding area within the Kolkata Metropolitan Area.
- To assess the land use and land cover changes around Kolkata city in recent years. (2010, 2015)
- To find out the nature of present vegetative cover in and around Kolkata City.
- To analyze the changes in the land use pattern of Kolkata Metropolitan Area between year 2010-2015.

DATABASE AND METHODOLOGY

In this study demographic related data from two census year i.e. 2001 and 2011 has been collected. In addition to this Landsat satellite images i.e. (Landsat 5 TM image of 21th January, 2010 and Landsat 8 image of 8th march of 2015) were acquired for evaluating the temporal and spatial characteristics of urban expansion from 2010 to 2015.To show the city expansion supervised classification of two consecutive years has been used as described in (Fig. 2). To analyse the nature of vegetation cover NDVI (Normalized Difference Vegetation Index) has been used. All the remote sensing techniques have been done using Erdas Imagine 9.2 software. To analyze the growth rate of Kolkata Metropolitan Area within the municipalities different statistical techniques has been used.

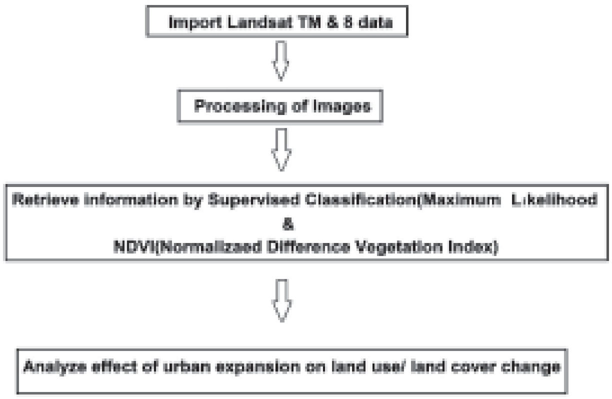

Fig. 2 : Flow Chart for Analyzing Urban Expansion

DISCUSSION AND ANALYSIS

Growth of Kolkata

Kolkata, formerly Calcutta is the Capital city of West Bengal. Its origin dates back to 1690 when a factory was set by the Job Charnock for the East India Company and is believed that he was the Founder of Calcutta City. Between the year 1773-1911, Calcutta was the major trade centre of East India Company and also the Capital of India. After the Independence huge number of refugees from Bangladesh, formerly 'East Pakistan' came to Kolkata which is the major cause of huge population increase in Kolkata city. Kolkata city is situated on the east bank of the river

Hooghly (Hugli) on the lower Gangetic delta which is part of the Bengal basin. It stands on a thick alluvial deposit of the great antiquity. Geologists agree that Kolkata is a part of submerged sundry trees found beneath the city (Nair 1986).

The cancerous growth of Calcutta as a primate city which is rounded by a backward agricultural hinterland and it is supported by any hierarchical structure of urban centre has become a subject matter of study of politicians; planners and social scientists in India and drawn the attention of urban researchers throughout the world. (Munsi, 1975).

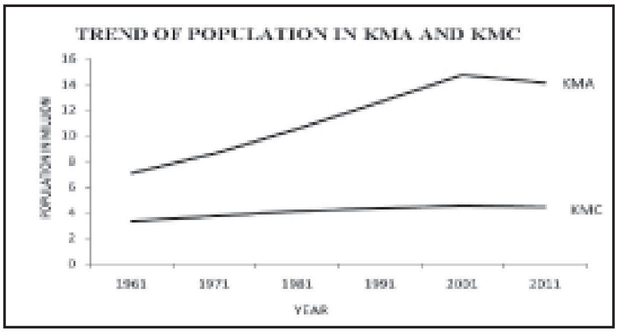

Fig. 3: Population Growth in Kolkata Metropolitan Area and Kolkata Municipal Corporation

The flow of migration from the other states of India and from the other regions of West Bengal to Kolkata now-a-days is increasing due to the concentrated development in business outsourcing, information technology enabled services, medical transcription etc in the city core areas. Other than that the commuters from different districts near and around Kolkata city used to come to city for their daily work.

Demographic Growth

The urban expansion is driven by the increase of population from 1991 to 2011 and it results into residential land *expansion from the city towards fringe areas.* The growth rate of population (Fig. 4) in Kolkata Metropolitan Area in recent decades is very high which creates extreme pressure on land resources. Over the last 20 years of time, the process of urban growth or urban population concentration in Kolkata Metropolitan Area experiences high growth. For e.g. different municipalities like Bhadreswar, Rajpur-Sonarpur, Bidhannagar, Barasat, Madhyamgram, Kalyani, Naihati and Kanchrapara experience high growth rate from the year 1991-2001 which is also higher than the state average population growth rate. But in case of the year from 2001-2011 Maheshtala, Budge Budge, Bidhannagar, Rajarhat Gopalpur, Madhyamgram, Barasat, Kalyani and Gayeshpur Municiplaity experiences high growth rate. It clearly indicates the growth is towards city fringe areas. This growth rate is relatively high in south western and north eastern Kolkata in the recent decades. As a result large percentage of non-built up areas are converted into residential areas.

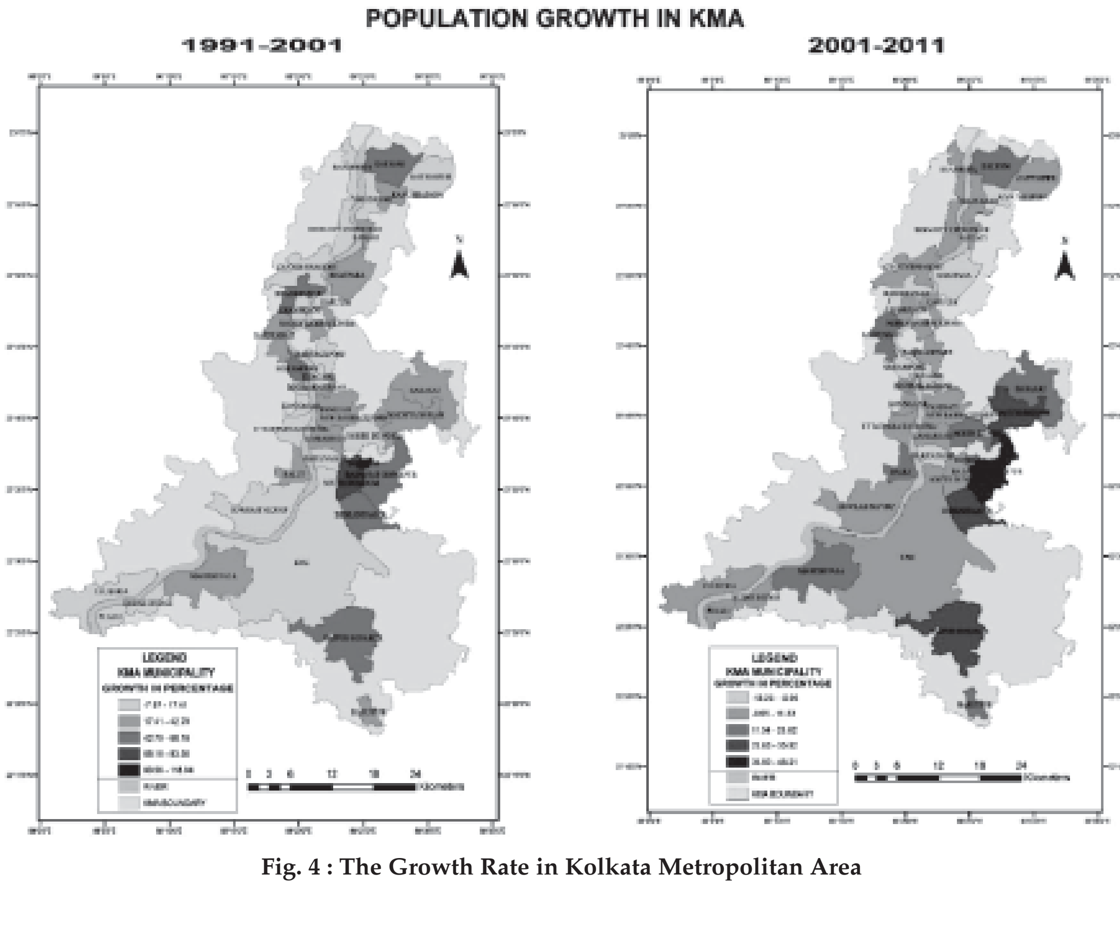

Fig. 4 : The Growth Rate in Kolkata Metropolitan Area

Due to lack of open spaces and high land prices in the city core areas the people are unable to purchase land to their desirable prices. So they moved towards metropolitan areas or suburbs for the better standard of living. As a result the population density of those areas are increasing day by day (Figure: 5). This expansion of city mainly towards semi-urban areas because of a 'city centrifugal forces' that is forced by lack of open spaces in city core areas. These forces are extremely active from city towards non urban areas. It develops many urban centers in the city fringe areas. Some of these urban centers are very well developed for e.g. Eden city, Hiland-Greens in Maheshtala region and Rajawada Lakebliss, Southwinds in Sonarpur region etc.

Land Use and Land Cover Change

Supervised classification is the most common method to show the Spatio-temporal change of land use and land cover. From the classified images of 2010 (Figure: 6) it has seen that percentage of built up area is high in city core areas. Only 28.96% (Table: 2) or 217.39 sq.mile (Table: 1) of the total area is under vegetation cover and 5.22% or 39.21 sq.mile of the total area is under wet land. But most striking land use feature in the year 2010 in and around Kolkata city is nearly half i.e. 45.33% of the total land are under the built up area or residential area. It is followed by the agricultural area which is 20.46%. The percentage of agricultural land and wetland are relatively high in city fringe areas because vegetables and fishes from

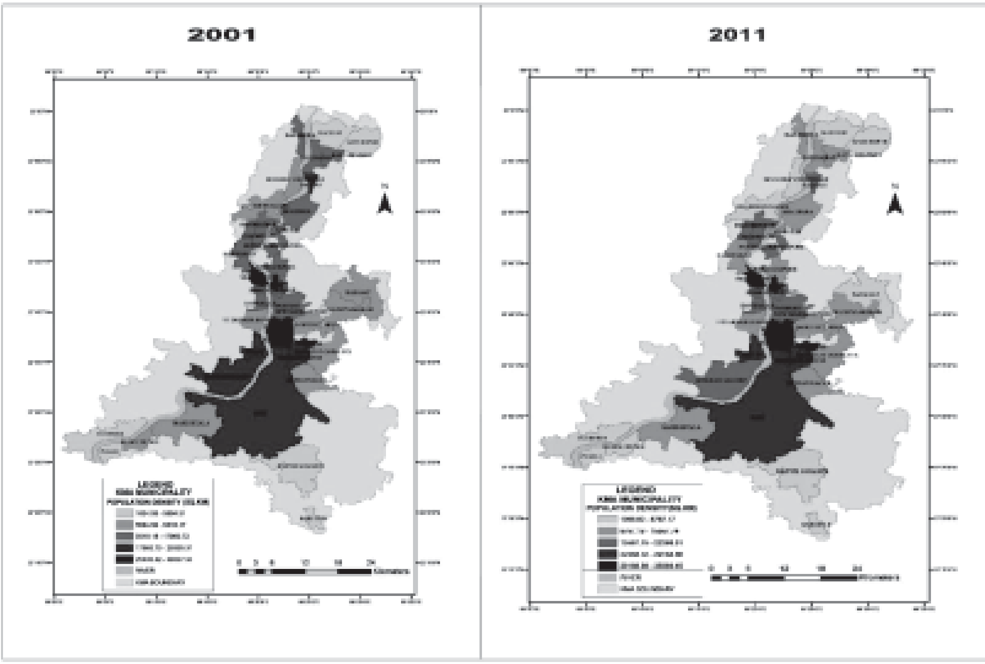

Fig. 5 : Population Densities in KMA

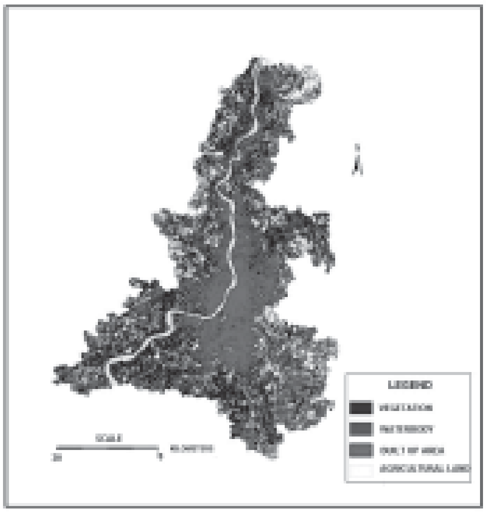

Fig. 6 : Land Use and Land Cover Classification in 2010.

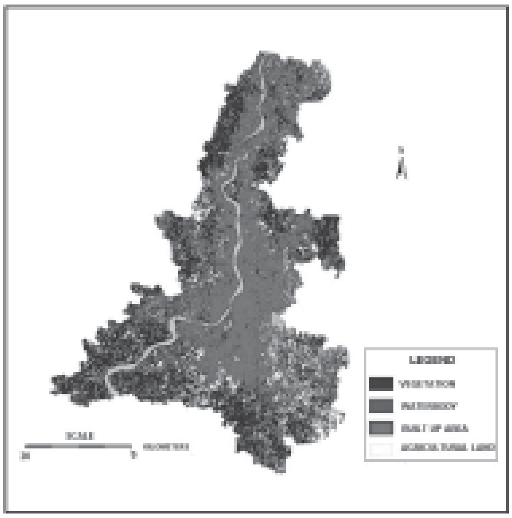

Fig. 7 : Land Use and Land Cover Classification in 2015.

those areas used to come to city for the basic needs of city people and those regions acts as a storehouse of vegetables of Kolkata city

Table: 1
Land Use Features in and Around Kolkata City

Features Name	*Area in Sq miles*	
	2010	*2015*
Vegetation	217.39	191.21
Water body	39.21	38.84
Built up Area	340.24	414.47
Agricultural Area	153.61	105.91

Source: Computed by the Authors.

But from the classified images of 2015 (Fig. 7) it has been seen that the percentage of vegetation cover was reduced by nearly 3% i.e.25.48% within five years span of time. The main reason for the reduction of water body are because of residential expansion in city suburbs which is mainly driven by promoters who are uses those wet land for new construction or for real estate development. For *e.g.* beside the Barrackpore-Kalyani expressway large percentage of wetland are converted into settlement area. But the percentage of built up area has increased up to 9.90% i.e. 55.23% which is greater than half of the area. For the expansion of the built up area, agricultural area has also reduced up to 6%. These type of conversion (i.e. from agriculture to built up area) is much high in Barasat, Bansberia, Gayeshpur, Pujali, Maheshtala municipal area as we have seen in the classification of satellite imageries.

Table: 2
Percentage of Land Conversion

Features Name	*Areas in Percentage*		*Change in Percentage*
	2010	*2015*	*2010-2015*
Vegetation	28.96	25.48	3.48
Water body	5.22	5.17	0.04
Built up Area	45.33	55.23	-9.81
Agricultural Area	20.46	14.11	6.35

Source: Computed by the Authors.

The primary feature of land cover change of this area is that large areas of agricultural land and wet land are occupied by urban construction.

Vegetation Cover Analysis using NDVI

NDVI was used as an index of vegetation abundance. This index is related to biomass, chlorophyll content and water stress. The lowest values are found on less vegetative soils because reflection from the soil is high and produces low values in the infrared band and high values in the red band. High NDVI value indicates high vegetation cover. It was calculated by using:

NDVI=TM Band4- TM Band3/TM Band4+TM Band3

Water body are dark toned in both the images. In case of images in 2015 low NDVI values (Fig. 8) are concentrated in north and central Kolkata areas (Table 3). Other areas except these two experience high NDVI values which are always increasing towards city fringe areas.

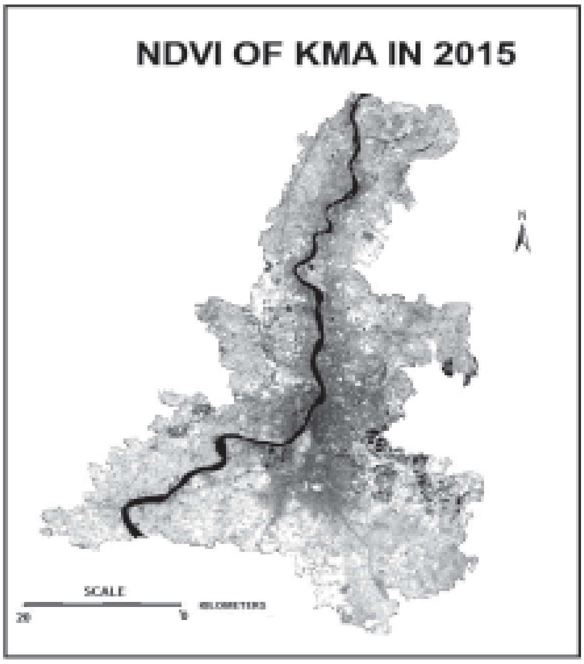

Fig. 8 : NDVI Classification

Table: 3
NDVI values in the images of 2015

Value	*Indicate*	*Places*
0.31 to 0.45	Moderate vegetation	Mainly Western and southern part of KMA
0.30 to 0.15	Stressed vegetation	In East Kolkata wetlands
0 to 0.14	Bare rock or soil	Central Kolkata and Northern Kolkata

Source: Computed by the Authors.

CONCLUSION

Kolkata has been developing fast in recent decades because of high employment opportunity, good health infrastructure etc. e.g. in Kolkata city Bidhannagar (Sector-V) experiences large scale development because of the concentration of IT Industries and technological development. Continuous increase of population and housing demands accelerated the real estate development on the outskirts of Kolkata city basically in south-western Kolkata (e.g Maheshtala, Pujali region). It leads to the conversion of farmland and wetland into the residential area. As a result large scale construction or major real estate projects has been taken place in the city fringe areas. These type of major constructions resulted into land use change.

From the above analysis of land use and land cover change in Kolkata during the past twenty years, it can be found that built up area or residential area are increased a lot while agricultural land or non-built up areas reduced very rapidly. The reason for this change is lack of open space in the city core areas which influenced people to move to less urbanized areas. In recent years Maheshtala, Pujali, Madhyamgram, Rajarhat Gopalpur, Baidyabati, Bally and Kalyani municipality experiences high growth rate. But more minutely observation it can be found that in recent decades there are a tendency of people are to live in those places which are nearer to city. This tendency indicates us that connectivity is one of the major criteria of the local people to choice their residents.

REFERENCES

1. Bourne, L. S., (1996). Reurbanization, Uneven urban development and the Debate on New Urban Forms. *Urban geography*. Vol. 7(8): 690-713.
2. Calcutta Metropolitan Development Authority. (1976). Development Perspective and Investment Plan- 1976-80, Report No.28.
3. Chaudhuri, S. (1990). Calcutta- The Living City (Volume I and II), Oxford, Calcutta.
4. Cloy, M.C., & Keith R., (1995). Resource Management Information System: Process and Practice. *Taylor and Francis*.
5. Fischel. W. A. (1982). The urbanization of Agricultural Land: A review of the National Agricultural Lands Study. *Land Economics*. Vol. 5(8): 236-259
6. Kolkata Metropolitan Development Authority. (2010). Annual Report, 2009-2010, KMDA Kolkata.
7. Kolkata Metropolitan Planning Committee. (2005). The Vision Plan for Kolkata Metropolitan Area (Draft)- 2005-2025.
8. Liu. S., Wu. C., & Chen. T., (2001). A Critical Review on the Progress of Urban Land Use Theories in the West. *Geographical Research*. Vol. 20(1): 111-119.
9. Munsi, S.K. (1975). Calcutta Metropolitan Explosion: Its nature and roots. *People's Publishing House.*
10. Nair, P.T. (1989). Calcutta in the 19^{th} century. *Firma KLM,* Calcutta.
11. Nayak, L.T., (2014). Trend of Land Use and Land Cover Change in Bellary District, Karnataka Using Geo-spatial Technique. Vol.76: 236-257.
12. Peiser. R. (1989). Density and Urban Sprawl. *Land Economics*. Vol. 65: 193-194.
13. Seto. K. C., Woodcock. C. E., Song. C., Huang. X., Lu. J., & Kaufmann. R. K. (2002). Monitoring Land-use Change in the Pearl River Delta Using Landsat TM. *International. Journal of Remote Sensing*. Vol. 23(10): 1985–2004.
14. Shenghe. L., Prieler. S., & Xiubin. L. (2002). Spatial Patterns of Urban Land Use Growth in Beijing, *Journal of Geographical Sciences. Vol.* 12(3):266-274
15. Vink, A.P.A. (1975). Land Use in Advancing Agriculture, *Springer-Verlag.*

MAPPING OF URBAN EXPANSION AND POPULATION GROWTH IN ROHTAK CITY, HARYANA

Sushil DALAL[1] & ARCHNA[2]

ABSTRACT

Though India's population is increasing at a fast rate, it is not equally distributed over the geographical space. The spatial pattern of population growth varies in rural and urban areas. This growth is skewed more in the urban areas as compared to rural areas, resulting in the creation of high population pressure in urban areas. As a consequence, people from the urban centres tend to reside/settle in the outer/fringe areas. The present paper is a modest attempt to study urban expansion viz-a-viz spatial sprawl and population growth of Rohtak City. An effort has been made to find out the land use and land cover of urban space by using the remote sensing data and geographic information system techniques. It has been observed that despite the proximity of national capital, the population growth in the city is not very high. With a passage of time, the geographical limit of the city has expanded from about ten square kilometers to more than hundred square kilometers by merging eight hinterland villages in the city with the formation of Municipal Corporation in 2010.

Keywords: *Geographic Information System (GIS), Land Use, Population Growth, Remote Sensing, Urban Sprawl.*

INTRODUCTION

Human population in the world is increasing at a fast rate. India is also experiencing high growth rate of population. Before independence, the growth of population was comparatively low because of equally high death rate. But after independence, although death rate has declined at a fast rate due to development of medical and other facilities, birth rate still stands at high level. Hence, the trend of population growth is quite fast till 1981. It is also pertinent to note that the distribution and growth of population is not equal over all geographical spaces.

The urban areas indicate high rate of population growth than rural areas. The states in south India have high level of urbanization as compared to the northern areas (Ramachandran, 1989). The spatial pattern of population growth and level of urbanization in the country has been widely examined by various scholars. The southern region of India indicates low growth rates in comparison to north. It may be due to the declining birth rates and migration in the southern states of the country (Hassan, 2005). The patterns of urbanization are different among towns of different sizes. The class I cities show high growth rates than the lower order town and rural settlements. The population in large sized cities is growing at a rapid rate whereas stagnation or declining trend is observed in small towns (Wishwakarma et al, 1985).

Migration is one of the major reasons of the population growth in urban areas. People tend to migrate from rural areas to urban centers for different reasons, particularly for economic and occupational opportunities. As these urban areas have higher job opportunities in organized and unorganized sectors, occupation becomes the most important factor of migration to the urban centers. In-migration of workers is one of major reasons of tremendous pressure on large cities. As a result, people start residing in the unplanned and unauthorized hinterlands or fringe areas of urban centres in a haphazard manner particularly along the road sides. This spread of residential and commercial area in the peripheral region of the town is termed as 'urban sprawl'. It means spreading of an urban area in the peripheral region. The spread of these residential and commercial activities put pressure on the resources such as civic and infrastructure facilities of the town. The expansion of geographic space in the outer area of the city regions changes the land use and land cover of the region with the increase of built up area for residence (Sudhira et al, 2003).

The concept of 'urban sprawl' attracted attention of scholars in the west particularly after the World War II when the 'suburban boom' took place for the purpose of speedy development. The expansion of geographic space in the outer area of the city regions with scattered new development resulted into high demand of civic and infrastructure facilities and other resources. It is characterized by unplanned growth of residential and commercial development on isolated tracts on the cost of loss of agricultural land and open space.

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ROHTAK THROUGH AGES

Rohtak urban area has been selected for the present analysis which is situated 70 kilometers west of the National Capital Region (NCR) of Delhi. The center government gave emphasis on the growth of satellite towns in NCR area to release population pressure from national capital. Hence, this urban area has been selected to find out the population growth and sprawl of the city. Chronologically, the city has a long and glorious history. The available records indicate that it has been mentioned as "Rohitika" in the Mahabharta and "Rohtasgarh" in Puranic literature . Some scholars believe that the word has derived from "Roherra Tree" which was abundantly available here.

It was a capital city during the Yaudhyas period. During the medieval period, it achieved great importance due to its being located on the "Uttarapatha" trade route. In 12th century, the town was controlled by Prithviraj III who built a fort here. Although Mohammad Gori destroyed the town, Kutub-ud-din Aibek renovated the fort for establishment of a garrison camp in the city. Babar, under the leadership of Feroz Khan, also garrisoned a military camp in the city. But after the death of Feroz Khan in 1527 AD, many Nawabs and representatives of Kings ruled over the city till 1803 when the British usurped the area and kept it under their control.

During the British regime, it emerged as a province in 1824 which was abolished in 1841 and was reestablished again in the following year. The town 'Rohtak' was first constituted as municipality in 1867. In the later years, under Punjab Municipal Act of 1884, the municipal committee was constituted in it. The town is situated on 28° 54' north latitude and 76° 35' east longitude. In 2010, the city got the status of Municipal Corporation with an expansion of an area more than hundred square kilometers which included eight villages viz. Sunari Kalan, Sunari Khurd, Kanehli, Majra, Kheri Sadh, Bohar, Asthal Bohar and Garhi Bohar in its geographical limits.

OBJECTIVES

The present paper is a modest attempt to study population growth and spatial expansion of Rohtak City. An effort has also been made to find out the land use and land cover of urban area by using remote sensing data and geographic information system techniques. The following objectives have been considered for the present study:

1. To analyse population growth in the municipal area of the town.
2. To find out spatial growth of the town.
3. To identify land use and land cover of the study area.

DATA BASE AND METHODOLOGY

The present study is mainly based on secondary sources of information. The data on population has been collected from census of different decades. The information regarding the genesis and development of the city has been taken from various gazetteers and resettlement reports. To achieve the objectives, the topographical sheets and the administrative maps have been used to find out the area of the city. The city boundary has been digitized by geographical information system (GIS) software. The images of remote sensing data with one meter resolution have been used to find out the land use and land cover in the city. To identify the spatial expansion and temporal change, the various layers of data have been superimposed with the help of GIS technique.

The visual interpretation technique is applied to find out the growth of population and expansion of geographical area of the city. The simple statistical technique is applied to find out the change in growth of population with expansion of geographical area of the city. The urban spatial expansion has been examined by using Remote Sensing and GIS techniques.

RESULTS AND DISCUSSION

The city came into existence as municipality in 1867 and formed municipal committee in 1885 under Punjab Municipal Act of 1884, having a population of nearly sixteen thousand which was mainly concentrated within the walled area of the city. Table 1 indicates that the population in the study area has grown continuously since 1881 except 1901-1911 decade. The first decade of the 20th century (1901-1911) experienced lowest increase ever due to outbreak and spread of epidemic such as malaria and plague diseases in the region.

During 1891-1901, the growth has been observed at a rate of more than 21 percent. This increase is due to expansion of municipal limit in 1897 and construction of railway station in 1896. The highest growth has been observed during 1941-1951 decade. The settlement of refugee families from Pakistan in 1947 was the main reason for this steep increase in population of Rohtak. During that time, the town had an area of about ten square kilometers. During 1951-61 decade, the population declined drastically because of definitional change in urban area in 1961 wherein some adjacent settlements were not counted under the city population. It is interesting to note that the decade 1951-61 indicates a slower growth rate due to natural calamity which occurred in 1960 and the people temporarily out-migrated from the city and were not enumerated in the city (Sharma:1985). The census decade 1961-71 shows highest growth of population. After 1981, a continuous marginal increase in population growth has been observed in the city.

Table 1
Population Growth in Rohtak Municipal Area

S. No.	*Census Year*	*Population*	*Growth Rate*
1.	1881	15699	-
2.	1891	16702	6.39
3.	1901	20323	21.68
4.	1911	20361	0.19
5.	1921	25240	23.96
6.	1931	35235	39.60
7.	1941	48148	36.65
8.	1951	71902	49.34
9.	1961	88193	22.66
10.	1971	124755	41.46
11.	1981	166767	33.68
12.	1991	216096	29.58
13.	2001	286773	32.71
14.	2011	373133	30.11

Source: Census of India & Rohtak District Gazetteers

The population growth of Rohtak City can be analyzed in three phases viz. before independence; between 1947 to 1966 till the formation of Haryana State; and after the formation of the state. A wide fluctuation in population growth has been noticed in the city before independence. At the time of independence, a large number of refugee people from West Pakistan opted to settle in the city. During the third phase, the population of the city grows steadily.

SPATIAL PATTERN OF URBAN EXPANSION AND SPRAWL OF ROHTAK CITY

The urban geographical limits of the urban area changed over time. The urban expansion and sprawl changed the land use and land cover of the area. It further affected the land use of agricultural land and open fields of the hinterland/outer fringe into industrial and residential purposes. Migration for socio-economic purposes towards urban centres is seen as the main cause of urban sprawl. It is characterized by unplanned, unorganized and uneven sectoral growth of different activities which leads to under utilization of the agricultural land, open fields and other resources in the region. The spatial and temporal changes in land use and land cover in the hinterland zones of the suburb area provide information to the urban planners for making balanced and sustainable development policy of the area.

The geographical limit of the Rohtak Municipality has been changed since 1885. At the time of formation of Haryana State, the city had 11.66 square kilometer area. After 1966, the area of Rohtak municipal boundary has increased to more than 22 square kilometers during 1971-81; 28 kilometer square during 1981-91; 30 kilometer square during 1991-2001; and 100 kilometer square during 2001-11 (Table 2). During the decade of 2001-11, the boundary has been expended many times (in 2004, 2007 and 2010). In 2010, it achieved the status of a Municipal Corporation.

Table 2
Growth in Area of Rohtak City, 1961-2011

S.. No	*Years*	*Area in km²*	*Growth in Area (in percent)*
1.	1961	11.66	-
2.	1971	11.66	0
3.	1981	22.03	88.94
4.	1991	28.38	28.82
5.	2001	30.17	6.31
6.	2011	100.57	233.34

Source: Rohtak District Gazetteers & Government Reports

The spatio-temporal change in land use and land cover of Rohtak city has been analyzed to find out the nature and pattern of sprawl. It is pertinent to note that after 2010 the geographical limits of the city has extended to neighbouring rural hinterland and has swallowed the land of eight villages due to sprawl in these areas. Resultantly, the agricultural land of fringe area was also included in the corporation boundary. Table 3 indicates that agricultural area, plotted land, rural settlement, water bodies, recreational area and waste land have increased within the town. The percentage share of agricultural land, rural settlement, water bodies and waste land increased over the last two decades during 1991-2011 because of inclusion of rural villages in the urban area. The table indicates that there was no rural settlement in 1991 but it existed at a rate of about 3 percent of the total area in 2011. On the other side, public and semi public area and vacant land has decreased drastically and have been replaced by residential, plotted land, recreational areas and others.

The spatio-temporal expansion of the city is visualized in Fig.1. The initial growth of the town started in the walled city. During the 19th century, the growth of city was restricted to within the wall of the fort in the city. During the first half of 20th century in British period, the city had an important position being situated at a strategic location near Delhi. It was ruled by the eastern Punjab provincial government. All the economic activities from farming to trading pursuits were performed here. It is found that the area near railway station emerged as an educational hub as various institutions were developed by Vaish Education Society in 1920s. An Inter College also was established in present day Palika Bazaar and some economic activities came up near the college and

Table 3
Land Use Pattern in Rohtak City: 1981-2011

Category	1991		2011	
	Area in km²	Percent Area	Area in km²	Percent Area
Agricultural Land	9.42	33.17	44.46	44.21
Public & Semipublic Area	5.87	20.70	8.29	8.24
Residential Area	5.85	20.59	20.56	20.44
Vacant Land	3.97	13.98	3.47	3.45
Plotted Land	0.35	1.25	8.82	8.77
Rural Settlement	0.00	0.00	2.89	2.87
Transportation & communication	1.04	3.67	2.07	2.06
Water Body	0.54	1.91	2.45	2.44
Forest	0.17	0.59	0.00	0.00
Recreational Area	0.17	0.59	1.72	1.71
Wasteland	0.26	0.92	3.19	3.17
Commercial Area	0.45	1.58	0.95	0.94
Industrial Area	0.30	1.06	1.69	1.68
Total	28.38	100	100.57	100

Source: calculated by authors

Gohana Stand. The grain and vegetable markets were functioning near old bus stand area. The residential area was restricted to the mount land called Quilla Road, Bada Bazaar, Kewal Gunj and so on within the walled city.

After independence, a number of residential areas for resettled families, educational institutes and trade & commercial centres emerged. These activities attracted the population from outside and put pressure on the existing resources. The model town emerged as the residential colony for the refugee families having kuchha houses with round shaped roads. As a result, population density and congestion on roads increased. There was no proper land use zoning at the time of this haphazard growth. A new demand of bypass of NH 10 and better internal road network has been put forward by people due to the increase in population and traffic.

CONCLUSION

The high concentration and growth of human population in urban areas is one of the major causes of the spatial expansion of the urban area and changes the land use and land cover in the city region. The increase in urbanization in Rohtak made a dynamic change in of urban and its hinterland area. Being located in National Capital Region (NCR) of Delhi, the city was included in the list of main cities of NCR area and the Government of India as well as state governments gave emphasis on planned

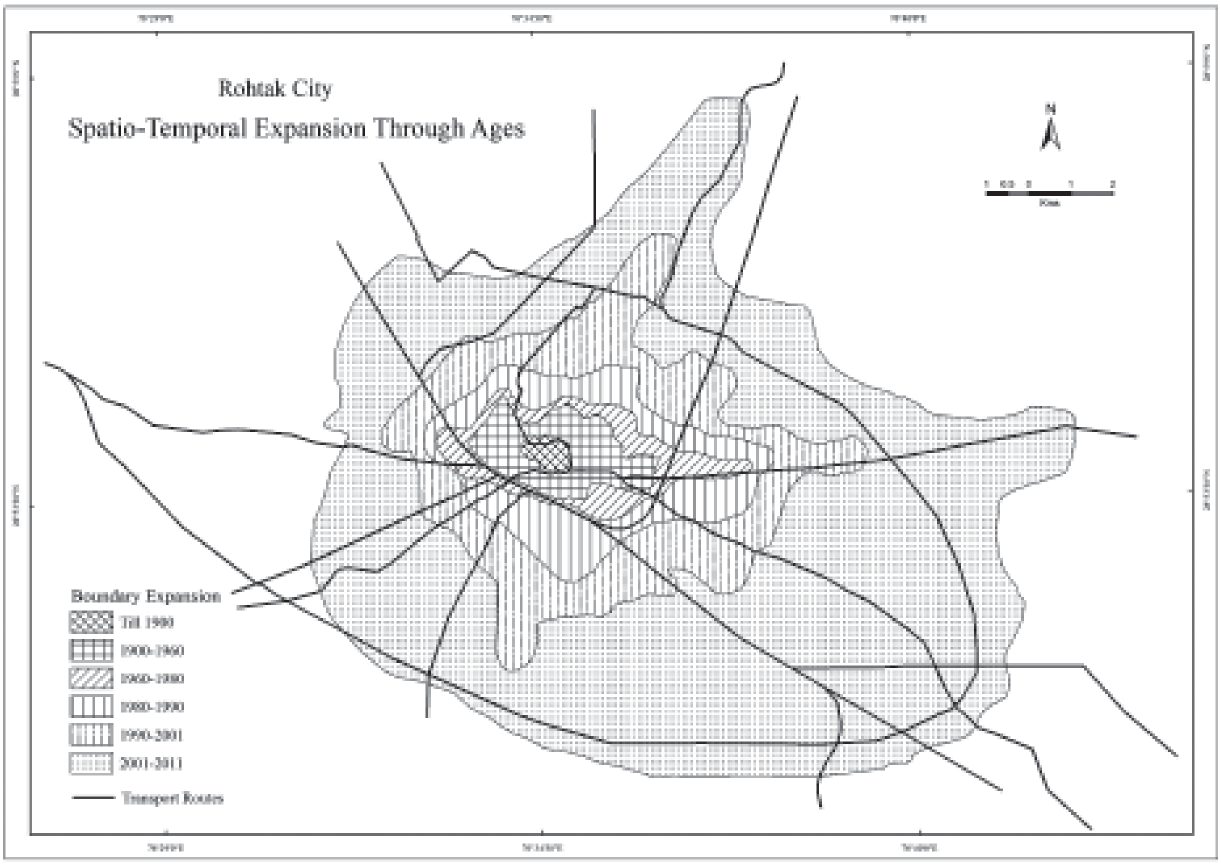

Fig. 1

development of the city. It has been assumed that the population of the city would grow at a faster rate and would be able to reduce the population pressure of the country's capital. The analysis indicated that the population growth of the city was not linear during all periods as was assumed. The highest growth has been observed during 1941-1951 decade when the refuges came to settle here in 1947. After independence, an average change in population growth has been observed in the city which may be because of out-migration to Delhi due to proximity.

The patterns of land use and land cover are observed with these changes in the city. The percentage share of agricultural land, rural settlement, water bodies and waste land increased which can be partially attributed to the reorganization of the Rohtak Municipal Corporation boundary. On the other hand, public and semi public area and vacant land have decreased drastically which are replaced by residential, plotted land, recreational activities.

The initial growth of the town started in the walled city. During the British period, the spatial expansion occurred in the southern part of the walled city i.e. near the railway station like education institutions, grain and fruit markets. After independence, the residential houses were constructed in the eastern part of the old city as refugee camps. The industrial activities started initially in the western side of the central city, but now, many industries are being established in all areas of the city centre. In nutshell, the city has witnessed large spatial expansion whereas the population has increased at a comparatively slow pace.

Acknowledgement

The authors express gratitude to Dr. Pradeep Kumar for helping in preparation of Map.

REFERENCES

1. Census of India (1981 through 2011); "Primary Census Abstract of Rohtak District," Director of Census Operations, Chandigarh.
2. Chandana R.C. (2005), A Geography of Population: Concepts, Determinants and Patterns, Kalyani Publishers, New Delhi.
3. Hassan M.I. (2005), Population Geography, Rawat Publication, Jaipur.
4. Joseph E. (1911); "Final Report of the Third Regular Settlement (1905-10) of the Rohtak District", Reprinted in 2010 by Gazetteers Organization, Revenue and Disaster Management Department, Government of Haryana, Chandigarh.
5. Premi M.K. (1991) India's Population Heading Towards a Billion: An Analysis of 1991 Census Provisional Results, B.R. Publishing Corporation, Delhi.
6. Ramachandran R. (1989), Urbanization and Urban Systems in India, Oxford University Press, Delhi.
7. Rohtak District Gazetteers (1883-84); Reprinted by Gazetteers Organization, Revenue Department, Government of Haryana, Chandigarh.
8. Rohtak District Gazetteers (1910); Reprinted by Gazetteers Organization, Revenue Department, Government of Haryana, Chandigarh.
9. Rohtak District Gazetteers (1970); Reprinted by Gazetteers Organization, Revenue Department, Government of Haryana, Chandigarh.
10. Sharma, K.D. (1985); "Urban Development in the Metropolitan Shadow: A Case Study from Haryana," Inter-India Publication, New Delhi.
11. Singh, N. and J. Kumar (2012); "Urban Growth and Its Impact on Cityscape: A Geospatial Analysis of Rohtak City, India," Journal of Geographic Information System, Vol. 4 No. 1, 2012, pp. 12-19.
12. Sudhira H. S. and T.V. Ramachandra, KS Raj & KS Jagadish (2003), 'Urban Growth Analysis using Spatial and Temporal Data, Journal of the Indian Society of Remote Sensing, Vol. 31, No. 4, pp.299-311.

SPATIAL PATTERN AND ACCESS TO HEALTH CARE SERVICES IN JORHAT DISTRICT, ASSAM

Swapnali SAIKIA[1]& Barnali GOGOI[2]

ABSTRACT

Health care service is regarded as one of the key factor for complete development of a society. In present time, there are lots of people from rural areas which have very poor access to medical facilities. In comparison to the other districts of Assam, Jorhat district holds first rank in state Human Development Index, 2003. But there are some places within the district where medical facilities are not available and even where available those are not satisfactory. Therefore, an attempt has been made in this paper to explore the spatial pattern and accessibility of health care services. The spatial units considered in this study are developmental blocks. It has been observed that among the eight development blocks of the district, the North-West and Titabar development blocks have registered highest number of primary health centre (PHC) and sub-health centres. On the other hand, Central Jorhat block has showed highest number of doctors per 10,000 populations. Access to health services has been assessed using database like health centres location and major road network layers under GIS environment. Moreover, a primary survey is also conducted in some selected villages and towns of Jorhat district in order to understand the accessibility and the people's perception towards the available health care services. It has been also observed that there are some people who have never attended a hospital and also found that children are born at home without doctors or nurses. The study is considered to be helpful in assessing spatial status of health care services and its proper development in future.

Keywords*: Health Care Services, Access to Health Services, GIS, Jorhat District.*

INTRODUCTION

The Constitution of the World Health Organisation (WHO) defines health 'as a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity *(Joe, 2010)*. 'Heath is seen as part of the basic human capabilities and an integral part of human welfare. It is an important aspect of human resource development' *(Kore, 2014)*. It also helps to pursue the various goals in life that one has reason to value (*Joe, 2010)*.

Health care service is regarded as one of the key factor for complete development of a society. 'Good health care facilities and services are essential input for creating healthy citizens and society that can effectively contribute for overall human resource development' (Kore, 2014). In present time, there are a lot of people from rural areas which have very poor access to medical facilities. Inequality in health services is apparent between rural and urban areas. Access to health service is also determined by economic and social factors in addition to the infrastructure. Recent research has witnessed ever-increasing engagement with this issue thus creating a huge body of academic literature that systematically documents socio-economic inequalities in health in varying contexts *(Joe, 2010)*.

THE STUDY AREA

The study area is Jorhat district of the State of Assam. It is bounded by Lakhimpur district on the north, Sibsagar district in the east, Golaghat district in the west, and the south is flanked by Naga Hills. The area of the district is 2,852 sq. k.m. and population is 1,091,295 (2011). The district comprises three sub-divisions, six revenue circles, and eight development blocks namely Jorhat (Baghchung), North-West

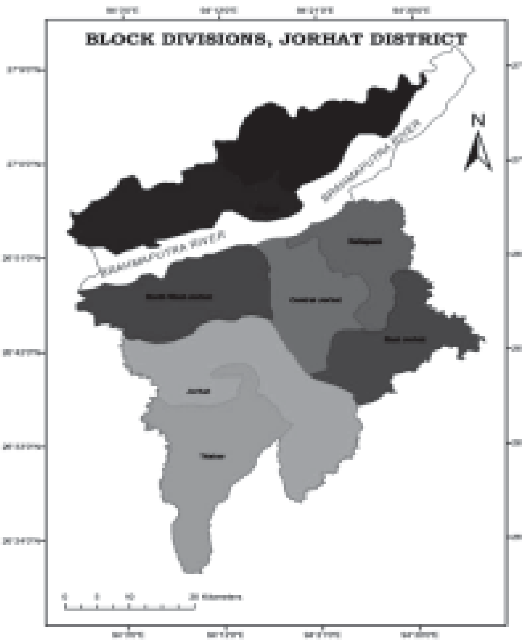

Fig 1: Study Area

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Jorhat (Dhekorgarah), Central Jorhat (Chipahikhola), Kaliapani, East Jorhat (Selenghat), Titabor, Majuli and Ujoni Majuli.

In comparison to the other districts of Assam, Jorhat district holds first rank in state Human Development Index, 2003. But there are some places within the district where medical facilities are not available and even where available those are not satisfactory. Therefore, an attempt has been made in this paper to explore the spatial pattern and accessibility of health care services.

OBJECTIVES

(1) To show the distribution of health centres in the district.

(2) To find the spatial pattern of health services in Jorhat district of Assam.

(3) To analyse the accessibility of health services in terms of transportation network, economy and other social aspects in the blocks of Jorhat district.

DATA AND METHODOLOGY

Data Sources

This paper is based on both primary and secondary data. Secondary data have been obtained from the District Statistical Handbook, Assam Statistical Handbook, The Village and Town Directory, Planning map of Jorhat District etc. On the other hand a primary field survey is also done in eight development blocks of Jorhat District.

Methods

To show the spatial pattern of health services of Jorhat district, health centre density/10sq.k.m. *(No. of health centre ÷ area*10)*, no. of doctors/10,000 population *(No. of Doctors ÷ total population*10,000)* and no. of beds/10,000 population (*no. of beds ÷ total population*10,000)* are calculated *(Roy, 2008, Ashraf, Ahmed and Rawal2013).* To show the accessibility of health services in terms of distance from the major road network, health centres location and major road network layers are prepared under GIS environment. In this regard, from the major road layer, three buffer layers are created i.e. within 500m, within 500m to 1000m and within 1000m to 2000m in GIS environment. Moreover, a primary survey is also conducted in some selected villages of eight development blocks of the district in order to understand the accessibility in terms of distance from the villages and the people's perception towards the available health care services. In this regard some health service related questions are prepared like distance to nearest health centre, care at child birth and the problem of access to health services which are divided into three groups i.e. economic problem (low income, lack of health insurance, high transportation cost), social problem (believe in traditional medicine, lack of awareness), physical problem (flood, poor road condition, lack of public transportation etc.).

RESULTS AND DISCUSSION

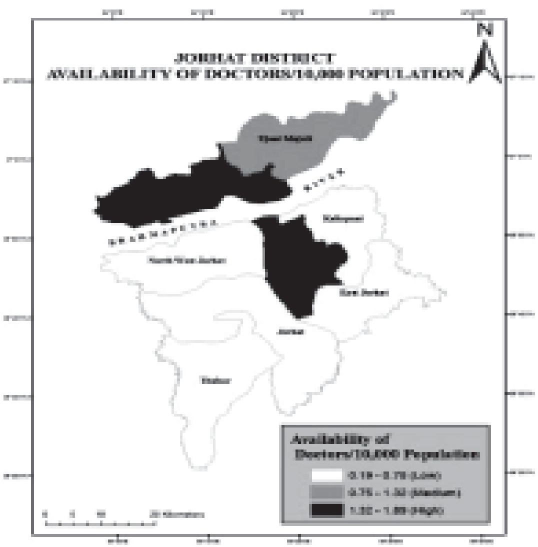
Table-1 shows the block wise health centre density/10sq.k.m. (Primary and sub centre), no. of doctors/10,000 population and no. of beds/10,000 population in Jorhat district of Assam. It is found that health

Table-1
Block wise Spatial Pattern of Health Services, Jorhat District

Block Name	*Health centre Density/ 10sq.km.*	*No. of doctors/ 10,000 population*	*No. of beds/ 10,000 population*
Ujoni Majuli	0.32	1.16	0.29
Majuli	0.30	1.62	1.32
North-West Jorhat	1.13	0.63	0.06
Central Jorhat	1.18	1.89	0.59
Kaliapani	0.76	0.52	0.12
Jorhat development	1.06	0.59	0.17
East Jorhat	0.67	0.56	0.11
Titabar	0.87	0.19	0.25

Source: Calculated by the authors from Planning map of Jorhat District, Assam, 2012-2013.

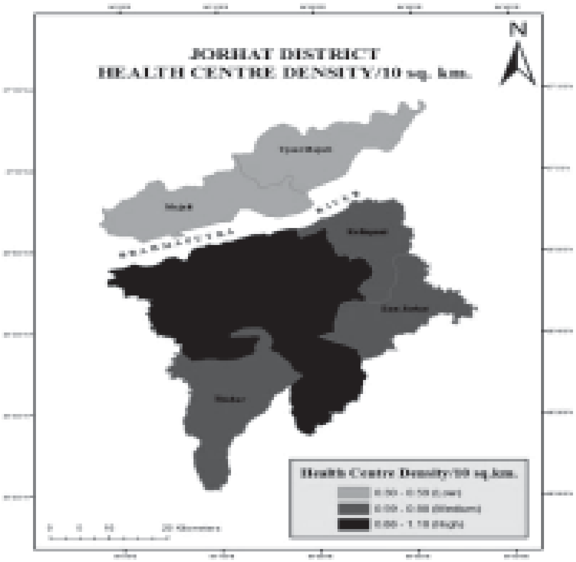
centre density is high only in three blocks (Central jorhat, North-West jorhat and Jorhat development block). On the other hand three blocks (Ujoni Majuli, Majuli and Central jorhat) show comparatively high value in terms of number of doctors/10,000 population. No. of beds/10,000 population is very



Source: Table-1

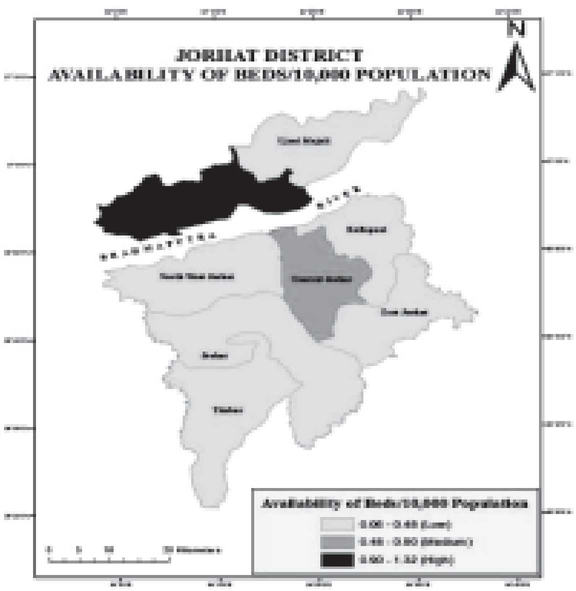
Fig. 2: Availability of Doctors/10,000 population, Jorhat district, 2011

low in all the blocks except in one block i.e. Majuli development block which scores 1.32.



Source: Table-1.

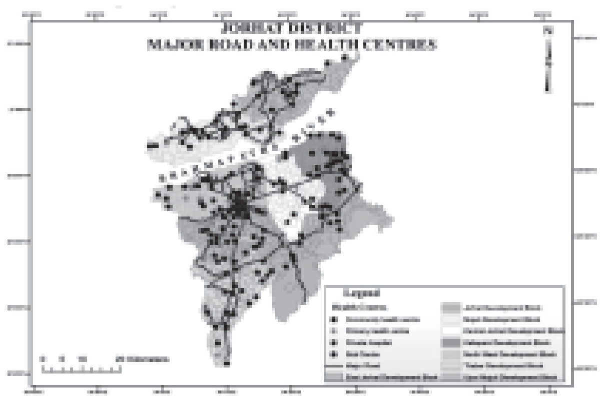
Fig. 3 : Health Centre Density/10 sq. km., Jorhat district, 2011



Source: Table-1

Fig. 4: Availability of Beds/10,000 population, Jorhat district, 2011

Fig.5 shows the location of health centres (Primary health centre, Community health centre, Sub-centre and private hospitals) and the major roads in the eight development blocks of Jorhat district. The highest no. of health centres including primary, community, sub-centre is in Titabar development block (32) followed by North-West Jorhat (31) and Jorhat development block (30) *(Table-2)*. On the other hand East Jorhat



Source: State Disaster Management Authority, Assam

Fig. 5: Major Road and Health Centres, Jorhat District

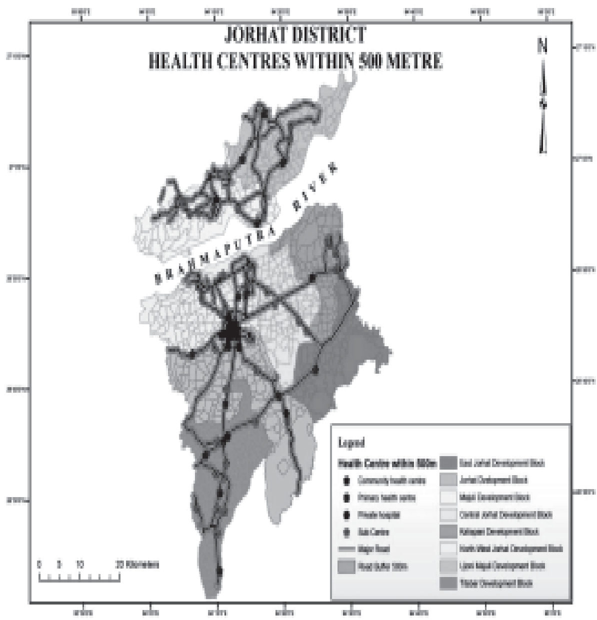
development block has the lowest number of health centres i.e., 9 which includes 1 primary health centre and 8 sub-centres *(Table-2)*. There are 17 private hospitals in the area of Jorhat Municipal Board, the services of which is availed by neighbouring rural areas also.

Table. 2
Block wise Total no. of Health Centres in Jorhat District

Block Name	*Total no. health centre*	*Primary health centre*	*Sub-centre*	*Community health centre*	*Private hospital*
Ujoni Majuli	22	3	17	2	0
Majuli	15	4	11	0	0
North-West Jorhat	31	8	23	0	0
Central Jorhat	10	1	9	0	0
Kaliapani	28	2	25	1	0
Jorhat Development	30	7	21	2	0
East Jorhat	9	1	8	0	0
Titabar	32	6	24	2	0
Jorhat Municipality Board	17	0	0	0	17

Source: Fig. 5

Fig.6 shows the 500m buffer from the major roads in the eight development blocks of Jorhat district and block wise health centres are identified which are located within 500m *(fig-6)*. It is found that within 500m, the highest number of health centre is in Titabar block (15) where number of primary health centre is 4, sub-centre 10 and community health centre 1, followed by North-West Jorhat block (11) and Jorhat development block (7). Private hospitals (16) are also within 500m from the major road network. On the other hand East Jorhat development block shows the lowest value i.e. 1 and which is a primary health centre within 500m.



Source: fig. 5.

Fig. 6: Health Centres Within 500m, Jorhat District

Table. 3
No. of Health Centres within 500m, Jorhat District

Block Name	*Total no. health centre within 500m*	*Primary health centre*	*Sub-centre*	*Community health centre*	*Private hospital*
Majuli	15	4	11	0	0
Ujoni Majuli	7	3	4	0	0
Majuli	8	1	6	1	0
North-West Jorhat	11	3	8	0	0
Central Jorhat	4	0	4	0	0
Kaliapani	6	0	5	1	0
Jorhat Development	7	1	4	2	
East Jorhat	1	1	0	0	0
Titabar	15	4	10	1	0
Jorhat Municipality Board	16	0	0	0	16

Source: Fig. 6.

Again fig. 7 shows the 500m to 1000m buffer from the major road and health centres are identified which are located within this area. It is found that *(Table-4)* highest no. of health centres are located within this layer is in Jorhat development block (10), where 3 primary health centres, 7 sub-centres are there followed by Majuli development block (7). Other seven blocks shows almost equal value which is very low in comparison to these two blocks.

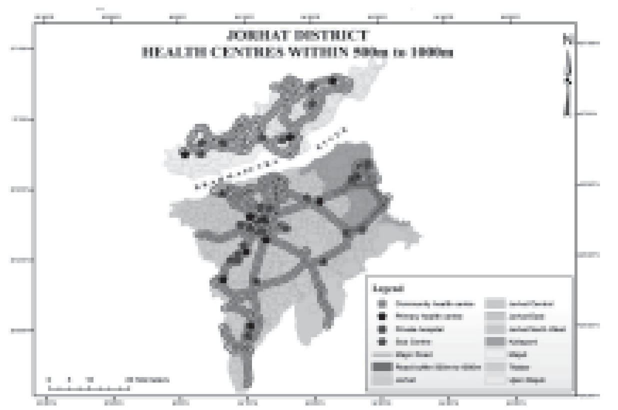


Fig.7 : Health Centres Within 500m to 1000m, Jorhat district.

Table. 4
No. of Health Centres Within 500m to 1000m, Jorhat District

Block Name	*Total no. health centre within 500m-1000m*	*Primary health centre*	*Sub-centre*	*Community health centre*	*Private hospital*
Majuli	15	4	11	0	0
Ujoni Majuli	3	1	2	0	0
Majuli	7	1	5	1	0
North-West Jorhat	4	1	3	0	0
Central Jorhat	2	1	1	0	0
Kaliapani	3	0	3	0	0
Jorhat Development	10	3	7	0	0
East Jorhat	3	0	3	0	0
Titabar	3	0	3	0	0
Jorhat Municipality Board	1	0	0	0	1

Source: Fig. 7.

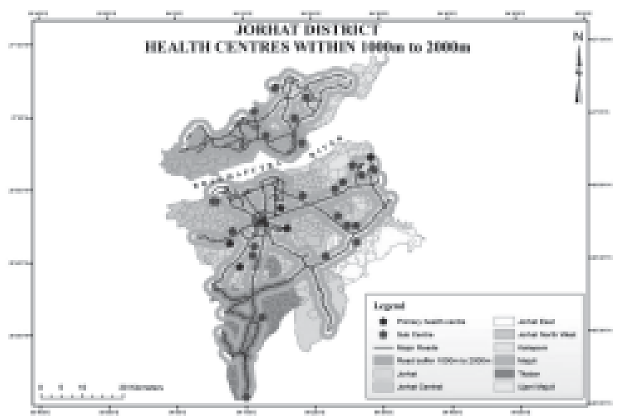


Fig. 8: Health Centres Within 1000m to 2000m, Jorhat district.

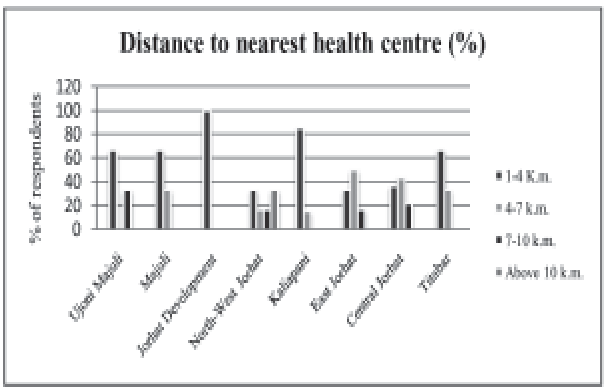
Table. 5
Block wise No. of Health Centres within 1000m to 2000m, Jorhat District

Block Name	*Total no. health centre within 1000m-2000m*	*Primary health centre*	*Sub-centre*	*Community health centre*	*Private hospital*
Ujoni Majuli	3	0	3	0	0
Majuli	3	0	3	0	0
North-West Jorhat	3	1	2	0	0
Central Jorhat	4	0	4	0	0
Kaliapani	6	1	5	0	0
Jorhat Development	5	3	2	0	0
East Jorhat	2	0	2	0	0
Titabar	2	0	2	0	0

Source: Fig. 8.

Fig. 8 shows 1000m to 2000m buffer from the major road network and health centres located within this area. It is found that the number of health centres in all development block is very low. All the values are almost same except three blocks i.e. Kaliapani (6), Jorhat development (5) and Central Jorhat (4). It is also found that community health centres and private hospitals are not present within 1000m-2000m from the major road network in Jorhat district.

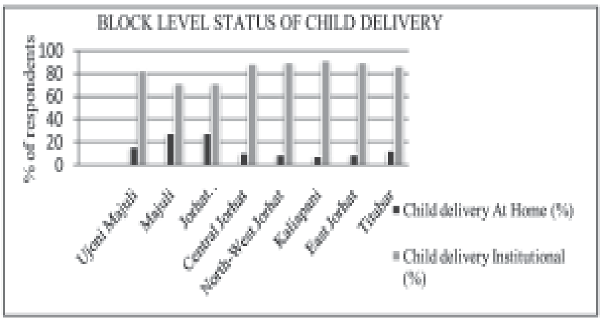
Fig.8 shows 1000m to 2000m buffer from the major road network and health centres located within this area. It is found that the number of health centres in all development block is very low. All the values are almost same except three blocks i.e. Kaliapani (6), Jorhat development (5) and Central Jorhat (4). It is also found that community health centres and private hospitals are not present within 1000m-2000m from the major road network in Jorhat district.



Source: Primary survey

Fig.9 : Block wise Distance to Nearest Health Centre, Jorhat district

As mentioned earlier that a primary survey is also conducted to know the accessibility in terms of distance from the different villages of eight development blocks. It is found that in Jorhat development block all the respondents said that they have to travel a distance of 1-4k.m to the health centres. In Kaliapani block 85% and in East Jorhat 33% respondents said that they have to travel this distance to avail health services. On the other hand 50% respondents of East Jorhat have to travel 4-7k.m. for health centres. In Ujoni Majuli nearest health centres are at a distance of 7-10k.m of 33% respondents. On the other hand in North-West development block 33.3% respondents have to cover above 10k.m. to reach their nearest health centre. It is also the only block where people have to travel such a long distance to avail health services.



Source: Primary Survey.

Fig.10 : Institutional and Non-institutional Child Birth in Jorhat district.

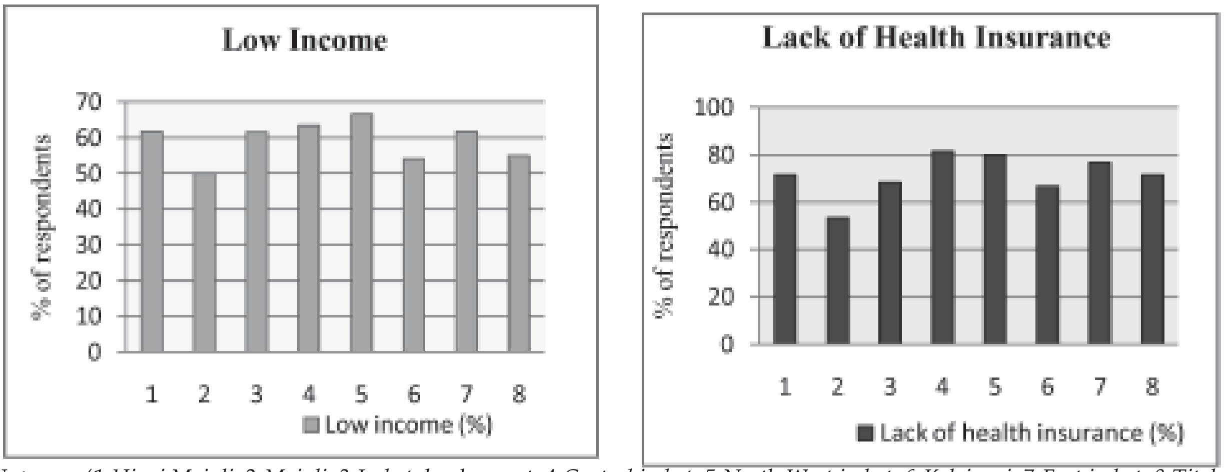
From the primary survey it is also found that some people from rural areas never attended the health centres during the child birth and above figure shows that the highest percentage of child birth at home is from Jorhat development block and Majuli block which is 28.33% of the respondents followed by Ujoni Majuli (16.6%) and Titabar (13.3%) block. In the *table-*

Table. 6:
Child Birth in Presence of

Block Name	*Lady health instructor/ Dhai (%)*	*Doctor (%)*	*Friends and relatives (%)*	*No one present (%)*
Ujoni Majuli	16.6	83.3	0	0
Majuli	26.6	71.6	0	1.6
Jorhat development	20	71.6	8.3	0
Central Jorhat	11.6	88.3	0	0
North-West Jorhat	10	90	0	0
Kaliapani	5	91.6	0	3.3
East Jorhat	10	90	0	0
Titabar	13.3	86.6	0	0

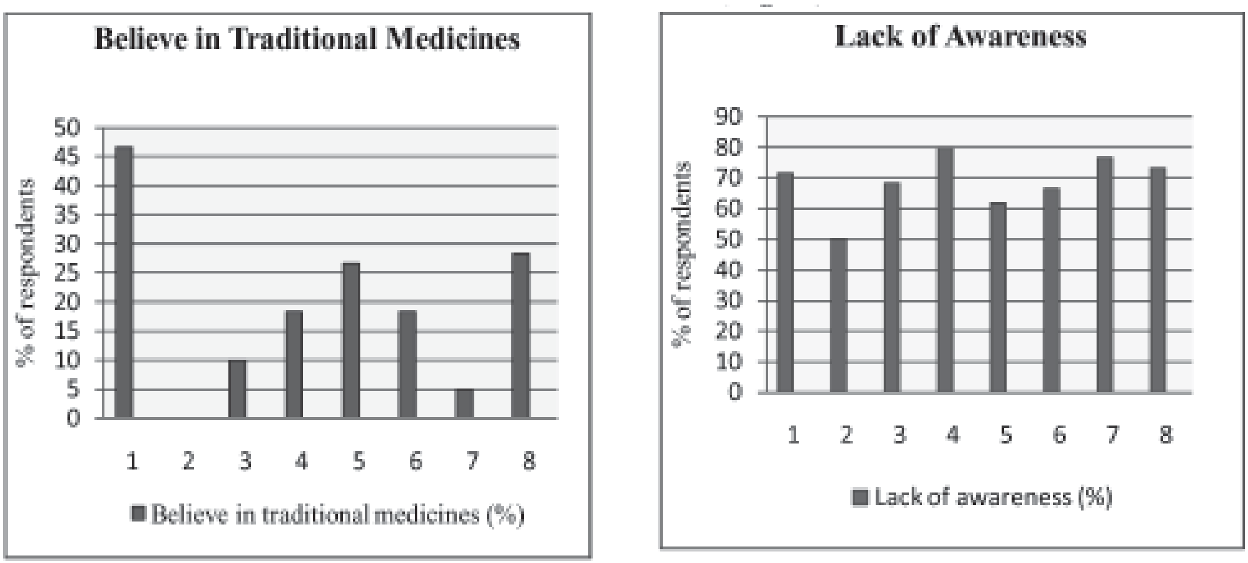
Source: Primary survey.

6 it is found that in Majuli development block 26.6% of child birth is in presence of lady health instructor/ dhai which is the highest among the eight development blocks followed by Jorhat development block which also shows 8.3% child birth in presence of friends and relatives. In Majuli development block 1.6% respondents revealed that no one was present during the child birth. On the other hand Kaliapani development block shows the highest percentage of child birth in presence of doctor (91.6%), but 3.3% people is in the category of no person present during the child birth *(Table-6.)*



Notes : (*1-Ujoni Majuli, 2-Majuli, 3-Jorhat development, 4-Central jorhat, 5-North-West jorhat, 6-Kalaiapni, 7-East jorhat, 8-Titabar.*
Source : Primary Survey.

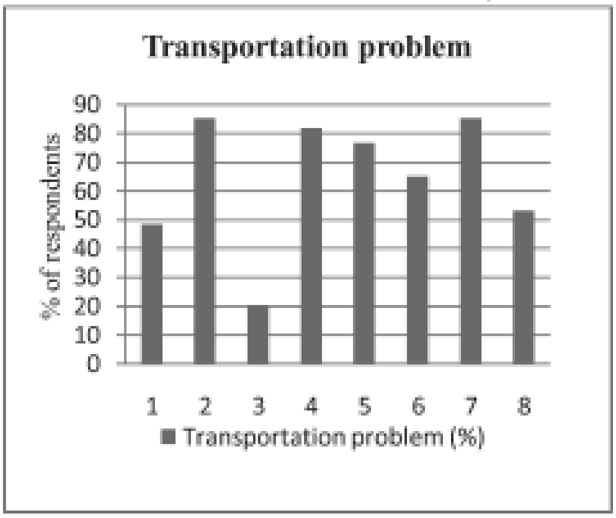
Fig. 11 Economic Problem

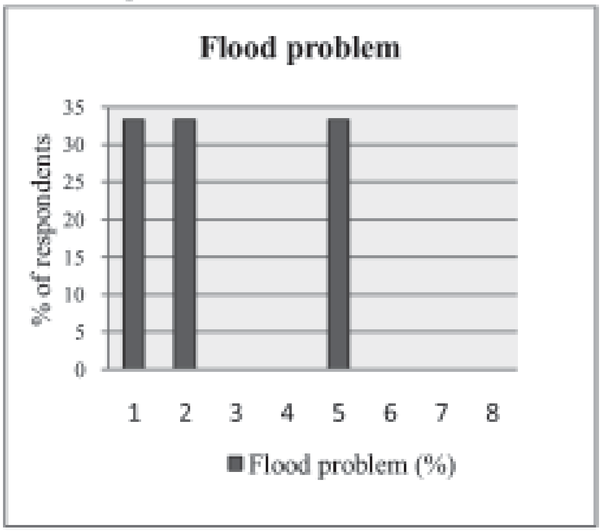


Notes : (*1-Ujoni Majuli, 2-Majuli, 3-Jorhat development, 4-Central jorhat, 5-North-West jorhat, 6-Kalaiapni, 7-East jorhat, 8-Titabar.*
Source : Primary Survey.

Fig. 12 : Social Problem

As mentioned earlier through the primary survey it is also tried to find out the problem of village people to access the health services in their daily life and questions are put related to their economic, social and physical problem. The results show that highest respondents i.e. 66.6% from North-West development block consider 'low income' as the main problem and 81.6% people from central Jorhat development block have identified 'lack of health insurance' as the problem to access the health services *(Fig-11)*. To identify the social problems two indicators are selected i.e. 'believe in traditional medicines' and 'lack of awareness'. In Majuli development block 46.6% people believe in traditional medicines and 76.6% rural people from East Jorhat block are not properly aware of health services which is the highest among eight development blocks *(Fig-12)*. On the other hand, 33.3% people from three blocks i.e. Majuli, Ujoni Majuli and North-West Jorhat consider flood as a major problem to access the health centres *(Fig-13)*. Again 85% people from Majuli and East Jorhat development block consider transportation and





Notes : (*1-Ujoni Majuli, 2-Majuli, 3-Jorhat development, 4-Central jorhat, 5-North-West jorhat, 6-Kalaiapni, 7-East jorhat, 8-Titabar.*

Source: Primary survey.

Fig. 13 Physical Problem

distance as the main problem in this regard. Again the highest percentage of people from North-West Jorhat and Jorhat development block face economic problem to access the health services.

SUMMARY AND CONCLUSION

From the above analysis it is found that within the eight development blocks of Jorhat district the distribution of health services is uneven. From the secondary data it is observed that three blocks i.e. Titabar, North-West Jorhat and Jorhat development block have the highest health centres including primary, sub-centre, and community health centres. In these blocks most of the health centres are located within a distance of 500m from the major roads. But according to primary survey accessibility in terms of distance from the different villages, in North-West Jorhat block 33.3% people said that they have to travel more than 10 kms to the nearest health centre. Again 16.6% respondents travel 7-10k.m. distance in this block. On the other hand though Jorhat development block shows good picture in terms of availability of health services but the primary survey shows that the highest percentage of child delivery at home i.e. 28.3% is in this block also. Majuli development block also share this position in terms of child birth at home which also registers the highest percentage of child birth in presence of lady health instructor/dhai at home. East Jorhat block shows very poor picture in terms of accessibility to health centres from the road layer as well as distance from the village as obtained from primary survey, but it shows the low values in terms of child birth at home which is 10% and also high value in terms of child birth in presence of doctor. Therefore it is found that availability of health services is not everything to get an equal accessibility to it but result says though the impressive picture of accessibility from the road network and accessibility in terms of distance from the villages, some people never attend the health centre in the time of child delivery. Moreover accessibility to health centres in terms of road network does not necessarily mean easy access for villagers rather; health centres away from the main roads may serve the remote areas better. The quality and reliability of health care in the nearest health centres determine the willingness of the people to avail those services. The important point is that a large section of rural people are still facing the problems of low income, lack of health insurance, lack of awareness, believes in traditional medicines, flood and transportation problem which play as major barriers in the path of a development of health care in the Jorhat district of Assam. The study is considered to be helpful in assessing spatial status of health care services and its proper development in future.

REFERENCES

(1) Ashraf, Ahmed and Rawal (2013): "Status of Human Development in Murshidabad District of West Bengal'', *Indian Journal of Human Development, Vol 7, No1*

(2) Joe, W., (2010): "On Measurement and Interpretation of Health Inequalities, An Application in Indian Context", *An unpublished Phd thesis, Jawaharlal Nehru University.*

(3) Kore, R. (2014): "Regional Analysis of Healthcare Facilities in Ratnagiri District of Maharashtra", *International Journal of Advance and Applied Research, Vol. 1, No. 5*

(4) Roy, A. (2008): "Status of Human Development in the District of Puruliya", *Geographical Review of India, Vol. LXX, No. 1.*

CRIME AGAINST WOMEN IN DELHI A NEWS PAPER CONTENT ANALYSIS OF CRIMES

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ABSTRACT

Crime is vastly prevalent across all class, caste, religion, ethnicity, and region in the country. It's against basic human rights and social justice. It's a matter of public health and social well being. Crime is a challenge to the law and order. In a city like Delhi which is being called 'crime capital', crime against women has become a serious concern. This study is based on a content analysis of the crimes reported in the news paper. Three crimes namely rape, sexual harassment and molestation have been taken for the analysis. Apart from spatial distribution, other aspects of crime such as timing of the crime, place and location of the crime, age and sex of the victim and offenders and relationship between them, are tried to explain. This paper also tries to explain the nature and pattern of above crimes. Some crime theories are used to explain the probable causes behind the emerging pattern. it is fund that incest rapes and gang rapes are on rise. 77% rapists were found known to the victims. North East Delhi, South Delhi and South-West Delhi are most crime prone districts of Delhi. Most of the victims are found below 18 years of age. Reporting has gone up after the Nirbhaya gang rapes incident.

***Keywords**: Incest, Rape, Molestation, Vulnerability setting, Rational Choice, Routine activity, Crime Pattern, NCRB*

INTRODUCTION

Delhi as a metro city is one of the most crime prevalent urban space especially when crime against women is talked about. Mapping crime is the first step towards understanding its magnitude and spatial distribution and then solution. Cartographic school (in nineteenth century) and Geography of crime (Harries 1974, Herbert 1989) have tried to map and predict the crime phenomenon with the help of cartographic tools and techniques. Ecological studies at University of Chicago can be said the first step towards the spatial study of crime. The focus of the police is often on where crimes take place rather than the perpetrator. The relationship between crime and place has been the centre of criminology. In the first half of the nineteenth century, many French scholars analyzed the distribution pattern of crime with diverse ecological and social characteristics of the regions (Guerry, 1833; Quetelet, 1842). In America, scholars belonged to "Chicago School" examined the location of crime in the city (Burgess, 1925; Thrasher, 1927; Shaw and McKay, 1942).

Most of these studies were "macro" in approach who looked at bigger places such as regions, states, cities etc not the places themselves. Of late, studies are focused on crime and place with micro-level relationships (Jeffrey, 1971, Newman, 1972) and crime, but also included the larger set of characteristics of physical space and criminal opportunity (Brantingham and Brantingham, 1975, 1977, 1981; Mayhew et al., 1976; Duffala, 1976; Rengert, 1980, 1981; Stoks, 1981; Le Beau, 1987; Hunter, 1988). These studies separated the differences between the place of crime and the larger geographical area that surrounds it.

Three recent theoretical perspectives on crime—*rational choice, routine activity theory* and *crime pattern theory* have also highlighted the importance of place or location in crime studies (Cornish and Clarke, 1986). It is possible to test various forms of rational choice (Hogarth and Reder, 1987) if it is used in conjunction with routine activity theory (Clarke and Felson, 1993). The offender always has some rationale and logical choices before committing crime which motivate him such as time, place, age etc. For example the time after sunset provides hiding opportunity so dark hours are better for crime. Age is another important component. Most of the rape victims are of lower age group. Place as well act as a stimuli to crime. Traditionally home is considered as safe haven for women but now it's turning out to be scary hell.

Routine activity approach explains that crime is a fixed activity for a criminal and he commits it if circumstances go smooth. Like during the weekend the suitability and availability of target increases which provide motivation to the offender. This theory states that for crime to be committed, three elements must be present: an available target, a motivated offender, and a lack of guardians. Routine activity theory seeks to explain the occurrence of crime events as the confluence of several circumstances (Cohen and Felson, 1979; Felson, 1986, 1994).

Crime pattern theory says that crime is not a random phenomenon and criminality never misses the pattern. This theory expresses the concept of

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awareness of space. Every person has his personal awareness space which encourages the crime to occur again and again. Awareness space is also connected to societal aspects as it is seen that most of the crime against women are committed by well known persons.

Crime pattern theory combines rational choice and routine activity theory to help explain the distribution of crime across places. The distribution of offenders, targets, handlers, guardians, and place managers over time and place will describe crime patterns (Brantingham and Brantingham, 1993).

But the problem with some of these studies is that they often do not differentiate between crime density (crimes per land area) and victimization risk (crimes per target) (Wikstrom, 1993, Boggs, 1965). Crime events are not uniformly distributed, at every level of aggregation; some geographic areas have less crime than others (Brantingham and Brantingham, 1982). Offenders themselves should be able to describe their decision- making processes, and a number of studies have examined crime site selection from their point of view. These studies consistently conclude that offenders are rational, even though their rationality is bounded (Rengert and Wasilchick, 1990; Feeney, 1986; Kube, 1988; Maguire, 1988; Biron and Ladouceur, 1991; Cromwell et al., 1991)

OBJECTIVES

(1) To find out the pattern of spatial distribution of crime in Delhi

(2) To discuss the nature and pattern of the distribution

DATA BASE AND METHODOLOGY

This paper is based on the crime data published in a news paper. The Times of India (one of the most widely circulated news paper in Delhi) has been selected for the content analysis of the reported crime. Three years of 2011, 2012 and 2013 are taken as the study period. Data is analyzed with the help of some existing crime theories. For spatial distribution pattern and more clear visualization, I have used GIS to make maps. Since the data published by NCRB do not cover many aspects of crime such as timing and place of the crime, age and sex of the victims as well as offenders, or motives behind crime, socio-familial background of the victim and offender, media coverage etc; an attempt is made to analyze these aspects on the basis of content analysis of crime reporting in the news papers. Following is the format used for the data collection:

Name of Crime	*Place of the Crime*			*Timing of the Crime*			*Sex of the Victim & Offender*				*Age*		*Relationship between Victim & Offender*		
	Location	House premise	Outside	Evening	Night	Day	*Victim*		*Offender*		Victim	Offender	Relative/ Family members	Known	Unknown
							M	F	M	F					

DISCUSSION AND ANALYSIS

A similar study is done in 2009. It was found that in Delhi 60% of total crimes against women were committed within the house premise. Half of the total female victims were found of age below 18 years. The average age of the victims were found below 18 years whereas it is found 30 for offenders. When victims and offenders divided into male and female, a new picture emerges that most of the male victims are concentrated in the age group of 30-60, but in case of female victims more than 70% are concentrated in the age group below 30 years (Chaudhary T.S. 2011).[1]

It will be interesting to find out the vulnerability setting of the crime in this paper i.e.

(i) What is the most vulnerable time? (*i.e.,* day, evening, night etc.).

(ii) Who (age group) are the most vulnerable group?

(iii) Most vulnerable place and location (house premise, outside, market, work place etc.).

Present study of content analysis found a total 298 cases of rape reported in last three years (2011, 2012 and 2013). Apparently when most of the cases go under reported, we must keep this fact in mind that number of cases reported in news paper reporting is less than the reporting at police station. Hence lot of limitations is there in content analysis. Nevertheless keeping the under-reporting as a constant, a generalization of criminality pattern can be drawn to some extent.

Table 1
Number of Crime against Women (Rape, Sexual Harassment and Molestation) Reported in TOI

Year	*No. of Cases Reported in TOI*
2011	93
2012	95
2013	217
Total	405

Source: The Times of India.

It is visible that number of reporting has gone up consistently over the period (see table 1). Year 2013 the reported cases just doubled because of the

Nirbhaya case happened on December 16, 2012. For example NCRB reports 1623 rape cases in 2013 Delhi in comparison with 706 in 2012. This trend can also be explained as increasing awareness about reporting or may be higher number of occurrence. Nirbhaya incidence seems has emboldened many rape victims to come forward to report the crime. And perhaps police has also started reporting such heinous crimes more promptly under pressure from public, civil society, government and judiciary.

Generally summers are the most crime prone season when all the crime are taken into the consideration (Tara Shanker Chaudhary, 2009, Nandini 2006), but here winter seems more conducive for offenders when sexual crime are taken into the account. The probable explanation for this pattern might be the long dark hours in winter, lesser guardianship, easy to escape etc. (table 2).

Two third rape cases were committed outside the house but what is noticeable is that 30% cases were committed either at home or in neighbourhood. Most of the molestations as apparent were committed outside the home. In case of the timing of the offence, maximum rape cases were committed in day time because women are out of home in day time or we can say other way round also that women are most likely to be alone in day time. Other time they are mostly with family, hence chances of rape reduces be it stranger rape or incest. But in case of molestation all the three time span were equally vulnerable for women. Sexual harassment are mostly done by strangers, hence they are likely to be done in day time at offices, in the market, on the road etc. (table 3).

Table 2
Year and Month wise Reporting of Crime against Women in TOI

Months	*2011*	*2012*	*2013*
January	3	8	9
February	12	10	13
March	9	3	14
April	8	5	11
May	11	5	12
June	8	6	25
July	3	7	15
August	11	6	31
September	9	7	11
October	6	6	10
November	4	12	25
December	9	20	41
Total	93	95	217

Source: Times of India.

Table 3: Cases (%) in Different Categories of Vulnerability Setting

Name of Crime	Place of Crime		Timing of the Crime			Age (Years)		Relationship bt Vic & Off		
	House Premise	Outside	Day	Evening	Night	Vict_Age	Offen_Age	Relative	Known	Stranger
Rape	30.20	66.78	51.01	14.43	15.77	17.5	31	24.50	50.34	22.82
Molestation	5.97	94.03	37.31	29.85	26.87	19	34	7.46	32.84	58.21
Sexual Harassment	26.83	68.29	63.41	9.76	17.07	18	31	12.20	46.34	36.59

Source: TOI, Content Analysis done by Author

Average age of the victim and offender is very important while analyzing the crime. In all the three types of crimes average age of victims were found below 20 years whereas offenders were found above 30 years. This shows that offenders chose the victims which were much younger than them. Because they could control, threaten, over power them. Above table shows that quite a large number (30%) cases are committee within four walls of the house premise or in neighbourhood. In case of sexual harassment is it clear that 63% cases happen to occur in the day time because most the women including working women are out of home in the daytime. Most of the molester is found strangers/unknown because maximum cases are committed in public conveyance or private transport (bus, metro, auto, cab). Still one third of total molesters are known to the victim

Table 4
Rape Cases Reported in Times of India for Last Three Years (2011-11-13)

Nature of Rape	*No. of Cases*
Gang Rape	73
Incest Rape	30
Victims Below 18	179
Victims Below 10	68
Victims Below 5	38
Total Rape Cases Reported	298

Source: TOI, content analysis done by author.

It is apparent from the above table (Table 4) that about one fourth cases are of gang rape. This is something we should think about deeply that why gang rape takes place and what would be the motive behind it. It can be explained in many ways such as gang rape is power exertion in order to take an absolute control over the victim. It helps the perpetrators in threatening the victim, in blackmailing her. It helps rapists to make the act a planned success because otherwise it would not be easy for a single perpetrator to make this act possible easily when girls are becoming more aware and strong and now women are challenging the male chauvinism mentally as well as physically.

Number of incest rape is rising. Only recently NCRB has started collecting data in this category. This indicates a very grim situation which shows that very own family members and relatives are becoming dangers to women. Report says that even no relation is exception now. Father, step father, brother, cousin, uncle and sometimes even son can be rapists above table clearly says that relatives, neighbours, friends and family members constitute almost 45% of total rapes. Other are husband's friend, teacher, father-in-law, landlord, fiancé, tantric, boyfriend, brother-in-law. Thus among all the rapes 77% rapists were found known to the victim.

Table 5
Relationship between Rape Victim and Rapist

Type of Relationship	*Cases (%)*
Neighbours	16
Friends	9
Father	5
Boyfriend	3
Uncle	2
Father in law	1
Brother in law	1
Husband and Friends	1
Teacher	1
Landlord	1
Tantrik or Priest	1
Total Strangers	23
Total Known/Acquaintances	59
Relatives and Close Kins	15
Offenders not mentioned	3
Total	100

Source: TOI, content analysis done by author.

Above table shows that out of total known offenders, most of them turned out to be the neighbours. That means most of the offenders knew the where about of the victim as well as victim's family as well. They probably knew that at what time victim would be alone or how to allure her and when to act etc.

Another aspect the crime is age. Studies in abroad says that the rapist and victim belong to same age cohort (Radzinovicz, 1957 and Amir, 1971) but in India it is found different. Here the average age of victims are found much less than the average age of the perpetrators (Ahuja 1987). Present study shows that the average age of victims is 17.5 years while same is 31 years for the perpetrators. What is more noticeable is that when we look at the minor victim's age it is very low but the average age of rapists does not go low accordingly.

Table 6 is showing that the average age of rapists is well above 25 even when victims are below 5 years of age. That means the most age group of women is 15-20 while most violent age group of offenders is 25-30. This is true that no woman is safe when rape is concerned. Even the content analysis found that from 6 months to 85 years old women got raped. But still the average age of the victims and the offenders are very crucial while explaining the nature and severity of the crime.

Table 6
Average Age of Rape Victims and Offenders

Average Age of Victims	*Average Age of Offenders*
Victims Below 5	26
Victims Below 10	29
Victims Below 18	29.5
All Victims 17.5 years	31 years

Source: TOI, content analysis done by author.

Although day time is most vulnerable time for women but evening is also very dangerous for women in when we talk about molestation. Rapes within house premise infers that rapist knows the victim very well and he knows even the time when victim would be alone and there would be no chance of being caught i.e. it was a well planned crime. This shows how geography of crime matters. Most of the cases were committed in vicinity of the victim's house this is perhaps so because the mobility of women/girls is very limited and it is near or around her locality.

Most of the victims were unmarried (Table 7). There is a notion that married women are safer at homes and they are less likely to go out of home. Moreover they are more likely to raise their voice in case of rape because this society attaches more honour/value to the virgin and unmarried women while on the other hand half of the rapists were found married. The married rapists take advantage of their being married that no one would apprehend them.

Table 7
Marital Status of Rape Victims and Offenders

Marital Status	*Percent*
Unmarried Rape Victims	74
Unmarried Rape Offenders	46

Source: TOI, content analysis done by author.

Place and timing of the crime is very important aspect of criminology. Place theory of crime explains it very extensively that why an offender chooses some specific place of the particular crime. When incest rape is concerned, rapist chooses home as the place of crime because victim is at home and offender is a family member. It is just the lonely hour to be selected for committing the act. When stranger rape is concerned it would be some place unknown to victim and dark time is selected.

Table 8
Rape (Committed By Father) and Related Factors

Father's Age	*Daughters Age*	*Nature of Rape*		*Other Information*
		Prolonged	*First time*	
*	14	1		Wife dead, father living with his second wife
43	16	1		Raping for past three years
*	12	1		Past 7 months, divorce seeking, already a domestic violence case
33	10	1		Father married twice, a rickshaw puller, mother domestic help,
31	5	1		For last one month
30	10	1	1	Past one year
35	7	*	*	Couple living separately
37	13	1		Employed man, wife is teacher
40	13		1	Stepfather
40	14		1	Drunkard, bad relation with daughter, attempted earlier too
40	14		1	Step father, labourer by occupation
47	13	1		Drunkard (past three years)
37	14	1		Step daughter, attempted earlier too
38	13		1	Drunkard

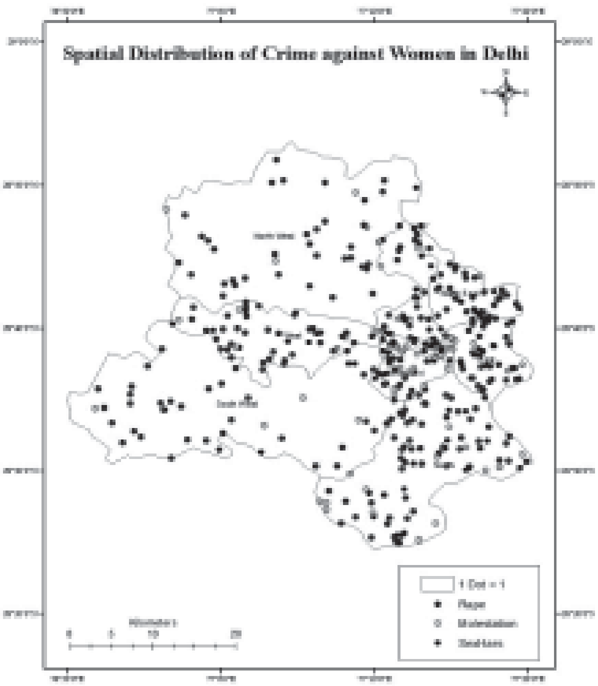
Source: TOI, content analysis done by author.

*No information

In the study 14 rape cases were found in which fathers themselves turned out to be the rapists. It is astonishing to anyone. It would be interesting to analyze those 14 rapes which are beyond the wildest imagination of the society that a father commits rape to his own daughter. Home is considered the safe haven for women but such cases just opposite. What table above (Table 8) says is that all the victims were minor and all the offenders were two-three times elder than the victims. In 9 cases (Out of all 14 cases) offenders have done or attempted such acts repeatedly to their daughters i.e. that it was not just an erratic behaviour out of frustration or under alcohol or any else excuse. These were planned crimes in full senses. In most of the cases, either victim's mother was not living with her or a divorce case was going on between the mother and father or the family was disorganized. Most of the offender were drunkard and used to commit domestic violence their wives. Most of them were of very low economic status. Here fits the social disorganization theory which focuses on the family bonds and healthy relationship. Healthy family relations incur high moral values.

Usually in urban spaces potential victims are with their family members in the evening and night. At day time people are away from their homes due to their job and hence the chances of victimization are perhaps enhanced at day time. Girls are also out more on day time in comparison with evening or night. Minors were raped when they were playing outside the house or at the time of school off when parents are away for their job or so. Most of the neighbours and unknown rapists were found of low living standards. And most of the rape victims belong to middle or low class.

When I plotted the cases of rape incidences on Delhi's map, I found that South Delhi reported maximum number of rape cases followed by West and South west Delhi which matches with the NCRB distribution of rape incidences. That means news paper reporting and police reporting can be taken identical keeping the underreporting as equally constant. Spatial distribution of news paper reporting of molestation is concentrated in South Delhi. Hence again South Delhi is found most crime prone district of the Delhi. Most of the molesters were found unknown to the victim in content analysis. This scenario is also very much dependent upon the reporting. (Fig 1)



Source: TOI, content analysis done by author.

Fig 1: District wise Distribution of Crimes against Women Reported in TOI (2011-12-13).

Although in most of the cases, the victim is chosen to be lower in age by offenders but in some cases this is found to be just opposite. But look at the data carefully that in most of such cases, crime had to be rape and it further had to be gang rape where offenders come into large numbers and control the victim. Most of such cases happened outside the home and in broad day light. Other than this, one more thing is noticeable is that in many such cases victim is much aged that the offender hence physically very weak to oppose the offender. In some cases victims are above 60 years of age when it is least to be believed that old women could be raped and this might be the reason why offender chose her.

Out of 406 cases of rape, molestation and sexual harassment, only 13 cases are there in which victim's age is higher than the respective Offender. The star marked on some cases of rape incidences are gang rapes. What this table infers? That whenever the age of the offender is more than the victim, it's a gang rape (means physical overpowering the victims by many offenders) or victim is too old to stop the offender to rape her. Gang rapes are often committed in day time because gang rapes are often followed by abduction/kidnapping which is mostly done in day time.

Information below was collected from the detail of the news paper reporting. These were the factors that determined the rape besides male chauvinism being

Table 9
Total No. of Cases in which Age of Victims Found Higher than the Offender

Name_Crime	Place of Crime		Timing_Crime			Age		Relationship btw Victim & Offender		
	Home	Outside	D	E	N	Victim	Offender	Relative	Known	Stranger
Sexual Harassment		1	1			32	30			1
Rape*		1		1		34	30		1	
Rape		1	1			19	17		1	
Rape*		1	1			40	38	1		
Rape (under alcohol)			1			85	32	1		
Sexual Harassment		1				30	26		1	
Rape*	1					60	45	1		
Rape*		1	1			40	25			1
Rape	1		1			77	22			
Rape	1				1	75	22		1	
Rape	1				1	35	30		1	
Rape*		1			1	35	29		1	
Rape		1		1		32	30	1		

*denotes Gang Rapes

ultimate reason. Explain above table with the view of social disorganization theory, impact of alcohol on rape cases, motive theory, economic theory, rational choice theory etc. a disorganized family results deviance.

Table 10
Determining Factors of Rape

Determining Factors	*Cases (%)*
Rapist was under the influence of alcohol	10
Victim was alone in her home	22
Family disorganization (divorce, single parent, pending divorce etc)	18
Rapist had some criminal history	8
Victim was drugged before rape	8
Victim was lured/convinced	10
Victim was promised a marriage by offender	14
Victim was promised a job	7
The main motive was to take revenge	2

Source: content analysis by author.

An offender of criminal history is more likely to commit crime because either he has not been caught before or he has no value or respect for other's consent/denial. On the false promise of marriage or job, a quite large number of rapes have been committed since long. Alcohol is another excuse which makes offender more violent keeping other things (such as male chauvinism, patriarchy, hatred, gender bias etc) constant.

Table 11
Gang rapes and Vulnerability Setting

Home	12	Place of Crime
Outside	61	
Day	37	Timing of the Crime
Evening	13	
Night	23	
Victim	22	Average Age of the Victim
Offender	28	
Relative & Close kins	16	Relationship Between Victim and Offender
Known	30	
Stranger/unknown	25	

Source: TOI, content analysis done by author.

Gang rapes are often committed after kidnapping or abduction. So assumption and common sense behind this is that gang rapes will be committed in the outer city where there is a lonely street, chances of easily run away out of border, least chances of being caught, low security and surveillance etc. though in most of the rape cases, it is known offenders but in case of gang rapes strangers are quite large in numbers as compared to usual rape cases. It is very clear from the above table that most of the cases of gang rate have taken place outside the home and in broad day light which is quite understandable because most of the women are out of home in the day time. Average age of the offender is 28 years. Physical fitness is also important while kidnapping which can be assumed looking at the average age of the offenders.

Table 12
Spatial Distribution of Gang Rapes in Delhi

Districts	*No. of Cases*
South	13
South West	12
East	11
North East	10
West	9
North West	8
North	7
Central	2
New Delhi	1
All Delhi	73

Source: TOI, content analysis done by author.

Most of the cases were concentrated in South and South West Delhi which is known for lonely highways and dark streets. While East and North East Delhi are adjacent to Uttar Pradesh where law and order situation is not that good and it is easy to escape to other states from there. Delhi police also mentioned this cause in its report that in Delhi's borders areas such crimes have gone up in recent years. (table 12),

CONCLUSION

Thus it can be concluded that crime against women in Delhi is more concentrated in some specific areas. South, South West and North East Delhi are found most crime prone districts. Some of the crime place theories are helpful in explaining the pattern of crime distribution. Socio-economic background of victim and offenders is the main determinants. Incest rape, gang rapes and rapes of minor is rampant in Delhi which shows a very grave situation. Day time is most dangerous time, known persons are the main perpetrators and minors are the most vulnerable victims.

Notes

1. Chaudhary T.S. (2011), 'Socio-economic Correlates of crime in Delhi-NCR'. Unpublished Dissertation Submitted to Centre for Study of Regional Development, Jawaharlal Nehru University, New Delhi

REFERENCES

1. Ahuja. Ram. 1987. *Crime against Women*. Jaipur. India: Rawat Publications
2. Biron, L.L. and C. Ladouceur (1991). "The Boy Next

Door: Local Teen-age Burglars in Montreal." *Security Journal* 2:200-204.

3. Brantingham, P.L. and P.J. Brantingham (1975). "Residential Burglary and Urban Form." *Urban Studies* 2:273-84.
4. - (1982): Environmental Criminology pp 147-165, Prospects Heights. IL: Waveland Press
5. Burgess, E.W. (1925). "The Growth of the City." In: R.E. Park, E.W. Burgess and R.D. MacKenzie (eds.), The City. Chicago, IL: University of Chicago Press.
6. Chaudhary, T.S. (2011): *Socio-economic Correlates of crime in Delhi-NCR,* Unpublished Dissertation Submitted to Centre for Study of Regional Development, Jawaharlal Nehru University, New Delhi
7. Cohen, L. and Felson, M. (1979): 'Social Change and Crime Rate Trends: A Routine Activity Approach', *American Sociological Review*, 44:588–608.
8. Cohen, L. and Felson, M. (1979): 'Social Change and Crime Rate Trends: A Routine Activity Approach'. *American Sociological Review*, 44:588–608.
9. Cohen. Joseph. (1941), 'The Geography of Crime' *Annals of the American Academy of Political and Social Sciences*, 217 (September, 1941): 29-37
10. Cornish, D. and R.V. Clarke, eds. (1986). *The Reasoning Criminal: Rational Choice Perspectives on Offending.* New York, NY: Springer-Verlag.
11. E. Eck. John and David Weisburd (2009), 'Crime Places in Crime Theory', 2009
12. Felson. M. 1986. 'Linking Criminal Choices. Routine Activities. Informal Control and Criminal Outcomes.' in D. Cornish and Clarke, R.V. (eds.). The Reasoning Criminal: Ration;:JChoice Perspectives on Offending. New York. NY: Springer-Verlag.
13. Herbert T. David (1989), 'Crime and Place: an Introduction' in *The Geography of Crime*, 1989, pp. 1-15
14. Hogarth, R.M. and M.W. Reder (eds.) (1981). *Rational Choice: The Contrast between Economics and Psychology.* Chicago, IL: University of Chicago Press.
15. Jeffrey, C.R. (1971). *Crime Prevention Through Environmental Design.* Beverly Hills, CA: Sage.
16. Koper, C. (1995). "Just Enough Police Presence: Reducing Crime and Disorderly Behavior by Optimizing Patrol Time in Crime Hotspots." *Justice Quarterly* (forthcoming).
17. Kube, E. (1988). "Preventing Bank Robbery: Lessons from Interviewing Robbers." *Journal of Security Administration.* 11:78-83.
18. Mayhew, P. (1979). "Defensible Space: The Current Status of a Crime Prevention Theory." *Howard Journal of Penology and Crime Prevention* 18:150-59.
19. Nandini (2006): *Social Space and Crime in Delhi*. Unpublished Dissertation submitted to Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi
20. Newman, O. (1972). *Defensible Space.* New York, NY: Macmillan.
21. Quetelet. A.J. (1842) A Treatise on Man. Gainesville. Scholars Fascsimiles and Reprints 1969
22. Rengert, G. (1980). "Theory and Practice in Urban Police Response." In: D.E. Georges-Abeyie and K. Harries (eds.), *Crime: A Spatial Perspective.*
23. Sarah L. Boggs (1965), 'Urban Crime Patterns' *American Sociological Review, Vol*. 30, No. 6 (Dec., 1965), pp. 899-908
24. Shaw, C.R. and McKay. H. D. (1942): 'Juvenile Delinquency and Urban Areas'. Chicago University Press
25. Sherman, L.W. (1992a). "Attacking Crime: Policing and Crime Control." *Modern Policing.* Crime and Justice, Vol. 15. Chicago, IL: University of Chicago Press.
26. Thrasher, F.M. (1927). *The Gang: A Study of 1,313 Gangs in Chicago.* Chicago, IL: Phoenix Books. (Abridged ed.. 1963).
27. Wikstrom, P.H. (1995). "Preventing City Center Street Crimes." *Building a Safer Society: Strategic Approaches to Crime Prevention.* Crime and Justice Annual, Vol. 19. Chicago, IL: University of Chicago Press.

DEVELOPMENT INDUCED DISPLACEMENT AND SUSTAINABILITY: A STUDY OF SARDAR SAROVAR PROJECT

Sushil DALAL

ABSTRACT

Development is essential for economic growth of the region and the construction of big dams is one of them. However, the construction of big dams is resulted into displacement of human population and has long term social, political, demographic, economic and environmental repercussions. These are manifold and complicated which accentuate severe pressure on already existing settlements at resettlement areas. The displaced population tries to interact with nature, land and the living entity of surrounding environment for livelihood. The present paper attempts to elaborate methods and materials used for survival system adopted by the resettled populace to investigate interrelationship among environment, society and economy at local level due to the construction of Sardar Sarovar Project. Results show that people have partially adopted social and economic adaptability while the relation with environment and ecology has been loosened in the process of resettlement.

Keywords: *Displacement; Environment; Resettlement; Survival System; Sustainability*

INTRODUCTION

Development is essential for the growth and progress of an area. It is a process of economic change from potential to actual with the construction of development activities. The development is created through harnessing the natural resources of the earth surface and water resource is one of them. Water resource is harnessed by constructing dams on the rivers for irrigation and power projects. These planned developmental activities through river projects accrue to the economic growth of the region; however, there are some contradictions in the process of development. The social, human and environmental aspects have not been entertained in the planning process and often have resulted into human displacement, particularly, of the people from rural areas, tribals and the poor community. This human displacement has long term social, political, demographic, economic and environmental consequences on the affected population.

The displacement of people from their traditional habitats along with other repercussions leads to landlessness, homelessness, joblessness, loss of access to common property assets and disarticulation of social fabric. It may adversely affect socio-economic conditions of the affected people, dismantle production system, and disorganize long established residential communities and settlements. The local, long-established life sustaining informal social network becomes non-functional and local exchange of items, labour linkages and self organized services may be wiped out. Thus, the consequences of development induced displacement are manifold and complicated which accentuate severe pressure on already existing settlements at resettlement areas.

The displaced communities are often forced to resettle in an alien environment which may be unfamiliar and unknown to them. Hence, the displacement becomes instrumental in annihilating interaction of lives and livelihood with nature and land, of the living entity with environment. Consequently, It becomes very difficult for them to get adjusted and adapt to the different milieu and the living conditions of the resettled population further deteriorate when they are uneducated and unskilled which leads to the condition of unemployment, overcrowding of housing facilities and public amenities etc. and thus have long-term consequences. All these result into disruption of subsistence systems which control the community and management of economic and ecological resources.

It is also evident in India after independence that a majority of policy makers wanted to develop the country through big projects in planning period. But in later stage in 1980s, their enthusiasm dimmed when the independent empirical researchers incorporated these facets. The development should be achieved by including the social goals of the poor and affected communities. The studies related to displacement as a result of the construction of development projects mainly cover the ways in which compensation amount was spent by the displaced population, the socio-economic conditions of displaced persons, governments' rehabilitation and resettlement programmes. Less emphasis has been given on the social problems and sustainable survival for the affected communities that depend on non-market common property resources (CPR) in the natural surroundings of the river system/ecology. Most of the studies so far have not covered the social and ecological perspective along with the socio-economic development.

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Some social scientists have mentioned some of the above mentioned problems. But what are the steps used in managing the problems faced due to forced resettlement and how they have to be adjusted and resettled in different environment have not been examined to a great extent till now. Thus, to fulfill the above-mentioned gap, a modest attempt has been made to examine the impact of resettlement on the affected in the present analysis. Thus, there should be a people-oriented approach to study the ecological and sustainable perspective of the project-affected people and to explain how they assimilate within the community and with other communities having different social, economic, cultural and geographical environment. An attempt has also been made to elaborate methods and materials used for survival system of resettled populace to investigate interrelationship between nature (environment), culture (society) and economy/polity at local level.

STUDY AREA

The present study is conducted on the displaced human population with the construction of Sardar Sarovar Project on the river Narmada. The construction of dam affected the families of three states of Gujarat, Madhya Pradesh and Maharashtra. These affected people are forced to move to the different places which have different social, cultural, economic and physical factors from Nimar, Rath and Bhagor of Narmada valley regions. Among all the three states, Gujarat made the provision to resettle the displaced people from other two states too. Hence, to study the adaptability and sustainability of the displaced families from all the above mentioned three states, who opted to live at the same socio-economic conditions i.e. Gujarat, have been taken into consideration for the present study.

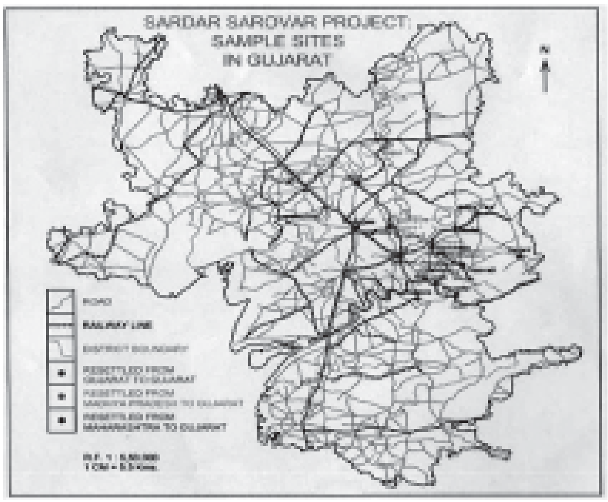


Fig. 1 Study Area

OBJECTIVES

The studies related to displacement and resettlement as a result of the construction of development projects have emphasized less on the adaptability and survival for the displaced communities. Earlier they were dependent on non-market common property resources (CPR) in the natural environment of the river system and forest ecology. Most of the studies so far have not covered the survival system adopted by the affected families. The questions related to the problems faced due to forced displacement and how they have to be adjusted and resettled in that environment have not been examined to a great extent. There should be a people-oriented approach to study the social ecology of the project-affected people. Thus, to fulfill the above-mentioned gap, the present study attempts to examine the adaptability and sustainability of livelihood on the displaced population. The following objectives are taken for the study

1. To find out the short term and long term economic sustainability by the affected population.
2. To identify the levels of socio-cultural adaptability by the resettled families.
3. To examine the ecological and environmental viability by the displaced communities.

METHODOLOGY

The present study is based on an empirical-descriptive analysis. The relevant data is collected from the primary source of information that has been obtained through field survey from the study area. To fulfill the objectives, the areas of submergence and resettlement have been identified. About fifty thousand families have been displaced due to the construction of Sardar Sarovar Dam on river Narmada. To resettle these families in Gujarat, Sardar Sarovar Punarvasvat Agency (SSPA) has developed 235 sites spread over different physiographic divisions in seven districts in the state. Out of the total, ten resettlement sites have been selected through stratified random sampling method for generation of information. On the basis of the physical setting of resettlement sites in Gujarat, four sites viz. Vyara-1, Junarampura, Pansoli and Vyara-2 have been taken from Vadodara Plain, three viz. Golagambdi, Parveta (Gather) and Parveta (Manibeli) from Orsang-Heran Plain, one each viz. Vejpur-1, Gora and Dhefa from Mahi Plain, Narmada Gorge and Lower Narmada Valley respectively.

Out of the total selected sites, four sites each from Madhya Pradesh and Gujarat have been selected that are resettled by the families displaced. Two sites have been selected where the displaced families from Maharashtra are resettled. Spot inquiry has been conducted in the sample villages that reveals a good number of resettled families who are not permanently residing at these resettlement sites. Hence, only 338 households have been found available at the time of survey and information has been collected from these households for the detailed analysis.

To find out the short term economic sustainability, the utilization patterns of compensation money has been analyzed. The utilization of compensation money has been broadly classified into three categories viz. essential, income generating and non-income generating use. For long term economic sustainability, the occupation, income and expenditure patterns have been analysed. To identify the levels of socio-cultural adaptability, the change in social customs and rituals, civic amenities and sanitation facilities in context of belief associated with house construction, adaptability of the use of instruments in ceremonial occasions after displacement has been observed. The environmental and ecological viability is determined by the level of the access and use of natural resources which is measured by asking the questions from the respondents. To study the relations of social aspect with environment is measured with the level of co-operation and conflict.

RESULTS AND DISCUSSION

The Sardar Sarovar Project is one of the biggest multi-purpose river projects. It is constructed for generation of electricity and to quench the thurst of western part of India. However, it has displaced more than 45,000 families from 192 villages of Madhya Pradesh, 33 of Maharashtra, and 19 of Gujarat. To resettle these affected people who opted to settle in Gujarat state, 235 resettlement sites have been developed by SSPA. The government gave compensation (monetary and fixed assets) and other facilities to these affected people that has been raised from time to time with the help of NGOs, social activists and judiciary. However, the process of displacement and resettlement has resulted in changing the demographic, economic, social and cultural scenario of the area. On the other hand, distribution of the compensation has led in the creation of a new sense of thinking and behaviour, particularly adjustment with the other groups in the society.

(i) Economic Sustainability

To study the economic sustainability it has been classified into two categories, i.e., short term economic sustainability and long term economic sustainability. The short term economic sustainability is based on the utilisation of compensation money which has been received by the resettled families from government agencies while the long term economic sustainability is based on the occupational pattern and income of the families on which their subsistence depends.

(a) Pattern of Utilisation of Compensation Money

The nature of utilization of compensation is examined for short span of period at the time of resettlement period. The affected families used the compensation money to manage all necessary items for survival in an alien culture and environment where their socio-cultural and economic set-up has been disrupted and ruptured due to involuntary migration from their ancestral land. It is important to investigate whether the people have utilized it by investing in generating the productive assets or by spending the money on conspicuous items or in meeting the essential expenditure for survival such as housing, clothing, medicine, education and so on.

The consumption pattern of compensation money by the affected families indicates that 96 percent families received agricultural land as compensation. The benefit of free crop insurance for the first two years after resettlement has also been given to these people. However, during the survey only a few families have reported taking benefit of the crop insurance scheme due to unawareness of the scheme. 64 percent families reported to have taken one animal (bull, cow, buffalo) from the government. However, only 12 per cent families received an agricultural implement (cart or plough). A few families received subsidy for purchasing crop seeds and in levelling the agricultural land for cultivation.

House is one of the three basic needs for survival. 96 per cent of the surveyed families received a residential plot of 60x90 square feet and Rs. 45,000 in lieu of construction of the house or a constructed house at resettlement sites. About 4 per cent resettled families complained that they have not been allotted residential plots. The government also gave jobs to 16 persons in SSPA at Vadodara but these people complained that it is far from their place of residence. Hence, some of them left the job and some were planning to leave.

The respondents have utilised the compensation money in different ways. Some of them have invested major share of it in income generating activities mainly in agriculture and related activities while others have used it in conspicuous consumption and on non-income generating items. The utilization behaviour of the resettled population as indicated in table 1 shows that the most vital expenditure that involved nearly 74 per cent of the compensation money was the construction of house which is essential for survival. 64.2 per cent families had utilised money on essential expenditure particularly on food and clothing. The government and NGOs have insisted on saving the compensation money in banks and post offices. In spite of all the attempts of the government and NGOs, only 1.94 per cent of the compensation amount has been deposited in banks and post offices.

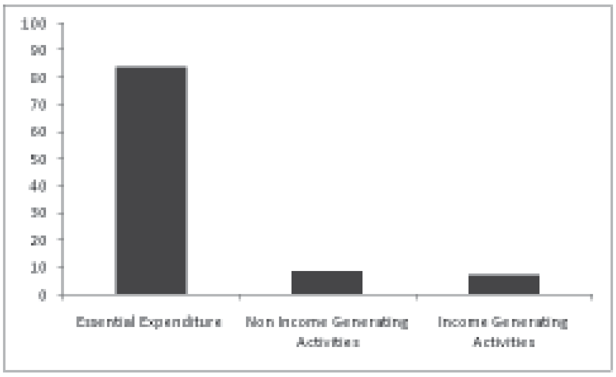
The expenditure pattern of compensation money on

Table 1
Utilization Pattern of the Compensation Money by the Resettled Families

S. No.	*Type of utilization*	*No. of Families*	*Percentage of Total utilization*	*Average amount per family (Rs.)*
1.	Purchased agricultural implements & equipment	93	3.78	4134
2.	Spent in agricultural land levelling, seeds purchase, developing irrigation facilities etc	53	1.35	2579
3.	Household industry & Small Business	1	0.20	20000
4.	Savings in Bank & post offices etc	29	1.94	6810
5.	House construction	239	73.98	31448
6.	Spent on food, household goods & clothing	217	9.17	4291
7.	Expenditure on Education	29	0.24	826
8.	Money Spent on medicine / health care	40	0.54	1361
9.	Spent on transporting the household goods from old village	14	0.26	1857
10.	Spent on marriage and social functions (rituals & worships)	38	4.33	11576
11.	Spent on luxury goods and Jewellery	21	1.78	8619
12.	Money spent on liquor etc	35	0.45	1311
13.	Repayment of debts	34	1.93	5765
14.	Spent on court case	2	0.07	3500
	Total	290	100.00	

Source: Compiled from primary survey.

three basic areas viz. income generating, essential expenditure and non income generating expenditure is shown in Fig. 2. It shows that 84.17 per cent of the total compensation received has been utilized on essential expenditure i.e. the money spent on medicine and health care practices; on food,



Source: Compiled from primary survey.

Fig. 2 Percentage of Utilisation of Money by the Affected Families

household goods and clothing; on education; on house construction; on transporting the household goods from old villages and so on. It is important to note that a meagre share (7.27 per cent) of compensation money has been used as an income generating investment i.e. to purchase agricultural equipment and implements; to establish household industry and small business investments such as opening of shops; levelling of agricultural land, purchase of seeds, developing irrigation facilities, saving in banks and so on. About 8.5 per cent has been spent on conspicuous consumption such as marriages and other social functions, on purchase of luxury items, on liquor, payment of old debts and on court cases.

Thus, it appears that the resettlers by and large have used the compensation money quite judiciously in trying to establish their base in the new land and have not wasted it, as only a small part of it has been

Table 2
Percentage of Occupational Structure of Families in Different Economic Activities

S. No.	*Name of economic activities*	*Per Family Income*	*Main occupation (in percent)*	*Subsidiary occupation (in percent)*
1.	Cultivation	30598	64.20	29.59
2.	Cattle rearing	924	0.00	15.98
3.	Agricultural Labour	12221	20.71	38.17
4.	Wage Labour	4464	8.28	9.47
5.	Service	3389	5.33	1.78
6.	Small business & household industries	991	1.48	2.66
	Average	8765		

Source: Compiled from survey data.

utilized for conspicuous consumption. Also, not much money was spent on income generating activities as the requirement of resettlement was of overriding importance.

(b) Income and Expenditure Patterns

The economic sustainability is measured with the study of income generation from different sources. The main sources are cultivation, agricultural labour and wage labour. Income from different sources is given in Table 2. The table exhibits that the highest source of income is from cultivation which is more than half of the total share. The occupational structure indicates that maximum percentage of families are engaged in cultivation. The variation in cultivation and cattle rearing is found among the affected families because of less availability of land for cultivation and fodder in some villages due to uncultivable waste land. Some villages are not well connected with nearby urban centre. Hence, the income from wage labour and service was absent in these villages (Dhefa). However, some villages have the favourable geographic situation for wage labour being near to stone mines and quarries (Kherwadi; 3km).

Small business and household industrial activities such as tailoring, cotton trade, shopkeeping, ironsmith work, vegetable vendor, floor mill, milk collection were found higher in few resettlement sites established in plain (Vadodara and Orsang-Heran) whereas additional income by making *ghar ghanti* (stone quern) is earned in the villages of Narmada Gorge being availability of stone in the area. Few families in the villages, situated in the foothill Zone of Vindhyachal Mountains which is near to the Sulpaneshwar Wild Life Sanctuary, are engaged in collection of Baz leaves for *Bidi* making and earn meagre income of Rs. 800 for 1000 leaves in a season.

The expenditure pattern has been analysed to find out the sustainability of the development induced displacement. The families have spent money partly on consumption and partly on investment. The annual household expenses on cultivation, animal rearing, education, social celebrations, and medicine have been examined to study the expenditure pattern among the affected communities. Families mainly spent the money on household items (including food, cloths), agriculture, cattle rearing and social celebrations. Social celebration and worship has an important place in the tribal communities and a good share of money is spent to perform these activities. However, education and entertainment have least importance. So, negligible amount of money is used in these activities. Table 3 exhibits that more than 63 per cent expenses has been incurred on household items by the resettled families. One-sixth share has been used on agriculture. This has been informed that they had no choice but to invest in it for agricultural output due to the infertile rocky land. People have not invested much in cattle rearing, education and medicine. These affected people mainly belong to tribal community. So, a comparatively higher share of expenditure is devoted to social and cultural practices, but least spent on entertainment. The regional variation of expenditure has also been observed. The low level of expenditure is made on the undulated riverine *Kotar* area (at the bank of river Men), rocky uncultivable and barren agricultural land in the study area.

Table 3
Average Annual Family Expenditure on Different Economic Activities

S. No.	*Items*	*Expenditure per family*	*percent*
1.	Cultivation	7514	17.22
2.	Cattle Rearing	1312	3.01
3.	Ornaments	1712	3.92
4.	Education	1342	3.07
5.	Worship	733	1.68
6.	Medicine	1421	3.26
7.	Household items including food & cloths	27652	63.36
8.	Festivals	1776	4.07
9.	Entertainment	183	0.42
10.	Average	7579	100

Source: compiled from survey data.

It can be concluded from the above analysis that the families have managed to sustain themselves with the construction of houses and purchasing of other essential household goods by utilising the compensation money and very little share of compensation money has been used in non-income generating investment. A long term sustainability analysis of income and occupation indicates that major share has been received from cultivation and agriculture labour activities. However, the income from service and small business is very low but it has increased after resettlement. On the other hand, the income from cattle is low due to less availability of CPR, Gochar Land and the families opted this occupation as subsidiary work. The villages less connected with the outside world have low income generation from wage labour and service sectors. The maximum expenses were incurred on managing household items. Agriculture is also important field of investment of money, but, animal rearing and education are least attracted fields.

(ii) Displacement and Socio-cultural Adaptability

The socio-cultural conditions reflect the way of life in a community. It is more important among the tribal people where all the activities revolve around and dominated by the social customs and rituals. The study area comprises about 98 per cent of tribal population of the total surveyed population. These people have faith in supernatural powers because of low level of education among them due to belief in social customs, lack of awareness and financial constraints. Among the tribal society particularly in Bhils, the housing pattern is manifested by geographical and socio-cultural circumstances. The pattern of settlement in Narmada Valley was scattered and spacing between the houses was large/ more. The thatched houses were mainly made of mud, wood, *Khakhra* (a kind of tree) leaves and grass material available in nearby forest. However, involuntary migration has forced them to live in pucca houses at resettled sites constructed with bricks and cement. Many people complain that these houses are not environment friendly and become too hot during summer and too cold during winter. However, it is observed that they leave the floor of their houses *kachcha* smeared with cowdung cakes and mud because of the socio-cultural reasons. These people believe that *Kuldev* and *Kuldevi* of the family walk on kachcha floor in the house.

The privacy of the individual family members has become obsolete as the room density in a household has decreased after resettlement. It was a practice in their ancestral land that the members of the society constructed a new hut for the newly married couple at nearby space available in fringe area. Resultantly, the family conflict and quarrel has increased. Among the civic amenities and sanitation facilities, the availability of drinking water, electricity and lavatory are the basic amenities. The tribal families used river and Kotar (small body of stored water in the river bed) water for drinking and households' chores but tap and hand pump water is being used after resettlement. Use of electricity for domestic consumption is studied. The government of Gujarat also made the provision of electric connection to all the resettled families free of cost but it has been disconnected due to non-submission of electric bills on time and only 68 per cent families have this connection in houses. However, it has increased manifold due to displacement. The provision of lavatory in the house was not socially acceptable to them. Hence, they used open space at riverside and forest was available to them for defecation. The same trend is also observed at present place of residence.

Social celebrations are the integral part of the day-to-day life of the tribal communities in India. All the new work starts with worship and related cerebrations. These social customs also determine the interaction with social ecology of the area. In the present study, the celebration of festivals; the beliefs in Gods, Pirs and Gurus; the practice of dance and musical instruments at ceremonial and other occasions have been included. It is interesting to note that about 88 names of Gods, Pir and Guru have been listed at the time of field survey. These people also changed their Gods and places of worship. In the resettlement sites the people travel to chelawada (near Pawagarh) to offer animal sacrifice to pay the tribute to Baba dev (Hanuman) but in their old villages they offered these sacrifice at Dev Sthan.

It has been found that every tribal family used to worship a *Kuldev/Kuldevi* (family God/Goddess) in their submerged villages. The God was placed at the common area of the village boundary. The people of *falia* and village gathered there at the time of worship. Hence, they had a sense of association and belongingness with the village boundary. But after resettlement, these people brought the image of their Kuldev/Kuldevi with them and placed them in their home courtyards. Thus, a sense of unity and belongingness with village boundary has been obliterated in their new place of residences.

It has been observed that there is change in the dances and the instruments played by the resettled families. The tribal people has been playing *Jhanjhri, thali, dhol,* flute, *shahnai, manjeera* in marriages, festivals and other ceremonial occasions since ancient times. But the popularity of these instruments has reduced after resettlement. However, the use of Drum has increased at the place of resettlement. People have started increasing use of the Drum in marriages and other functions on rent or hire basis due to increased hiring capacity. Secondly, this instrument along with *Dhol* was already in practice among the local people. The ladies dance wearing *Jhungharoo* on their ankles.

(iii) The Environmental and Ecological Viability

The analysis of surrounding environment is essential to study the sustainability of the population. In the present context, the population is forced to migrate to different environmental settings. Earlier, the tribal people were living in the natural conditions near the forest area on the river bank in the Narmada Valley. They consumed natural resources from river and forest to meet the basic needs of their demands and did not exploit the resources for their greed. For example, the woods and other forest produce were used for making the house, grazing for animal, hunting and for use at household level. The forests were not for making profit for them and these were conserved by them in the form of worship and ceremonies. But now the relationship with forest has been disrupted by the displacement process.

The resettlement sites have developed in the plain area where there is no forest cover. The animal rearing activity has declined drastically due to non-availability of grazing land. The river has always been the lifeline for the tribals. All the activities of day-to-day life had revolved around the river. They had used the river to collect the fishes, water for household activity and irrigation in agricultural fields. They had performed many celebrations on the bank of river. The forest soil was utilised for crop production, mainly coarse grains, such as Kodra, Bhadi etc. Only manure was used for the production of crops and no fertiliser was used which depleted the soil capacity. But at resettlement sites, people started using fertiliser to produce crops. It is observed that many people are facing stomach problem i.e., indigestion. The production cost has also increased but the profit is being used in purchasing the household items which was free of cost at old villages. Consequently, people have shifted from the worship of trees, forests, rivers, fire, *anaj* (food), animals, rain (Indal) and other natural phenomena to worship Gods of plain area.

The cooperation and conflict among tribals have been examined. The people responded that there was a good relation among the displaced but it has decreased over a period of time and space. The resettled people responded that they invited the community members in social function. The conflicts among the resettled communities are not of a very severe nature.

CONCLUSION

It can be summed up that the displaced families have made adjustment at new sites in spite of all difficulties. The government, NGOs and social organisation have made efforts in the process of adjustment. In the initial period, they had used the compensation money judiciously for making the provisions of basic needs for survival. Cultivation and animal rearing were the main occupation before displacement but the sustainability of animal rearing has decreased and people have shifted to labour (agriculture and wage labour) activities and small business according to geographical and environmental conditions. The expenditure pattern indicates that highest share of their income is utilised in household items (including food and clothing) and in agricultural activities (fertiliser, cultivation, irrigation etc). Results explain that education and entertainment is least important for them. However, a good share of income is devoted to perform the social and religious functions. Hence, the families have managed to sustain themselves.

The material condition of the houses have improved but the people have not got adapted and got acquainted with them. These houses become hot and cold in extreme climate. Further, the social belief that kuldev and kuldevi walk on kachcha floor has been neglected and people are hesitant to adapt it. The privacy of the individual family members has obsolete as the room density in a household has decreased after resettlement. The civic amenities and sanitation facilities has been marginally adopted by the people.

These people have reorganised their way of life in social celebration and worship. They have adopted the worshiping of Gods of plain area. However, a common place (village boundary) having been vanished, a sense of association and belongingness with the village boundary is obliterated in their new place of residences. The use of playing instruments in functions has been adopted according to new set-up, however, now it involves the cost of rent in it. Thus, it can be said socio-cultural adaptability has a mixed response.

The environmental and ecological viability is measured to study the relation of the affected people with forest and river. These relations have been disrupted by the displacement process and the people reduced to worship trees, forests, rivers, fire, *anaj* (food), animals, rain (Indal) and other natural phenomena. The cooperation among tribals has decreased over a period of time and space. In nutshell, the people are in the process of getting adapted to the new environment and trying to adjust themselves in the alien setting.

REFERENCES

Alagh, Y. K. (1995), "Economic Dimensions of the Sardar Sarovar Project" Har-Anand Publications, New Delhi.

Asian Development Bank (1998), "Handbook on Resettlement: A Guide to Good Practice" Manila, Philippines.

Baboo, B. (1992), Technology and Social Transformation: The Case of the Hirakud Multi-Purpose Dam Project in Orissa, Concept Publishing Company, New Delhi.

Baviskar, A. (1997), "In the Belly of the River: Tribal Conflict over Development in the Narmada Valley", Oxford university Press, New Delhi.

Cernea, M. M. (1985), "Involuntary Resettlement: Social Research, Policy and Planning", in M. M. Cernea (ed.), Putting People First: Sociological Variables in Rural Development", Oxford University Press, Berkeley.

Dash, N. R. (2009), "Sardar Sarovar Dam: A Case Study of Oustees in Gujarat, India" in Huhua Cao (Ed.) Ethnic minorities and Regional Development in Asia: Realities and Challenges, Amsterdam University Press, Amsterdam.

Doshi, S.L., “Bhils: Between Societal Self-awareness and Cultural Synthesis”, Sterling Publishers, New Delhi.

Drèze, J. M. Samson and S. Singh; Eds (1997), The Dams and the Nation, Oxford University Press, Delhi.

Fernandes, W. and V. Paranjpye (1997), “Rehabilitation Policy and law in India: A Right to Livelihood”, Indian Social Institute, New Delhi and Econet, Pune.

Ghanshyam Shah; Ed. (1997) Social Transformation in India, Rawat Publication, Jaipur.

Government of India (1985) “Report on the Committee on Rehabilitation of Displaced tribals due to Development Projects”, Ministry of Home Affairs, New Delhi.

Hakim, R. (1996), “Vasava Identity in Transition: Some Theoretical Issues”, Economic and Political Weekly, Vol. 31, No. 24, pp.1492-1499.

Independent Review Team (1997), “Displacement and Rehabilitation in Madhya Pradesh”, in J. Drèze et. al., The Dams and the Nation, Oxford University Press, New Delhi.

Kothari, A. and R. Bhartari (1984), “Narmada Valley Project: Development or destruction?” Economic and Political Weekly, Vol. 19, No. 22, pp. 907-920.

Lobo, L. & S. Kumar (2009), “Land Acquisition, Displacement and Resettlement in Gujarat: 1947-2004” Sage Publications, New Delhi.

Mathur, H. M. and D. Marsden (Eds.) (1998), Development Projects and Impoverishment Risk-Resettling Projects Affected People in India, Oxford University Press, New Delhi.

Naik, T. B. (1956), “The Bhils: A Study”, Bharatiya adimjati Sevak Sangh, Delhi.

Narmada Control Authority (1995), “Master Plan for R & R”, Indore.

Parasuraman, S. (1995), “Development Projects and Displacement: Impact on Families”, Indian Journal of Social Work, Vol. 56, No.2.

Patnaik, S. M. (1996), Displacement Rehabilitation and Social Change: The Case of the Paraja Highlanders, Inter-India Publications, New Delhi.

Ramaiah, S. (1998), “Impact of Involuntary Resettlement on Levels of Living”, in H. M. Mathur and D. Marsden (Eds.), Development Projects and Impoverishment Risk- Resettling Projects Affected People in India, Oxford University Press, New Delhi.

Sangvai, S. (1998), “The River and the Life: The People’s Struggle in Narmada Valley”, Narmada Bachao Andolan, Baroda.

Scudder, T. (1973), “The Human Ecology of Big Projects: River Basin Development and Resettlement”, Annual Review of Anthropology, Vol. 2, pp. 45-62, Palo Alto, CA, USA.

Singh, S. (1997) “Taming the Waters: The Political Economy of Large Dams in India”, Oxford University Press, New Delhi.

Srinivasan, S. (1995), “Disillusionment of the Displaced”, Economic and Political weekly, Vol. 30, No. 26, p. 1555.

Thukral, E. G. (Ed.) (1992), “Big Dams, Displaced People: Rivers of Sorrow Rivers of Change”, Sage Publications, New Delhi.

Tata Institute of Social Sciences (1997), “Experiences with Resettlement and Rehabilitation in Maharashtra”, in J. Drèze, M. Samson and S. Singh (Eds.), The Dams and the Nation, Oxford University Press, Delhi.

Whitehead, J. (2002), “Repopulating the Landscape: Space against Place in the Narmada Valley”, Economic and Political Weekly, Vol. 37, No. 14, pp. 1363-1369.

Geo-spatial Approach and Regional Development

LAND CAPABILITY IDENTIFICATION IN THE MIDLANDS OF KANNUR DISTRICT USING GEOSPATIAL TECHNOLOGY

Akhil.R[1] & Jayapal.G[2]

ABSTRACT

Land capability is the inherent ability of the land to support a particular land use for a long period or a particular period of time. On the basis of Land capability, land can be classified to their potentials and limitations for sustainable production. This classification of capabilities of soil also helps to identify hazards of soil in relation to other factors which may cause deterioration and damage to soil and also the lowering of fertility and even the productivity of the soil. Here a land use capability study has been made on the midland regions of Kannur district, Kerala. Kannur is one of the northern most districts of Kerala, lying between latitudes 11° 40′ to 12° 48′ North and longitudes 74° 52′ to 76° 56′ East. The midland region of Kannur district covers an area of 1594 Km^2 and is adorned with rolling hills and shallow valleys forming a gentler landscape. For the purpose of study land use capability map was prepared using various thematic maps namely slope map, land irrigability map, soil depth map, soil drainage map, soil type map, surface soil map, soil texture map, erosion map. Overlay method was done using Arc GIS software for land use capability identification. This capability classification is made on the basis of categorization of Kerala soil by National Bureau of Soil Survey and Land Use Planning Board. Based on the study nine Land Use Capability regions were identified. Land use capability class number 'llles' that represent moderately good cultivable land with limitation of soil and vulnerable to erosion is dominated in this region.

Keywords: *Land Capability, Soil, Thematic Maps, Arc GIS*

INTRODUCTION

Land capability is the ability of soil or land to accept a type of land use permanently or for a specific period of time without long term degradation. The land capability is influenced by the inherent soil characteristics, external land features and environment factors that limit the use of land. Land capability shows how soil is vulnerable to different external factors and which affect its fertility and potential in production. For the purpose of the study land use capability map was prepared using various thematic maps namely slope map, land irrigability map, soil depth map, soil drainage map, soil type map, surface soil map, soil texture map, erosion map. Here Land capability classification is made on the basis of categorization of Kerala soil by National Bureau of Soil Survey and Land Use Planning Board.

RELEVANCE OF THE STUDY

Land capability study helps to identify the hazard zone area, help to determine the factors influencing the soil fertility and vulnerability to different kinds of damages. It also helps to proper management of land use and increases the productivity of the land.

Limitations of the Study

The area of the study is very extensive so the study is mostly limited to secondary data.

OBJECTIVES

- Digitization of thematic maps
- Generation of Land capability map.
- Calculation of area of different land capability.
- Generation of land use map.
- Analysis of current land use and land capability.

METHODOLOGY

- Secondary data
- Hard copies of different thematic maps required for the preparation of Land Capability were collected from Kerala Land Use Board.
- Data analysis and interpretation using statistical tools and GIS software
- Maps collected were digitized and through overlay method (Map intersection) Land capability map prepared.

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- Examining the area by field visit.
- Statistical analysis was done using Microsoft Excel software.

STUDY AREA

Kannur district is one of the northern districts of Kerala, India, lying between latitudes 11° 40' to 12° 48' North and longitudes 74° 52' to 76° 56' East. It covers an area of 2966 km^2. Physiographical division diviiided it into Low land, Midland and High land. The Midland covers almost half of the district (1594 km^2) with an altitude ranging between 7.5 metres to 75 meters above mean sea level. This area is adorned with rolling hills and shallow valleys forming a gentler landscape. Lateritic soil and Brown hydromorphic soil are seen common in the midland regions of Kannur district. The geological formation is of Archeans type. The district has an annual rainfall of around 3453 mm. It experiences heavy rainfall during the South West monsoon season followed by North East monsoon. South West monsoon during June to September contributes 70 % of the total rainfall of the year. The northeast monsoon contributes only about 30%. Humidity ranges from 77% to 88%. Evaporation is high from March to May, on an average evaporation ranges from 2.6 to 5.7 mm/day.

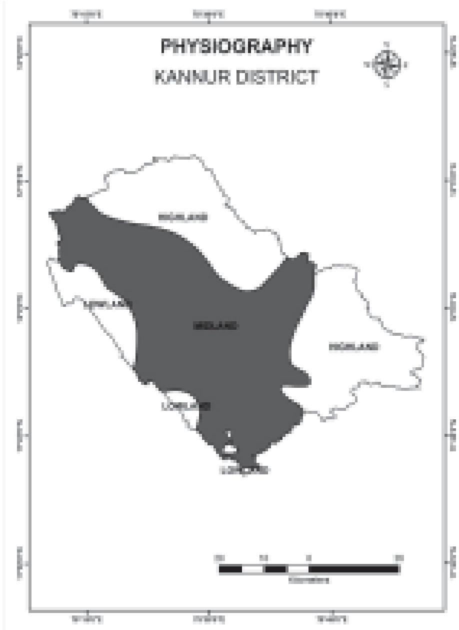
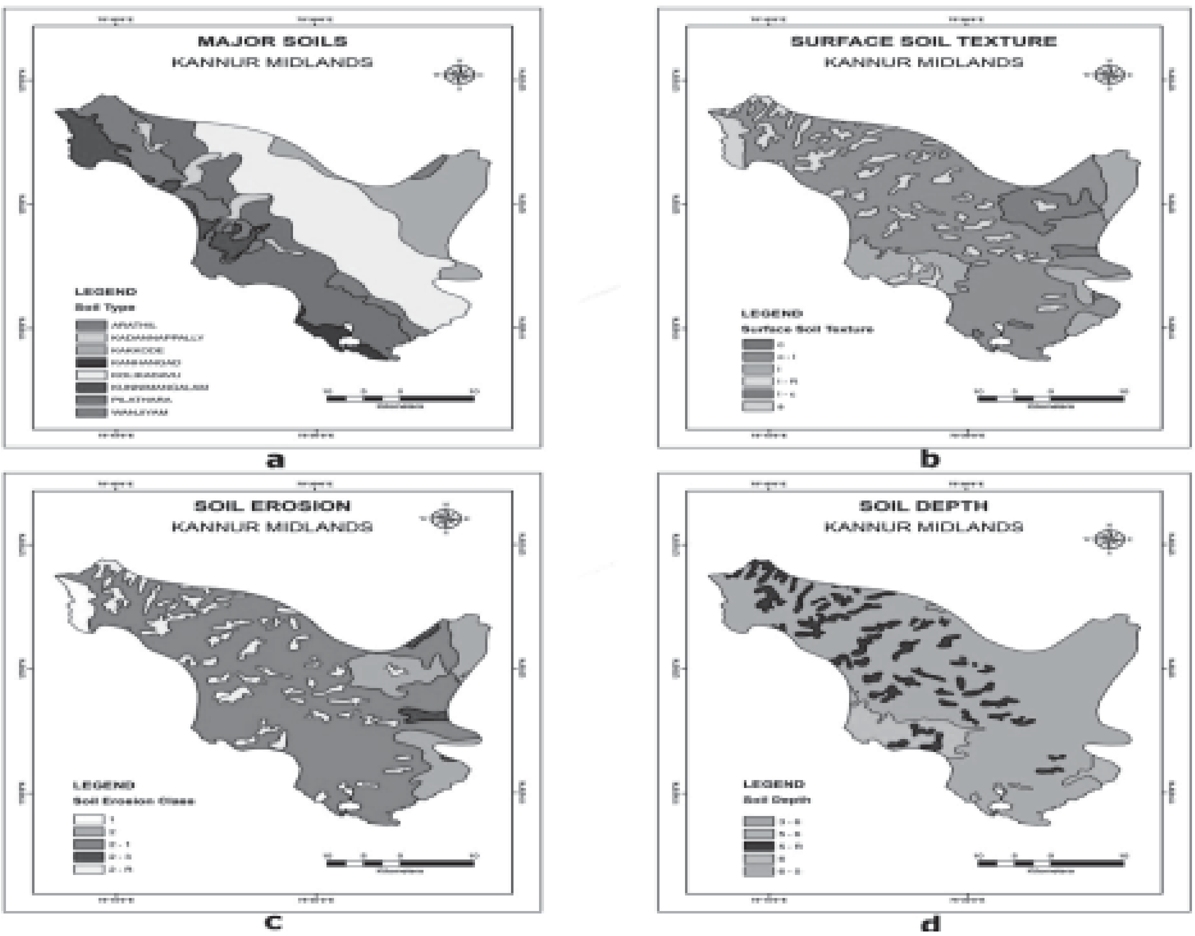
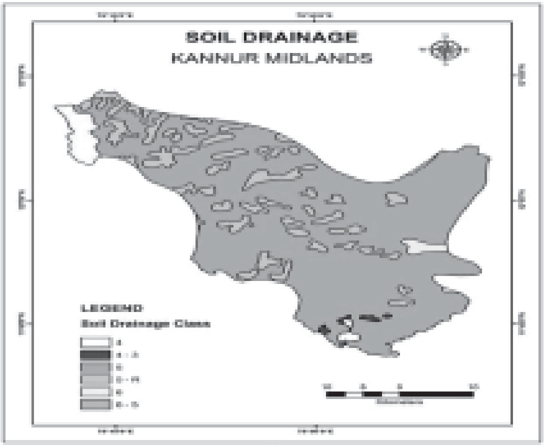


Fig: 1

LAND CAPABILITY

Land capability of an area is influenced by internal and external characteristics. Internal characters include parent material, colour, texture, structure,





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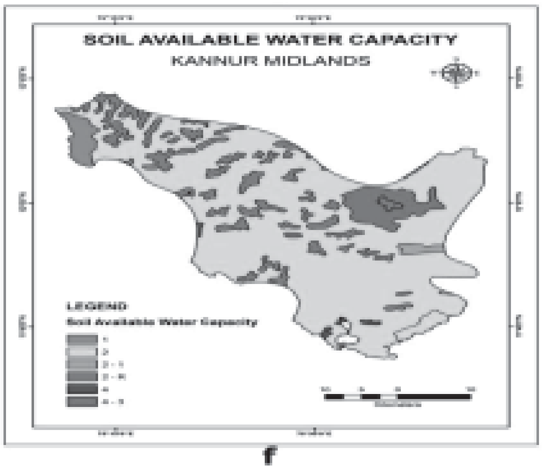

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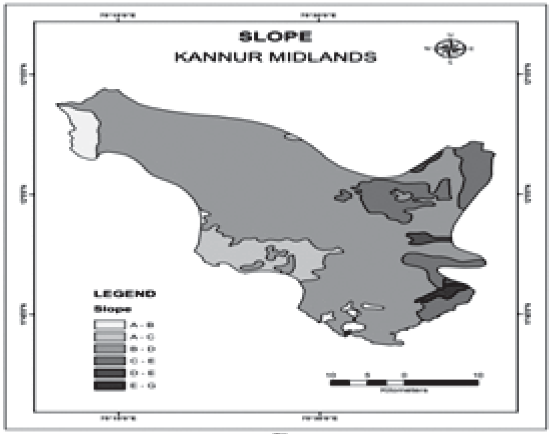

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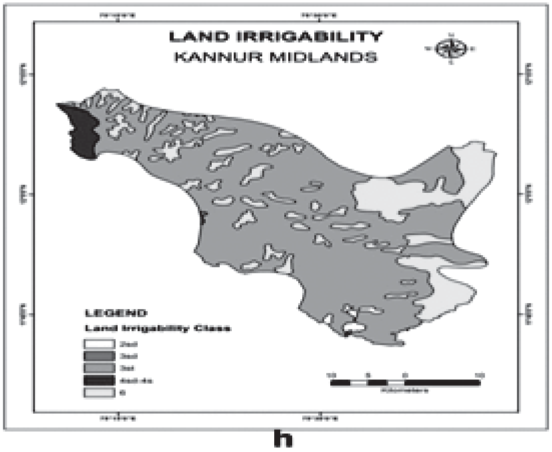

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depth etc. of soil. External characteristics include slope, irrigation, drainage, erosion, etc. For the generation of land capability map, eight different themes were selected. They are slope, land irrigability, soil depth, soil drainage, soil type, surface soil, soil texture, erosion.

Table : 1
Major Soils

Class	*Major Sols*	*Inclusons*
1.	Kanhangad	Dharmodom
2.	Kunnimangalam	Vellur, Chelapuram, Edanad
3.	Arathil	Narikat
4.	Kadannappally	
5.	Pilathara	Muthothy Vayalapra
6.	Kolikadavu	Palayad
7.	Kakkode	Panamkutty
8.	Wanjiyam	Kalayad

Table: 2
Soil Texture

s	sandy
l	loamy
c	clayey
R	Rock outcrops

Table : 3
Soil Erosion

1.	None To Slight
2.	Moderate
3.	Severe
R.	Rock Outcrops

Soil Type

Eight type of soils were seen in the midlands of Kannur District. Dominating soils are Kolikadavu formation and Pilathara formation which cover more than half of the area.

Table : 4
Soil Depth (Fig:2-d)

Depth Class	*Depth In cm*	*Description*
6	>150	Very deep
5	100 – 150	Deep
4	75 – 100	Moderately deep
3	50 – 75	Moderately shallow
R		Rock outcrop

Table: 5
Soil Drainage Capacity

Class	*Description*
3	Imperfectly Drained
4	Moderately Well Drained
5	Well Drained
6	Some What Excessively Drained
R	Rock Out Crop

Table: 6
Available Water Capacity

Class	*Water in mm*	*Description*
1	50	Very Low
2	50 - 100	Low
3	100 -150	Medium
4	150 - 200	High
R		Rock Outcrops

Table: 7
Slope

Class	*Range of Slope in Percentage*	*Description*
A	0 - 1	level to nearly level
B	1 - 3	very gentle sloping
C	3 - 8	gentle sloping
D	8 - 15	moderately sloping
E	15 - 30	moderately steeply sloping
G	>50	very steeply sloping

Soil Texture

Clayey to loamy texture is dominated in this region. That shows the soil grain size varies from medium to fine grained.

Soil Erosion

Soil erosion of this region is limited. Usually soil erosion ranges from slight to moderate range. This shows less vulnerability of land to soil erosion.

Soil Depth

Midlands of Kannur district has very deep soil. It ranges from 100 cm to 150 cm or more than that. Hard rocks are seen common here.

Soil Drainage Capacity

Except in the hard rock area soil is well drained.

Tab: 8
Land Irrigability

Class	*Discription*	*Symbols*	*Limitations*
2	Lands that have moderate limitations for sustained use under irrigation	s s	soil limitation
3	Lands that have severe limitations for sustained use under irrigation	d	drainage/ wetness limitation
4	Lands that are marginal for sustained use under irrigation	t	topographic limitation
6	Lands not suitable for sustained use under irrigation		

Available Water Capacity

Most of the area has a deficiency in available water capacity. The water capacity in an average is less than 100 mm during a rainy period.

Slope

This region has moderately sloping surface. Steep slopes are seen only in the south west portion.

Land Irrigability

Considering the irrigability of land Kannur midland has severe limitation to sustained use under irrigation. There is limitation for soil and drainage.

Tab: 9
Class Description: Based on Land Use Board, Kerala Classification

III	Moderately good cultivable land
IV	Fairly good cultivable land suites for occasional or limited cultivation
VI	Well suited for forest or grazing. Suited for plantation crops which require minimum tillage
VII	Fairly well suited for grazing or forestry
VIII	Land suited only for wild life

These classes based on their limitations have the following sub-class association

c - Climate limitation

e - Erosion and run- off

s - Soil limitations

w - Wetness, high water table, flooding, drainage, etc.

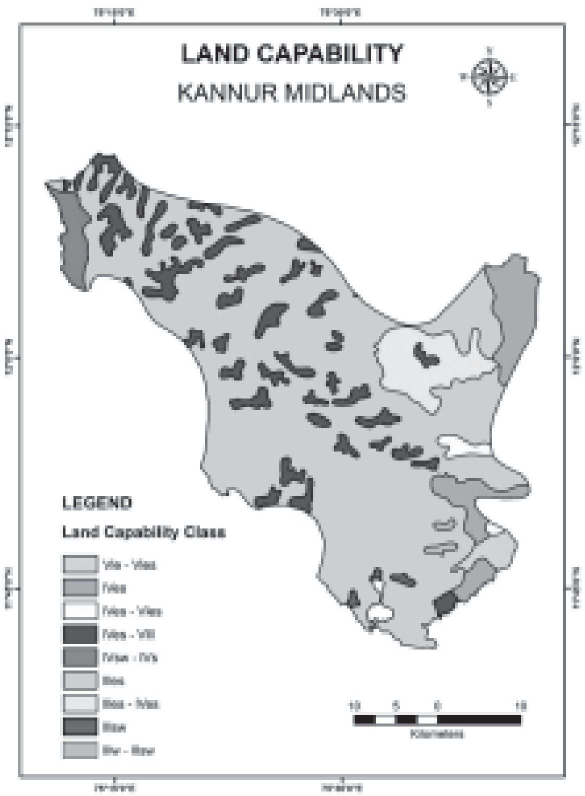

Fig: 3

Tab: 10
Land Capability Area in Sq.Km

llles	1148.703082
llles - lVes	82.41026855
lllsw	5.91464707
lllw - lllsw	5.38479357
lVes	103.624772
lVes - Vles	13.11139057
lVes - Vlll	184.2787519
lVsw - lVs	31.51855895
Vle - Vles	18.87258249
Total	1593.818847

Midlands of Kannur district is covered by five major capability classes. This includes III, IV, VI, VII, VII Classes of land capability. The study area is dominated by IIIes land capability class. This area is moderately good cultivable land with a limitation of erosion and soil. Class III land capability has moderately good soil. Usually, this area can be used for regular cropping. The limitation is that there will be some ecological problems like soil erosion or have climatic problem like rainfall deficiency or uneven distribution. Inherently this soil has low fertility. Other dominating classes are llles – lVes and lVes – Vlll.

SUGGESTIONS

- These soils require adequate plant cover. This can be made by cropping systems that can support plant cover.
- The area should be protected from soil erosion. Soil structure building and other check measures should be done.
- Proper surface drainage should be provided using irrigation facilities.
- Practices like contour tillage, check dams, terraced farming etc. can ensure soil and drainage security.

REFERENCE

1. Harold, Baker (1982): "Land Classification as a Basis of Land Use Planning in Hawaii, in proceedings of International Symposium on Land Use Planning in Developed Countries," Bangkok, pp 2.1-2.8
2. Dave Miller, Keith Matthews (2012): "Final Report, Future CAP Payments LCA Mix per Parish – An analysis of Land Capability for Agriculture (LCA areas) for each Agricultural Parish," James Hutton Institute.
3. R D, Doi (1990): "Land Capability Classification in Semiarid Moral River Basin- A case Study in the Methodology," Annals of the National Association of Geographers of India, Vol. 10, No. 1, pp. 47- 51.
4. H. Gaussen, P. Legris and Mehr Homji (1981): "Ecoclogical Approach to Land Capability Classification and Regional Planning," Perspective in Agricultural Geography- Land Use and Planning, Vol. III, pp. 89-108.
5. Nayak L. T. and D. S. Narayankar (2009): "Spatial Pattern of Carrying Capacity of Land in Bellary District, Karnataka State," The Deccan Geographer, Vol. 48, No. 2, pp. 49-57.
6. V, Nagarathinam (1982): "Terrain Evaluation for Land Use Planning- A Micro Level Study in Proceedings of International Symposium on Soil, Geology, Land Form," Impact of Land Use Planning in Developed Countries, Bangkok pp. 7.1 – 7.26.
7. Natural Resources Data Bank Kannur (2012), Kerala State Land Use Board.
8. Stray Creek Catchment Vegetation Survey (2005): "Northern Territory, Department of Infrastructure, Planning and Environment, Northern Territory," Australia, pp. 104-108.

WEBSITE

1. P Tiwari, Land Capability Classification of India, http://www.geographynotes.com/articles/land-capability-classification-of-india/962 (16/11/2015)
2. Brian Pack Inquiry, (Oct 2009 - Dec 2010)
3. http://www.gov.scot/Topics/farmingrural/Agriculture/inquiry (16/11/2015)

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MAPPING (UNDER) DEVELOPMENT AND SOCIAL CAPITAL AS A PART OF SPATIAL GOVERNANCE STRATEGY: A CASE STUDY OF MEWAT, HARYANA

Naresh KUMAR[1]

ABSTRACT

Underdevelopment does not mean the absence of development. It means dependent, distorted and truncated development, which also symbolizes disarticulation of the economy and society. Underdevelopment here is conceptualised as (under)development meaning thereby that it does not only looks at the material aspects of development but also the social aspects, which are equally important. Social Capital resides in relations of people. The accumulation of these relations generates instrumental use of resources and in turn generates Social Capital. Therefore, Social Capital is presented here as a 'missing link' to overcome (under)development. This paper proceeds with three objectives: to look at the structure of (under)development, to identify the aspects of Social Capital and what is the relationship between (under)development and Social Capital. To fulfil these objectives, a socio-economic field survey of 150 households was conducted in Mewat, Haryana. The field survey reveals that sample households show a very high level of (under)development in demographic structure, educational attainment, natural resource base, agriculture, use of common resources and household industry. Social Capital is a 'missing link' in spatial governance of development.

The field survey shows that more than half of the sample households reported participation while 30 percent did not participate in the last Panchayat elections. When asked why they did not vote, they said that nothing changed. It also highlights the lack of trust in the participation of Gram Panchayats elections. The majority of the sample households (97 percent) reported that they did not get employment under MGNREGA. There is a negative correlation between (under)development and Social Capital, which means that if there is a high level of (under)development, there is less possibility of formation of Social Capital there. Similarly, if there is high Social Capital, then there is less possibility of (under)development. Thus, it can be argued that Social Capital as a spatial governance strategy can be effective in overcoming the process of (under)development at the local level in Mewat, Haryana.

Keywords: *Spatial Governance of Development, Mapping (Under)development, Mapping Social Capital, (Under)development and Social Capital, Mewat.*

INTRODUCTION

This paper looks at the interface of underdevelopment and Social Capital as a part of spatial governance strategy in Mewat, Haryana[1]. It is an exploratory study. Development and underdevelopment both are related (Frank 1966, Patnaik 1990). Underdevelopment does not mean the absence of development. It means dependent, distorted and truncated development. Here development does not have a dynamism of its own and is affected by outside forces. It symbolizes disarticulation of the economy (Amin 1976). However, the concept only looks at the material aspects of development[2]. It ignores social dimensions of development, which are equally important. These social dimensions can be best captured in the form of Social Capital.

Social Capital resides in relations of people (Putnam, Leonardi and Nanetti 1993). It is a 'missing link' in development (Grootaert 1998)[3]. Also, there has to an interface between underdevelopment and Social Capital at the local level in the form of (under)development and it can be better analysed by looking at the unit level data. Mewat is a region in southern Haryana. The Mewat Development Board (MDB) was constituted in 1980 to improve the socio-economic condition of the people of this area. At the field level, Mewat Development Agency (MDA) looks at the work carried out by the MDB. The region comprises Taoru, Nuh, Ferozepur Jhirka, Punhana and Hathin tahsils. Mewat is at the lower ladder in almost all the parameters of development (Kumar, 2013)[4].

OBJECTIVES, DATA SOURCE AND METHODOLOGY

There is an acute paucity of secondary data to understand (under)development and Social Capital. This paucity of data has seriously hampered the process of acquiring an in-depth understanding of (under)development and Social Capital at the local level in Mewat. The paper proceeds with three objectives: to look at the structure of

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(under)development, to identify the aspects of Social Capital and what is the relationship between (under)development and Social Capital. To fulfil these objectives, a socio-economic field survey of 150 households was conducted in Taoru tahsil by selecting the three Panchayat villages of Raheri, Kharkhari and Sewka[5]. In each village, 50 households were surveyed. The households were selected by purposive random sampling. The survey was done through the questionnaire and the respondents were asked about their responses. Variables of (under)development include demographic structure, educational attainment, natural resource base, agricultural development, common resources and household industry. Variables of Social Capital are participation in the Panchayat elections, Mahatma Gandhi National Employment Guarantee Act (MNREGA). Pearson correlation is used to understand the relationship between the variables of development. Bar and thematic diagrams are used. This paper is organized into ten sections. The paper begins with the structure of (Under)development.

MAPPING (UNDER)DEVELOPMENT

Demographic Structure

Demographic structure constitutes an important part of the development process at any point in time. This constitutes the human resource and this human resource contributes to social advancement in one way or the other. Table 1 shows variables of the demographic structure.

Table 1
Demographic Structure of Sample Households
(in Percent)

Sex Composition	Male	54.5
	Female	45.5
	Sex Ratio	836
Age composition	Below 14	16.84
	15-59	64.03
	Above 60	17.30
	Dependency ratio	53.32
Household Size	Household Size	6.00
Marital Status	Currently Married	38.27
	Widowed	1.50
	Divorced	0.12

Source: Socio-economic Field Survey Mewat, 2011.

The variables include sex ratio, age composition, dependency ratio, household size and marital status of the sample households. Sex ratio in the sample households is 836 females per one thousand males. Age composition of the sample households reveals that there are about 16.84 percent households in the below 14 age group followed by 64.03 percent in 15-59 age group and 17.30 percent in above 60 age group. The dependency ratio is 53.32 percent. Household size is six per household in the sample households. Marital status of the households shows that there is about 38.27 percent currently married households, 1.50 percent widowed households and 0.12 divorced households.

Educational Attainment

Education is critical for social development in society. Table 2 shows the levels of education of the sample households. There are about 67.95 percent not literate sample households. About 3.61 percent sample households are literate without formal schooling. There are 1.05 percent sample households below primary followed by 17.13 percent in the primary, 6.29 percent in the middle school, 2.21 percent in the secondary school, 1.28 percent in the higher secondary and 0.35 percent graduates.

Table 2
Educational Attainment of Sample Households

Levels of education	*Percent*
Not literate	67.95
Literate without formal schooling	3.61
Below primary	1.05
Primary	17.13
Middle	6.29
Secondary	2.21
Higher Secondary	1.28
Graduate	0.35

Source: Socio-economic Field Survey Mewat, 2011.

Occupational Structure

The level of development and consequent (under)development depends on upon changes in the occupational structure of the population. Table 3 shows the occupational structure as employment status and types of work.

Table 3
Occupational Structure
(in Percent)

Employment Status	Employed	23.22
	Out of Labour Force	76.43
	Unemployed	0.35
Types of Work	Self-employed	1.75
	Casual Labour	20.42
	Others	77.83

Source: Socio-economic Field Survey Mewat, 2011.

Employment status shows that there are about 23.22 percent employed households followed by o.35 percent unemployed households. An overwhelming 76.43 percent of sample households are reported to be out of labour force. Type of work of the sample households shows that there are about there are about 1.75 percent sample households in the study area followed by 20.42 percent engaged in casual labour and 77.83 percent others.

Housing Amenities

Availability of amenities is a pre-requisite for development. Table 4 shows variables of amenities in the sample households. The first variable looks at the source of drinking water in the sample households. Hand pump (99.33 percent) is the main source of drinking water in the sample households while less than one percent (0.67 percent) use tape. The second variable looks at the location of drinking water. Most of the sample households (85.23 percent) report that the location of drinking water is away from the premises while 14.77 reports near the premises.

Table 4
Housing Amenities in the Sample Households

(in Percent)

Source of Drinking Water	Tape	0.67
	Hand Pump	99.33
Location of Drinking Water	Near the premises	14.77
	Away from the premises	85.23
Source of Light	Electricity	40.27
	No light	59.73
Latrine Facility	No Latrine	85.23
	Service Latrine	1.34
	Pit Latrine	13.42
Drainage Facility	Open Drainage	97.99
	No Drainage	1.34
Bathroom Facility	Yes	99.33
Kitchen Facility	Yes	0.67
	Cooking in the open	98.66
Fuel for Cooking	Firewood	85.51
	Crop residue	0.72
	Dung cake	13.77
Radio/Transistor	Yes	2.00
Television	Yes	6.00
Mobile	Yes	49.30
Bicycle	Yes	0.70
Scooter/motorcycle	Yes	2.00
Money lending	Commercial Bank	2.00
	Private Moneylender	98.00

Source: Socio-economic Field Survey Mewat, 2011.

The third variable is source of light. About 40.27 percent households report electricity as a source of light while 59.73 percent report no light. The fourth variable is latrine facility. The majority of the sample households (85.23 percent) report no latrine facility, service and pit latrine are available in 1.34 and 13.42 percent sample households. The fifth variable is drainage facility. About 97.99 percent sample households report open drainage facility while 1.34 percent households do not have any drainage facility.

The sixth variable looks at bathroom facility. Most of the sample households report bathroom facility. The seventh variable looks at kitchen facility. Most of the sample households (98.66 percent) report cooking in the open while 0.67 percent report kitchen facility. The eighth variable looks at the availability of fuel for cooking in the sample households. The majority of the sample households (85.51 percent) use firewood as a fuel for cooking followed by Dung cake (13.77 percent) and crop residue (0.37 percent). There is a general lack of modern amenities in the sample households, which is shown by radio (2 percent) and television (6 percent). Half of the households (49.30 percent) own mobile phones, bicycle (0.70 percent), scooter/motorcycle (2 percent). Majority of the sample households borrow from private moneylender (98 percent) followed by commercial banks (2 percent).

Migration

Majority of the sample households reported zero in and out migration in the sample villages. Most of the sample households reported daily commuting for work outside the village to Taoru city and the Bhiwadi industrial area for daily wage. It may be possible that the unskilled labour have less incentive to migrate as compared to the skilled and the rich. Migration is a dynamic agent of social and economic change.

(UNDER)DEVELOPMENT IN NATURAL RESOURCE BASE

Distribution of Landholdings

Natural resources play an important role in economic development and consequent social development. Table 5 shows the distribution of landholdings by size class in the sample households.

Table 5
Distribution of Landholdings by Size Class in the Sample Households (in Acres)

Size class of Operational Landholding	*Percent*
Landless	52.35
Less than 5	31.26
5-10	11.20
10-15	4.50
15-20	0.69
More than 20	0.00

Source: Socio-economic Field Survey Mewat, 2011.

It shows that more than 50 percent (52.35 percent) of the sample households are landless. Majority of the sample households are marginal. Small and semi-medium farmers (31.26 percent) followed by medium farmers (11.20 percent) and large farmers less than one percent (0.69 percent).

AGRICULTURAL (UNDER)DEVELOPMENT

Distribution of Landholdings

The main occupation of the people of Mewat is agriculture allied with animal husbandry. Agriculture plays an important role in the livelihood of the people. Therefore, the distribution of land becomes very important in this context. Table 5 shows the distribution of landholdings in the sample households. Table shows that more than 50 percent (52.35 percent) of the sample households do not have land. Thus, landlessness is the chief characteristic feature of the sample households. About 31.26 percent of the landholdings belong to the marginal, small and semi-medium farmers (less than 5 acres). About 11.20 percent landholdings belong to the medium farmers (5-10 size) while 5.19 percent landholdings belong to the large farmers of which 4.50 percent belong to the 10-15 landholding size class and 0.69 percent to the 15-20 size class. None of the sample households own more than 20 acres.

Table 6
Distribution of Landholdings by Size Class in Sample Households

Size class of Operational Landholding (Acres)	*Percent*
Landless	52.35
Less than 5	31.26
5-10	11.20
10-15	4.50
15-20	0.69
More than 20	0.00

Source: Socio-economic Field Survey Mewat, 2011.

Sources of Irrigation

In a semi-arid region, irrigation is important to agricultural economy. Table 6 shows the sources of irrigation. The major source of irrigation is tube well without electricity, reported by 36.73 percent of the sample households.

Table 7
Sources of Irrigation in the Sample Households

	Percent
Tube Well with Electricity	1.36
Tube Well without Electricity	36.73
Government Canal	3.40
Rain fed	58.51

Source: Socio-economic Field Survey Mewat, 2011.

About 3.40 percent sample households report irrigation by the government canal while 1.36 percent report irrigation by tube well with electricity. More than 50 percent (58.51 percent) of the sample households report that they are dependent upon rainfall for irrigation.

Tenure Status

Tenure status indicates the ownership of land. Most of the sample households reported having owned landholdings. Majority of the sample households (99.33 percent) reported that they neither leased-in nor leased-out land. Less than one percent (0.67 percent) of the sample households reported that they used fixed produce for leasing of land.

Use of Modern Inputs into Agriculture

Use of modern inputs is necessary for agricultural development. The modern inputs include chemical fertilizers, green manures and pesticides. About 20.81 percent sample households report the use of chemical fertilizers. About 66.44 percent of the sample households report that they did not use chemical fertilizers at all and 12.75 percent did not reply. About 48.98 percent of the sample households report the use of green manures while 36.73 percent did not use green manures. About 14.29 percent sample households did not give any response. Only 21.48 percent sample households report the use of pesticides and 66.44 percent report no use.

Table 8
Use of Modern Inputs

(in Percent)

Use of Chemical Fertilizers	Yes	20.81
	No	66.44
	Did not reply	12.75
Use of Green Manures	Yes	48.98
	No	36.73
	Did not reply	14.29
Use of Pesticides	Yes	21.48
	No	66.44

Source: Socio-economic Field Survey Mewat, 2011.

COMMON RESOURCE

Community Pastures and Sacred Groves

Common resources constitute an important resource for the village communities. They are crucial to the livelihood of people. Common resources here include community pastures and sacred groves. About 89.93 percent of the sample households report that community pastures exist in and around the village. The animals go for grazing there. The number of community pastures has decreased over a period of time. Due to the decline of pastures, there are only a few left to graze the animals. Some pastures are on the Shamlat Deh owned by the Gram Panchayat of the village. When animals are taken for grazing, sometimes they sneak into the nearby fields and destroy the crops. Due to this, there are often fights among the villagers. The sacred groves have been cleared indiscriminately. Therefore, there are only a few left and they are also in danger of being cleared.

Household Industry

Majority of the sample households reported that there is no household industry in the village. One household was reported to have a small shop for repairing of motorcycles and scooters in the village. Even the traditional *Atta Chakki* machine was operative in the sample households. The respondent households reported the lack of financial support from the government for household industries. The respondents were not aware of the Multi-sectoral development Programme (MSDP).

All the variables of (under)development indicate the persistence neglect and exclusion of Mewat from the mainstream development process. It also indicates that there is a continuance of ad-hoc approach towards the development of the region. It also highlights the apathy of the policymakers towards the region. All these aspects have resulted in (under)development in the region.

SOCIAL CAPITAL

Participation in Gram Panchayats

Social Capital resides in relations. It is an accumulation of these relations over a period of time that it builds itself in the form of trust, solidarity, associatedness and civic engagement. Social Capital is a 'missing' link in development (Grootaert: 1998). Gram Panchayat represents an important source of Social Capital in the village (Chopra 2002). They function properly if there is active participation of the people in its functioning. The participation of the people can be captured to some extent by looking at the voting in the last Panchayat elections.

About 68.06 percent sample households reported that they have voted in the last Panchayat elections in the village while 31.94 percent sample households reported that they did not vote. When asked why they did not vote, they reported that nothing changed due to voting in the village. Their condition remained the same. Along with lack of participation, it also indicated lack of trust in the Gram Panchayats. They have failed to deliver to the people. The lack of trust has resulted in factionalism in the village (Lewis 1954). All these have serious implications for Social Capital in the sample villages.

Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)

MGNREGA provides livelihood to the adult people and crucial in creating social assets in the rural areas. It provides 100 days of employment to every adult member of the household. Majority of the sample households (97 percent) reported that they did not get employment under this scheme. Most of the respondent household are not even aware of the scheme and its legal entitlements. Only 3 percent of the sample households reported that they got employment under this scheme. In Sewka village, levelling of road was going on and one road roller was working with two labourers.

Health Facilities

Provision of health care is a basic pre-requisite for development. Higher provision of health care facilities leads to all round development of the mother and the child. Anganwadi Centres in rural areas provide health and nutrition information to the pregnant and lactating mothers and children. Anganwadi centres also provide pre-school education to the children from three to six years. About 88.8 percent of the sample households reported that Anganwadi Centres is providing health and pre-school education to the pregnant and lactating mothers and the children (0-3 and 3-6 years).

Table 9
Provision of Education and Health Care

Mid day meal	96.50
Pre-school education	99.30
Nutrition and Health education	94.40
Vaccination of Polio, DPT and Measles	94.63

Source: Socio-economic Field Survey Mewat, 2011.

Mid day Meal (MDM) is an important component of school education and helps in fulfilling the nutritional needs of the population. About 96.5 percent of the sample households reported Mid Day Meal facility in school while 3.5 percent replied in the negative. About 99.30 percent of the sample households reported that pre-school education is being provided in the Anganwadi Centres and 0.70 percent reported that no pre-school education is provided there. About 94.4 percent of the sample households reported that Anganwadi Worker and Anganwadi Helper are providing health and nutrition facility in the Anganwadi Centre while 5.60 percent households reported no such facility. About 99.30 percent of the sample households reported polio vaccination followed by 95.10 percent households reporting DPT vaccination and 89.50 percent measles. About 5 percent of the sample households reported that they did not get DPT vaccination followed by 10.50 percent for measles.

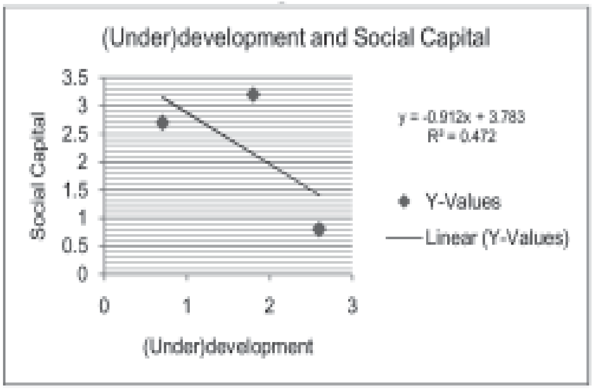
Correlation between (Under)development and Social Capital

This paper looks at the interface between (under)development and Social Capital and this can be done by looking at the correlation among the variables of (under)development and Social Capital.

Fig. 1

Variable	General Education	Employment Status	Availing Banking Services	Net Area Under Cultivation	Did you vote in the Last Panchayat Elections?	Mid Day Meal	Safe Delivery
General Education	1						
Employment Status	-0.02	1					
Sig. (2-tailed)	0.79						
Availing Banking Services	-0.06	-0.67	1				
Sig. (2-tailed)	0.48	0.00					
Net Area Under Cultivation	0.08	0.26	-0.15	1			
Sig. (2-tailed)	0.36	0.00	0.07				
Did you vote in the Last Panchayat Elections?	0.17	-0.12	0.1	0.09	1		
Sig. (2-tailed)	0.05	0.18	0.23	0.32			
Mid Day Meal	-0.04	-0.07	-0.07	-0.05	0.04	1	
Sig. (2-tailed)	0.64	0.42	0.41	0.58	0.65		
Safe Delivery	0.12	-0.05	0.04	-0.06	0.07	-0.03	1
Sig. (2-tailed)	0.15	0.60	0.65	0.51	0.41	0.77	

**. Correlation is significant at the 0.01 level (2-tailed).



Association among some variables is very weak if we look at the correlation matrix of some of the seven variables. General education shows low correlation (0.17) with voting share in the Panchayati elections although the significant level is very high (0.79). The variables, which are positively correlated although low, are net area under cultivation and employment status, safe delivery and general education. The negatively correlated are employment status and availing Banking services (-0.67), net area cultivation and availing Banking services (-0.15). Therefore, it shows that the various variables here do not show any strong association. It shows that development process is extremely fractured, complex, disarticulated and could be due to other factors. There is negative correlation between (under)development and Social Capital, which means that that if there is (under)development, there is less possibility of formation of Social Capital there. If there is high Social Capital, there would be low (under)development. Therefore, (under)development is very much entrenched in the region at the household level.

CONCLUSION

Thus on almost all parameters of development, sample households show a very high level of chronic (under)development. High level of illiteracy show extreme social deprivation and lack of awareness. Most of the households comprise non-workers. Non-workers show higher dependency ratio upon the working labour force. Even the basic amenities like drinking water are not available to all the sample households. Moreover, they get it away from the premises. The groundwater is brackish. Modern amenities like banking facilities are conspicuous by their absence. About 52.35 percent of the sample households are landless and show their poor resource base. Only 41.49 percent of the area is under irrigation and the rest depend upon rainfall for irrigation.

Majority of the sample households report the existence of community pastures. However, they are declining at a fast pace. The sacred groves are few and the illegal encroachers are clearing them indiscriminately in the absence of adequate community safeguards. There is no household industry as such. Thus, (under)development is heavily entrenched in Mewat at the household level. The process of (under)development can be overcome by generating Social Capital in Mewat. Social Capital is a 'missing link' in development. More than half of the sample households reported participation while 30 percent did not participate in the last Panchayat elections. When asked why they did not vote, they said that nothing changed. It also highlights lack of trust in the participation of elections.

Majority of the sample households (97 percent) reported that they did not get employment under MNREGA. In one sample village, sample households reported the use of heavy machines, which is prohibited in MNREGA, and highlights the violation of the field manual. It also means that the adult households are being denied the work under the scheme. Health and nutrition facility is being provided to the pregnant and lactating mothers in the sample households. Majority of the sample households report the use of Mid Day Meal in school and pre-school education in Anganwadi Centre. In the end, the paper looks at the relationship between (under)development and Social Capital.

It shows that the most of the variables here do not show any strong association. It shows that development process is extremely fractured, complex, disarticulated and could be due to other factors. It also shows that there is negative correlation between (under)development and Social Capital, which means that that if there is high level of (under)development, there is less possibility of formation of Social Capital there and vice-versa. Thus, it can be argued that Social Capital as a spatial governance strategy can be important in overcoming the process of (under)development at the unit level in Mewat, Haryana.

Acknowledgement

The author expresses his gratitude to Professor B.S. Butola for his comments and suggestions in the preparation of this paper.

Notes

2. The major reason behind the emergence of Social Capital as a spatial Governance strategy is that it is easily available to the poor communities. See Saegert, Susan. Hompson, J. Philip and Warren Mark R. (2005): *Social Capital and Poor Communities* (New York: The Russel Sage Foundation) for more details.
3. The major criticism of the Marxian theory is that it mainly looks at the material aspects of development and ignores other aspects. The other aspects include social and cultural. See Bourdieu (1986) for more details.
4. The missing link here refers to the institutions of governance. Institutions are an important part of the development process in the sense that these provide scope for interaction and discussion for cooperation and benefit. See Christiaan Grootaert (1998) for more details.
5. There are a number of anthropological studies, which look at the nature of development in Mewat region. These include Amir Ali (1970) and Aggarwal (1971).
6. Taoru is the adjacent tahsil of the Mewat region with Gurgaon district in the north and Rajasthan in the west. Gurgaon is comparatively more developed than Mewat. Therefore, this tahsil also shows the external economies of scale.

REFERENCES

1. Ali, Hashim Amir. (1970): *Meos of Mewat: Old Neighbours of New Delhi*, (New Delhi: Oxford and IBH Publishing Co.)
2. Amin, Samir (1976): *Unequal Development: An Essay on the Social Formations of Peripheral Capitalism*, (New York: Monthly Review Press).
3. Bourdieu, Pierre (1986): "The Forms of Capital" in John G. Richardson (ed.), *Handbook of theory and research for the sociology of education*, (London: Greenwood), 46-58.
4. Chopra, Kanchan (2002): "Social Capital and Development Processes: Role of Formal and Informal Institutions", *Economic and Political Weekly*, 37(28), 2911-2916.
5. Frank, Andre Gunder (1966): "The Development of Underdevelopment", *Monthly Review Press*, 18(4), 17-31.
6. Grootaert, Christiaan (1998): Social Capital: The Missing Link? Working Paper 3, WorldBank, Accessed at http://siteresources.worldbank.org/INTSOCIALCAPITAL/Resources/Social-Capital-Initiative-Working-Paper-Series/SCI-WPS-03.pdf.
7. Kumar, Naresh (2013): "Political Economy of Under Development in Mewat, Haryana", *Indian Cartographer*, 33(1), 235-241.

8. Lewis, Oscar (1954): Group *Dynamics in a North Indian Village: A Study of Factions*, (New Delhi: Programme Evaluation Organization, Planning Commission, Government of India).

9. Maheswari, Belu (2003): "The Meos of Mewat: Perspectives on Ethnicity and Nation Building", *Social Change*, 33(1), 81-91.

10. Mukherjee, Neela (2002): "Measuring Social Capital: Forest Protection Committees in West Bengal", *Economic and Political Weekly*, 37(29), 2994-2997.

11. Pal, Mahi (2005): "Role of Social Capital in Haryana", *Economic and Political Weekly*, 40(9), 822-823.

12. Patnaik, Utsa (1990): *Agrarian Relations and Accumulation: the 'mode of production' debate in India,* (Mumbai: Sameeksha Trust).

13. Patnaik, Prabhat (2001): "Imperialism and the Diffusion of Development", *Social Scientist*, 29(3/4), 3-18.

14. Putnam, Robert D., Robert Leonardi and. Raffaella Y. Nanetti (1993): *Making Democracy Work: Civic Traditions in Modern Italy*, (Princeton: Princeton University Press).

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INTRA-REGIONAL DISPARITIES IN DEVELOPMENT IN TELANGANA

P. Padmanabha RAO[1]

ABSTRACT

This paper focuses on inter-district and intra-district variation in development across different districts in the State of Telangana. The study relates to disparities in various indicators of agriculture, irrigation, industrial, infrastructure and human resource development. The analysis has been done by comparing averages for various development indicators from 1981-1982 and 2011-12 to compare the Inter-district and intra-district inequalities in Telangana. On the basis of these indices, the paper classified the different districts and sub-districts of Telangana into very backward, backward, developing and developed categories using GIS and other cartographic Techniques.

The basic objective is to examine whether micro-level disparities and deprivations are much wider and alarming than the aggregate level and whether region-specific, district-level planning needs to address these issues on a priority basis. This paper tries to answer some of the following questions. What is the pattern of change among different sub-sector of industry, agriculture, and Services sectors? What policy options would be effective in addressing regional disparities?

The analysis shows that the state's fluctuating growth rates could not keep pace with the national average. Agriculture and irrigation suffered neglect in plan expenditure. Almost all the districts in were in a lower state of development. The type of intervention would help to reduce regional imbalances, are the development of better communications between the core urban center and remote rural peripheries in order to encourage agricultural productivity and lower transaction costs for enterprises in the periphery, and innovative financial instruments for financing public-private partnership infrastructure projects in under-developed regions. Social support programmes for women and the elderly need to be encouraged. There is a need for policy intervention in these peripheral districts in order to reduce regional disparities.

Keyword(s): *Telangana, Regional Development, Disparities, agriculture, infrastructure.*

INTRODUCTION

Widespread inter-state disparities in levels of economic and social development can have serious economic, social and even political consequences, this being particularly so if these have persisted over long periods of time. The Regional problem in India has a multidimensional manifestation. The problem not only exists at the National level but also at the Sub-National and state levels. Thus, Inter-Regional and Intra-Regional Imbalances persist simultaneously. The prolonged agitations in various parts of the country illustrate the problem of Sub-Nationalism. A detailed study examining the nature, extent, possible causes and manner of change of inter-state economic and social disparities and drawing broad inferences regarding regional policy would hence be of considerable relevance to policy-makers and planners, particularly since the period covered by the study includes a decade before the economic reforms and afterwards.

Regional disparities in development have been growing in India, especially in the post-reform period. What is true of rising inter-State disparities in development would be true of regional disparities within some of the larger States, as the factors contributing to such disparities would be the same in both the situations. The neglect of agriculture, rural development and the social sectors in the post-reform period and the consequent rise in rural distress together with the concentration of private investment and proliferation of economic opportunities in the developed regions has brought into sharp focus the regional divide or the rise in inter-State as well as intra-State disparities in development.

Public investments in physical and social infrastructure have an equalizing impact because they can be focused on backward regions. Further, public investment, in turn, induces private investment. The role of the state has changed dramatically from that of the main provider of investment in infrastructure in the pre-liberalization period to a facilitator of private investment in the post-liberalization period. The earlier role had a moderating influence on regional disparities insofar as backward regions also benefited to some extent from investments in infrastructure, whereas the new role is fraught with adverse consequences for these regions within the State. This is because private investment and technology flow basically to the regions where physical and social infrastructure is already well-

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developed. The impact seems to be in the direction of increasing inequalities between different regions and income groups. This shows that certain backward regions may use this enormous potential offered by state power effectively for their development.

'Development' in the sense of equitable share in water resources, jobs, opportunities for enterprise and career advancement and adequate voice in political decision-making is not possible within the Region. Indeed, in a democratic polity, some development has to take place in different parts of the country including even the remotest areas. The issue really is about the rate and quality or pattern of development. Apart from equity, such as a due share in investment allocations, quality also refers to the cost, risks, and sustainability of development.

The basic objective is to examine whether micro-level disparities and deprivations are much wider and alarming than the aggregate level and whether region-specific, district-level planning needs to address these issues on a priority basis.

This paper tries to answer some of the following questions.

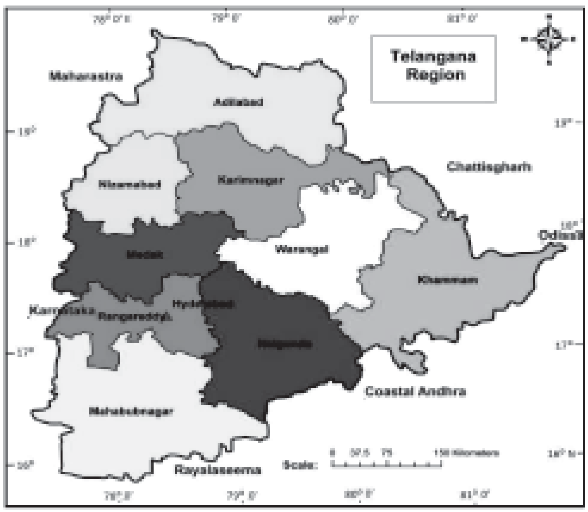
- What is the pattern of change among different sub-sectors of industry, agriculture, and Services sectors?
- What policy options would be effective in addressing regional disparities?

This paper focuses on inter-district and intra-district variation in development across different districts in the State of Telangana. The study relates to disparities in various indicators of agriculture, irrigation, industrial, infrastructure and human resource development. The analysis has been done by comparing averages for various development indicators from 1981-1982 and 2011-12 to compare the Inter-district and intra-district inequalities in Telangana. On the basis of these indices, the paper classified the different districts and sub-districts of Telangana into very backward, backward, developing and developed categories using GIS and other cartographic Techniques.

Telangana Emerged as a new state by dividing from AP. It has an area of 114000sq.km, including with state capital. Telangana became the 29th state of India. The newly created state consisting of 10 districts namely Adilabad, Nizamabad, Karimnagar, Medak, Warangal, Rangareddy, Khammam, Nalgonda and Mahbubnagar, apart from the metropolis of Hyderabad. Telangana is triangular with the Penganga, Wardha, Pranahita and Godavari as its northern boundary, while the rivers Krishna and Tungabhadra serve as the southern boundary. The state is surrounded in its northwestern and northern directions by Maharashtra. Karnataka encircles the state towards the west and Chhattisgarh lies to its northeastern direction, to the east is Odisha. Most part of the region lies on the Deccan plateau. Districts are grouped into poor, medium rich and rich, based on average monthly per capita expenditure; more than 10% of the rural population in Telangana lived in poverty in five out of 10 districts.

The region has a larger share of scheduled castes and tribes, whose socio-economic conditions are far inferior. The Scheduled Castes are distributed throughout the state; the Scheduled Tribes are concentrated in the hilly and forest areas of Khammam, Warangal and Adilabad districts.

Economic conditions, in general, are the outcomes of the availability of employment opportunities and the occupational structure. Most of the SC/STs continue in their traditional hereditary occupations, mostly agriculture, which is the principal source of



Figs. 1 and 2: Location of Telangana and Telangana Administrative Divisions

Table 1
Percentage Decadal Variation of Population and Sex Ratio

Sl. No.	District	Percentage of Decadal Variation					Sex Ratio (No. of Females per 1000 Males)					
		1961-71	1971-81	1981-91	1991-01	2001-11	1961	1971	1981	1991	2001	2011
1	Adilabad	27.65	27.32	26.95	19.47	10.18	981	976	980	980	989	1001
2	Nizamabad	29.01	27.90	21.31	15.12	8.77	1007	999	1013	1017	1017	1040
3	Karimnagar	21.12	24.05	24.68	14.96	8.15	996	985	994	986	998	1008
4	Medak	19.10	23.11	25.60	17.64	13.60	996	986	982	970	974	992
5	Hyderabad	41.17	33.81	39.76	21.74	2.97	953	936	920	933	933	954
6	Rangareddy	27.50	43.47	60.32	40.09	48.16	-	-	956	941	944	961
7	Mahabubnagar	21.46	26.53	25.87	14.20	15.34	1003	988	983	973	972	977
8	Nalgonda	16.82	25.28	25.11	13.88	7.41	950	965	969	962	966	983
9	Warangal	21.06	22.95	22.54	15.15	8.21	954	956	964	962	973	997
10	Khammam	29.54	27.86	26.50	16.39	8.47	958	957	957	961	975	1011
Telangana		**24.43**	**27.58**	**29.27**	**18.77**	**13.58**	**975**	**961**	**971**	**967**	**971**	**988**
India		**24.80**	**24.66**	**23.85**	**21.54**	**17.69**	**941**	**930**	**934**	**927**	**933**	**943**

Source: The Office of Registrar General & Census Commissioner of India.

livelihood for them. The work participation rates by social groups are the highest among STs followed by SCs, OBCs, and the others. It can be observed that more than two-thirds of the workforce belonging to SC community working as casual labourers. And this is three times higher than the 'other' category.

The total area of the state will be 1.14 lakh square kilometres, which makes it the 12th largest in India. As per the 2011 census, the population of Telangana stands at 3, 51, 93,978 which makes it the 12th most populous in India. The number of male and female population is 1, 77, 04,078 and 2, 46, 48,731 respectively. The state has a total area of 1, 33,103 kilometer squares and the density of population is 296 per square kilometer. Further, the total literacy rate in the districts of Andhra is 66 percent. Sex ratio Nizamabad is having more female to males and Hyderabad is very less female rate when compare to male.

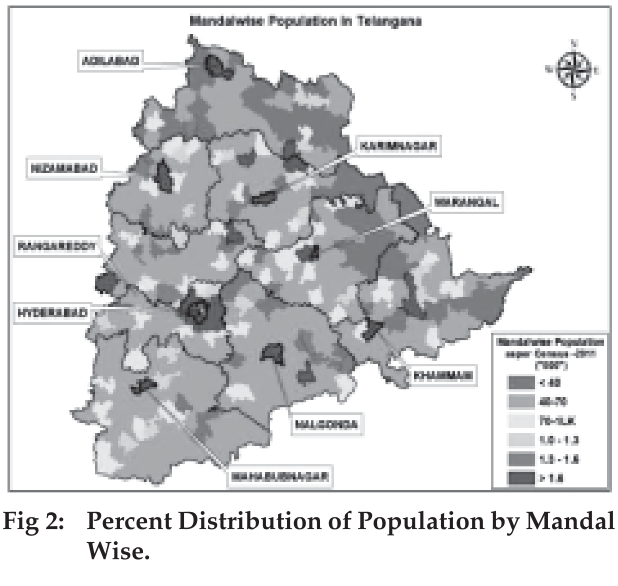


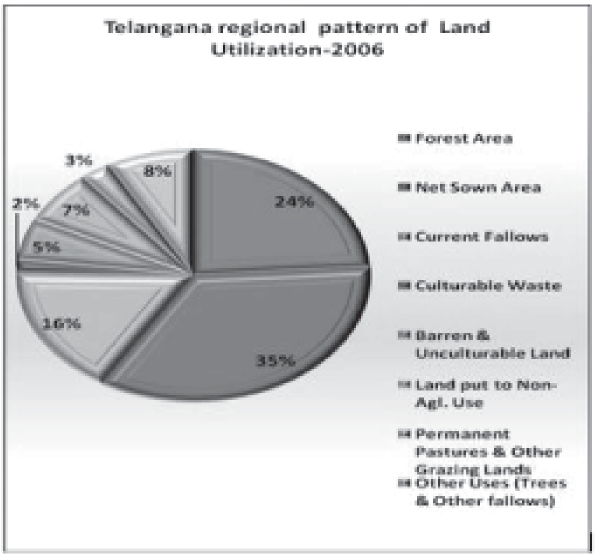
Fig 2: Percent Distribution of Population by Mandal Wise.

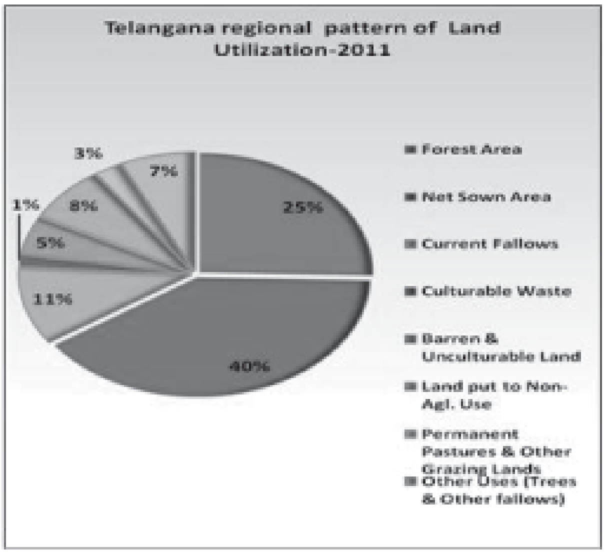
In 2001, the population of Telangana was 3,09,87,271 and had a 14.59% growth rate. However, in 2011, the growth rate dipped to 11.49%. Except for Rangareddy district, which registered a 48.15% growth in 2011 as against 40% in 2001, all the other districts showed a decline. The other exception being Mahbubnagar district which maintained the growth rate of 15%.

Agriculture plays a vital role in the economy of Telangana and the better performance of this sector is vital for inclusive growth. Although its contribution to gross state domestic product (GSDP) is around one-fourth, agriculture provides employment to nearly 60 percent of the workforce. There have been significant changes in the structure and performance of the agrarian economy in the state. In recent years, the state has also been facing a crisis in agriculture with a high incidence of suicides by farmers. Agriculture is the bedrock of the State's economy. Out of the total population, over 72.7% live in rural areas seeking their livelihood from Agriculture and allied sectors. The share of agriculture to state GSDP in 2013-14 is 13.86 percent at constant (2004-05) prices. The per-centage of agricultural workers according to 2011 Census is 55.7, which is slightly higher than All India at 54.6 percent. Agriculture is the main occupation for nearly 40 percent of households in the state of which 26.5 percent are self-employed and 12.5 percent are agricultural labour households.

The geographical area of the Telangana State is 114.84 lakh hectares, of which 43.20 percent is under Net Area Sown (49.61 lakh hectares), 23.89 percent is Forest Land (27.43 lakh hectares), 8.36 percent is Current Fallow Lands (9.60 lakh hectares), 7.79 percent Land is put to Non-Agricultural uses (8.95

lakh hectares), 5.36 percent is Barren and uncultivable land (6.15 lakh hectares) and 6.2 percent falls under Other fallows (7.17 lakh hectares) and remaining 5.2 percent is under Cultivable waste, Permanent pastures and other graz-ing lands, and Land under miscellaneous tree crops and groves are not included in the Net Area Sown (5.93 lakh hectares) in 2013-14.





Access to land is one of the important indicators of better livelihoods especially for those who depend on agriculture in rural areas. There was little difference in land owned and possessed across social groups and the SCs are, in fact, better placed in terms of land ownership. Landlessness became negligible. However, land available for cultivation is more important in an agrarian economy. All the land owned or possessed may not be available for cultivation for various reasons; about 45% of the population has been used only for the purpose of housing. The population living in households with cultivated land was 32% and 57% for SC and ST and the state average was 46.2%. Between 1993-94 and 2009-10 the percentage of rural population living in households with cultivated land declined to a considerable extent across all social groups, but the decline was the highest for ST followed by SC so that landlessness was increasing more among these socially disadvantaged groups.

The faster increase in the share of the population in Telangana reflects migration from other regions to Hyderabad. In spite of out-migration from Coastal Andhra to Hyderabad, mostly financed by the agricultural surplus generated from the 'green revolution'. In Telangana, only 40% of the total geographical area is used for agriculture and a large portion (23% of total geographical area) is fallow land (cultivable, but not cultivated in the reporting year). This large area of fallow land in Telangana is a sign of the neglect of the agricultural sector and a lack of investments in land development measures over the last five decades. Agricultural development of a region is dependent on the investments in the development of irrigation facilities. Tractors, electric pump sets and irrigated area are three important inputs in the agrarian economy. There was a shift of many districts in their relative position between 1956 and 2007 from low-to-high in electric pumps and fertilizer in Telangana region although this increased the irrigated area and productivity; it also raised the cost of production. In the use of farm machinery and other inputs, Telangana districts have also caught up.

The growth that has been taking place in Telangana may be characterized as high-cost growth. For example, the irrigation map of the region has changed completely. Tank irrigation occupied an important place a few decades ago. But now, over 70 percent of irrigation is through ground water and deep tube wells in large parts of Telangana. Moreover, we do not have any information on such vital aspects as the quantity of water to be supplied for Telangana on account of the proposed irrigation projects including from 'assured' sources.

Further, farming has become highly risky in Telangana. For a given failure of rainfall, the fluctuations in output are much greater now when compared to the earlier decades. There is much greater distress being reported from the rain-fed regions dependent on groundwater for irrigation where the suicide rates for farmers are high. Telangana region accounts for as many as two-thirds of the total number of farmers' suicides reported in the State between 1998-2006. The water crisis has affected sustainability: Land left fallow in Telangana has increased from 25 percent of cultivable land in the early 1970s to as much as 40 percent by 1999-2000. Pollution from industrial projects in certain areas has aggravated the crisis.

Agriculture is one of the key sectors of an economy development. Maximum people depend on it for their livelihood. It is also the backbone of the economy. Agriculture sector contributes the highest percentage in GDP. It is influenced to the state and central economy and growth and development of the economy of our country. After 60 years also we are not utilizing to water proper way. Agriculture in Telangana has attracted considerable attention in the past few years, mostly because of the suicides of hundreds of farmers during the 1997-98. Two perceptions have dominated the conventional wisdom. First, it is argued that agriculture in Telangana has long been both backward and stagnant. Second, it is argued that Telangana suffers from a serious insufficiency of irrigation resources, due to the neglect of by the government. This latter is regarded as one of the causes of the lack of agricultural growth.

Telangana has 22.89 lakh hectors area under irrigation. The state has Net Area Sown 50 lakh hectares, Net Irrigated Area 23 lakh hectares and Irrigation ratio% 46. The productivity of major crops is stagnant in recent years. The cost of cultivation has increased over the last decade, while farmer's income is not in tune with it. Over the years, the agriculture sector has been changed in Telangana. Farmers are influenced by modern technology. They are using mechanized tools to flow. Farmers are thinking different ways, after the Green Revolution they are producing cash crops. They want to continue with traditional agriculture crops and also implementing new cash crops such as Sugarcane, cotton. Increased labour cost, out-migration to nearby urban areas and inflationary pressures have added to the miseries of farmers' livelihoods.

Under canal irrigation, Warangal area has been increasing from 1987 to 2011(It is reached 0.9% to 3.5% mark). Rangareddy district has reverse situation; area decreased from 6 to 1% between the years of 1987 to 2011. Nizamabad (46%), Adilabad (41.4%), Nalgonda (41%) and Khammam (37%) districts were having good coverage under canal irrigation. Mahbubnagar (22%) and Karimnagar (28%) also had some good area

Table 2
District - wise Source of Irrigation in Telangana 1987-2011 (%)

Year	*1987*				*1997*				
Source	*Tank*	*Canal*	*TW+OW**	*OS*	*Tank*	*Canal*	*TW+OW**	*OS*	*Total*
Mahbubnagar	15.08	21.96	60.44	2.52	2.29	7.71	86.11	3.89	100
Ranga Reddy	17.64	5.9	71.67	4.78	2.31	1.37	93.17	3.15	100
Hyderabad	12.82	0	56.88	30.3	15.07	0.00	40.18	44.75	100
Medak	44.7	7.46	46.38	1.46	4.59	3.05	92.09	0.26	100
Nizamabad	19.07	46	28.29	6.64	6.07	12.77	78.86	2.30	100
Adilabad	38.74	41.48	18.1	1.68	17.16	17.13	63.77	1.94	100
Karimnagar	22.32	28.4	46.24	3.05	9.11	17.68	71.71	1.50	100
Warangal	50.88	0.93	46.19	2	9.05	0.15	90.04	0.76	100
Khammam	34.5	37.51	20.53	7.46	22.20	35.50	29.25	13.04	100
Nalgonda	9.11	41.13	46.19	3.57	5.44	37.49	51.23	5.84	100
Telangana	**28.96**	**26.01**	**41.26**	**3.77**	**8.87**	**16.88**	**70**	**3.97**	**100**
Year	**2007**				**2011**				
Source	Tank	Canal	TW+OW*	OS	Tank	Canal	TW+OW*	OS	Total
Mahbubnagar	3.76	16.44	75.95	3.85	1.31	12.12	83.23	3.35	100
Ranga Reddy	3.15	1.18	92.6	3.07	2.87	0.99	94.6	1.54	100
Hyderabad	0	0	0	0	0	0	0	0	100
Medak	2.14	1.2	95.78	0.87	4.16	1.76	92.37	1.71	100
Nizamabad	3.63	9.14	84	3.24	5.67	22.04	69.06	3.23	100
Adilabad	13.82	7.34	77.17	1.68	19.3	14.24	64.56	1.91	100
Karimnagar	7.1	4.62	88.18	0.09	7.53	22.17	70.26	0.03	100
Warangal	17.49	0.65	80.78	1.07	16.58	3.62	78.85	0.94	100
Khammam	20.75	34.33	35.48	9.45	21	31.47	39.77	7.75	100
Nalgonda	5.95	30.51	59.29	4.25	5.47	25.53	64.59	4.4	100
Telangana	**9.24**	**12.69**	**75.14**	**2.93**	**9.21**	**16.39**	**71.71**	**2.69**	**100**

Source: Statistical Abstract of Andhra Pradesh. TW+OW= tube well and other wells, OS= other sources, under canal irrigation in 1987. 2007 to 2011; Khammam (34 and 31%) has covered highest percentage area followed by Nalgonda (30 and 25%). Mahbubnagar (16 and 12%) also covered some area compared to other districts of Telangana. In 2007, all other districts were covered very low area (below 10%) due to these districts were got very less rainfall compare to 2011. These districts are picked up and covered good area because of received the heavy rainfall. Medak (1%) registered lowest coverage in 2007 whereas Rangareddy (1%) in 2011.

Well irrigation is the major source of all Telangana districts. For the past years, overall 70% of the area covered under Wells, Tube wells and dug wells. In 1987 all districts of the Telangana except Adilabad (18%), Khammam (21%) and Nizamabad (28%) districts, covered area between 46 to 71%. These seven districts were above Telangana (41%) average. Overall Telangana state districts tubewell and other well source covered a huge area in the year of 1997. Rangareddy covered 93% area and followed by Medak (92%) and Warangal (90%). Khammam had a very low area (30%) under wells. Tank and canal irrigation sources were lost their coverage area compare to 1987. In Telangana, 2007 year data tells how well irrigation important in the area. It covered 96% of the area in Medak district, due to received very low (817) rainfall. It was below Telangana average (948). Rangareddy also covered above 93% area due to decreasing of canal and tank irrigation area. This year received low rainfall. Other districts were also having more area irrigated area under wells. Such as Karimnagar (88%), Nizamabad (84), Warangal (81%), Adilabad (77%) and Mahbubnagar (76%) districts irrigated area between 76 to 88%. Nalgonda (60%) and Khammam (35%) districts were irrigated very less area. These districts are having more under canal and tank irrigation. Khammam district also covered very more area under other source irrigation. Karimnagar had a very low area under this other source irrigation.

In Telangana, some years ago farmers depended on canal irrigation and tanks irrigation but recently maximum no of the farmers are depending on borewells and dug wells. From 1987 to 2011, Telangana state depends on the tube and dug well irrigation; it's covered 41 to 72% of the area. From 2007 – 2011 area decreased under canal irrigation, increased area under well and other well irrigation. If observed wells irrigation in 1987 was 41% but in 2007 it increasing almost 2times. In 2007, Wells irrigation increased, but canal irrigation decreased 17 to 13%. Canal irrigation was decreasing in all years. In 1987, under this canal irrigation 26% was there, but in 2007 it decreased almost 50% of the area but in 2011, it increased 3% area. Tank irrigation maintains

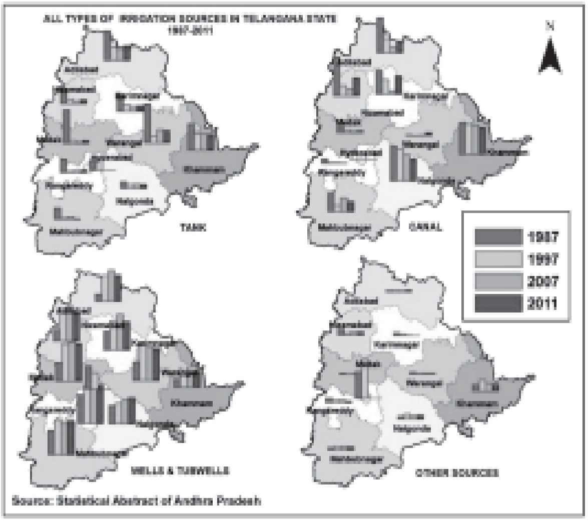


Fig. 3. District - wise source of Irrigation in Telangana 1987-2011 (%)

same percentage and 3% decreased in the area of under Canal irrigation. As per recent data (DES-2013) Net area irrigated by wells was the highest in 2009 at 84.33 percent and fell to 74.83 percent in 2013, while area irrigated by canals has increased from 5.07 percent in 2012 to 12.67 percent in 2013. During the given period, on an average, 76 percent of net irrigated area was through wells, showing the heavy dependence on well irrigation.

In the year of 1987, under tank irrigation, Warangal had highest area (51%), followed by Medak (45%), Adilabad (39%) and Khammam (34.5%). Other districts were lies between 9 to 22%. Nalgonda (9%) was covered lowest area. In 2007, Khammam (21%) had highest area under tank irrigation, followed by Warangal (17%), Adilabad (14%) and other all districts were 2 to 7% only. Medak district (2%) covered the lowest area. Whereas in 2011, Khammam has 21% area and followed by Adilabad (19%), Warangal (16.5%) and all other districts are having between 1-8%. Mahbubnagar is having very least area under tank irrigation. The government has taken the decision to provide water through the lift irrigation. This project has also not succeeded to facilitate water to irrigation. According to official sources, no water can be lifted from here unless the water level there was more than 74 metres. For the last one year, due to poor inflows the water level never went beyond 69 metres. As a result of it, Warangal district could not even get drinking water from this project which is meant to cater to the needs of Warangal, Karimnagar, Nalgonda and Medak districts through a series of 14 balancing reservoirs. It is designed to utilise 50 tmc of water from river Godavari.

Faster growth in the non-agricultural sector compared with the agricultural sector for an extended period and the concentration of the service sector in core cities has resulted in increased regional disparities in income between core (urban centers) and periphery (rural). Urbanization is higher in Telangana (38% of the population lives in urban areas in Telangana including Hyderabad). Districts surrounding the large urban center of Hyderabad in Telangana region are experiencing exponential growth in per capita income from the non-agricultural sector due to a fast-growing urban population, in part stimulated by a 'home market effect' (Reddy, 2011). However, the high growth of Hyderabad (the core region) is not sufficient to increase per capita incomes of the remote peripheral districts, namely Adilabad, Nizamabad and Karimnagar within Telangana.

Education inequalities across socio-religious groups are an important aspect that remained as a challenge for achieving educational development. Undoubtedly, there is a remarkable change across social groups regarding increasing demand for education and thereby participation rate over a period particularly during the last two decades. However, the gaps in the participation rates across socio-religious groups continue to persist. STs followed by SCs are formed to be the most disadvantaged groups in terms of educational development. Educational development affects, and in turn, gets affected by the pace of economic development. There is a bi-directional linkage, and in this process, the low rates of literacy and economic backwardness sustain each other. This precisely is the problem of Telangana.

Hyderabad is a cosmopolitan urban centre, attracts capital and labor not only from within the state but also from other states and countries, especially on account of its concentration in IT industry and both public and private service sectors. It also has better public services like primary health centers, roads, and educated and more skilled labor, hence the gulf between Hyderabad and the poorer peripheral districts has widened.

Telangana has been identified as one other educationally backward state in India. Regarding higher education identified 370 educationally backward districts in India in that list, there were four backward districts i.e. are Mahabubnagar, Nizamabad, Adilabad, and Medak in Telangana.

The Human Development Index (HDI) at the district level is constructed for the early 1990s and the early and latter years of 2000s. The three periods for education and health indicators relate to 1991, 2001 and 2011 respectively, while per capita income at the district level refers to 1993-94, 2003-04 and 2007-08 respectively. We refer to the early 1990s as Period I and early years of 2000s as Period II and the latter years of 2000s as Period III.

There are significant inter-district disparities in the index values. The values across districts vary from 0.887 in Hyderabad in Period III. A comparison of levels in the latter years of the 2000s shows that five districts had lower levels of human development (Warangal, Nizamabad, Adilabad, Nalgonda and Mahabubnagar) are in Telangana. The districts like Hyderabad, Rangareddy, Karimnagar, Khammam and Medak had higher levels of human development than the state average.

Table 3
HDI across Districts of Telangana State (2004-05 and 20011-12)

Sl. No.	*District*	*2004-05*	*Rank*	*2011-12*	*Rank*
1.	Hyderabad	0.631	1	0.765	1
2.	Ranga Reddy	0.364	2	0.605	2
3.	Warangal	0.356	3	0.534	3
4.	Karimnagar	0.351	4	0.521	4
5.	Nalgonda	0.320	5	0.500	7
6.	Adilabad	0.289	6	0.508	6
7.	Khammam	0.286	7	0.519	5
8.	Mahaboobnagar	0.270	8	0.464	9
9.	Medak	0.261	9	0.446	10
10.	Nizamabad	0.251	10	0.466	8

Source: Draft HDI Report 2011-12 (2014), CESS, Hyderabad.

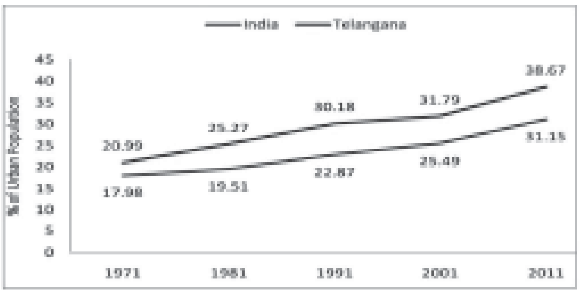
In terms of ranking that indicates the relative position of districts of the state, some districts like Medak, Rangareddy, Mahbubnagar and Nalgonda had improved rankings consistently over the three reference periods. The districts which had shown a consistent slip off their positions over the three reference periods were Nizamabad and Adilabad. The rate of change in HDI values during 1991-2001 was higher in those districts which had lower HDI levels in 1991.

The HDI values across the districts level also show a considerable increase, indicating good progress in human development. In both the years (2004-05 and 20011-12), Hyderabad, Rangareddy, Warangal and Karimnagar ranked at the top in that order. How-ever, there are changes in ranking in the middle and bottom range. Medak slipped from 9th to 10th and Mahabubnagar slipped from 8th to 9th during the period 2004-05 to 2011-12. Correspondingly, the district of Nizamabad improved its position from 10th to 8th. Among the middle ranking districts, Nalgonda district slipped its rank from 5th to 7th, while Khammam improved its position from 7th to 5$^{th.}$ While the overall HDI ranking in Telangana state has shown positive trends, the data reveals the need for emphasis in certain areas.

This indicates that the backward districts improved more than the relatively better developed districts in the state. It is apparently visible in the scatter plot showing the relationship between change (%) in HDI value during 1993-94 and 2007-08 and the HDI value in the base year (1993-94) across districts. It indicates that those districts with lower HDI value in the base year have shown a better improvement during the last one and half decade (i.e. between 1993-94 and 2007-08) as compared to those with higher HDI values in the base year.

Urban Development

About 39 percent of the population in Telangana is living in urban areas as per the census of 2011 compared to 31% at all India level. Compared to 2001, the level of urbanization has increased by sev-en percentage points in the State. Hyderabad is a hundred percent urban district, but the city of Hyderabad spreads much beyond the district boundary into the neighboring Rangareddy district. This has made Rangareddy, which surrounds Hyderabad, as the next highly urbanized district in Telangana with 70.08 percent of urban population. The ten municipalities, which were part of Hyderabad urban agglomeration and merged with Hyderabad City Corporation to form Greater Hyderabad Municipal Corporation (GHMC), are located in this district. Hyderabad Metropolitan Development Authority (HMDA) encompasses a total area of 7228 sq.km covering all 16 Mandals of Hyderabad district, 22 of Rangareddy, 10 of Medak, 5 of Nalgonda and 2 Mandals of Mahabubnagar district. However, the level of overall urbanization is low in the other districts surroundings the GHMC namely, Medak, Mahabubnagar, and Nalgonda.



Source: Registrar General of Census, Government of India

Fig. 4. Urbanization in Telangana and India

At the district level Rangareddy district recorded the highest growth rate of 70.47 percent which is basically due to the enlargement of Hyderabad city into the suburban areas. The core city of Hyderabad (i.e. the dis-trict) recorded very low growth of 2.70 percent. Only Medak district showed close to 30 percent growth. Adilabad is showing less than one percent urban growth despite having 27.41 percent urban population. The urban growth in the State is very low (9.89 percent) if Rangareddy district is excluded.

The primacy of Hyderabad city (GHMC) is very high over the urban settlement pattern in the state. The next biggest city in Telangana is Warangal which has about 6 lakh population is one-sixteenth or so of the size of Hyderabad. There are about 158 towns in the state (Table 2). Medak, Rangareddy and Adilabad districts have more than 20 towns followed by Mahabubnagar district. Many of these are small and medium towns in Class III to V category (in the range of 10000 to 49999 population category). The strengthening of the economic base of these towns is imperative for the growth of the economy of the state.

Growth of Industrial Sector

The growth of Industrial sector in Telangana has been impressive. During the decade 2004-05 to 2013-14 the state registered an average growth rate 9.4% per annum as against the national average of 6.9% at constant prices (2004-05). However, the growth path of the state exhibited more fluctuations than that of all India. Manufacturing sector growth across districts indicates that seven districts other than Medak, Rangareddy and Hyderabad require specific strategies and policy interventions. The growth in sub-sectors indicates a fall in the unregistered manufacturing sector represented by the micro and small enterprises, electricity, gas & water supply, and construction. The concentration of the Industrial sector is more in Medak, Ranga Reddy and Hyderabad together account-ing for more than half of the income from this sector. These districts contribute about 75% of the output from organized manufacturing sector and about 44% of the construction output.

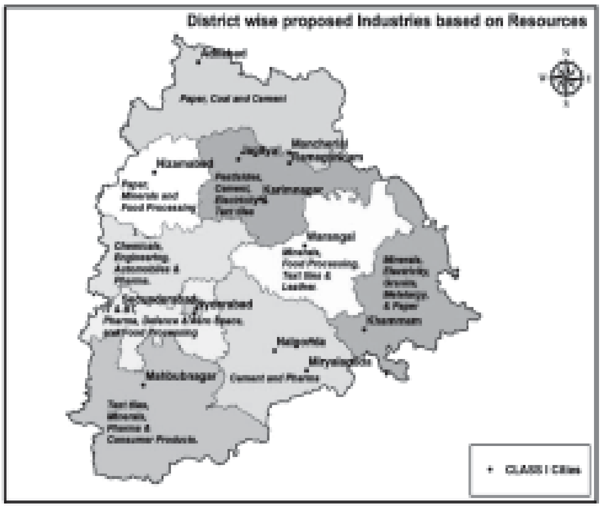


Fig.5. Industrial Development Resources

Key Industries in Telangana

Knowledge based industries such as ITES, Pharma and Engineering components have a strong presence in Telangana. They are largely located in Hyderabad and Ranga Reddy districts which have strong infrastructures such as SEZs, availability of skilled manpower and research institutions. The districts such as Nizamabad, Karimnagar and Warangal are largely dependent on agriculture and are in need of industrial development.

REGIONAL DEVELOPMENT

These indices of development have been treated statistically and the levels of development classified as poor, low, moderate and high of development. On the basis of above indices, the Telangana region are classified into four distinct regions.

Urban Industrial Region: This region account for 4.3 percent of the area and 20.26 percent of the population. Hyderabad metropolitan region, classified as an administrative town, accounts for eighty percent of the total urban population of this region.

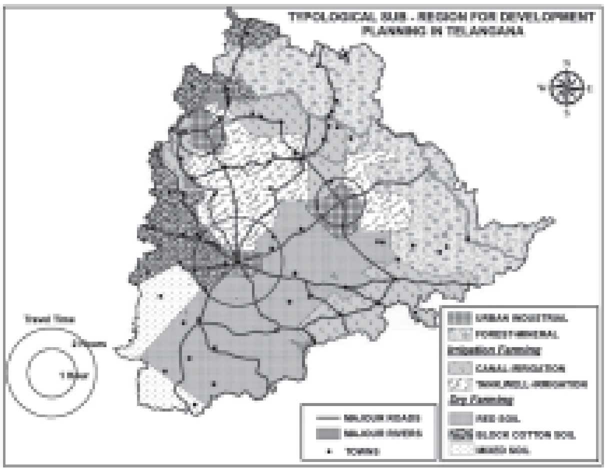


Fig. 6. Typological sub regions for development

Forest and Mineral Region: Comprises four districts namely, Adilabad, Warangal, Karimnagar and Khammam, and accounts for twenty-six percent of the area and 11.7 percent of the population. This area naturally has the highest percentage of area (58 percent) under against 24.3 percent for the region.

Irrigated Farming Region: This region comprises Karimnagar, Nalgonda, Medak and Nizamabad districts, under the command area of Nagarjunasagar and Sriramsagar project. This is the second largest region in Telangana in terms of area and population after dry farming region and accounts for 27.9 percent of the area and 32.26 percent of the population.

Dry Farming Region: This region comprises mostly in Mahbubnagar, Nalgonda and Rangareddy districts (South and Central parts of Telangana). This is the largest region in term of area and population, which accounts forty-two percent of the area and 35.7 percent of the population. Black cotton soils are found in this region along the western border.

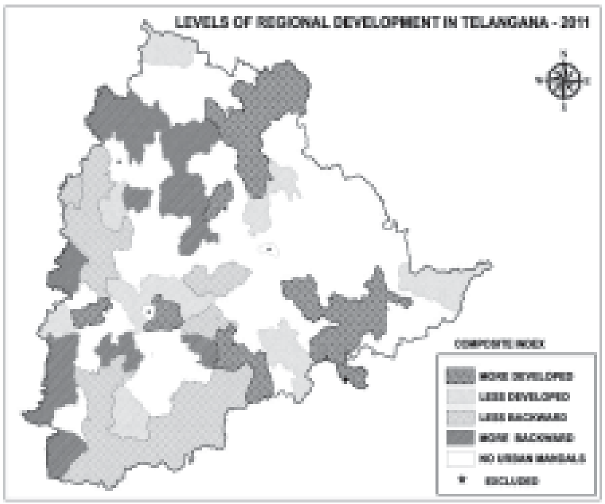


Fig.7. Levels of Regional Development

There is evidence in the study to suggest that infrastructural development is of great help in promoting regional development. This is particularly true if we consider an indicator of the level of living like HDI and seems true to some extent also in the case of per capita NSDP. A detailed analysis of the development of industry at the state level indicates that infrastructural development is particularly helpful for the development of both registered and unregistered manufacturing There are also two other indications with interesting policy implications. One is the already accepted finding that agricultural development is beneficial for the development of unregistered manufacturing at the regional level. The other is the interesting hint here that measures to reduce poverty in a region do not always go against the objective of improving the relative position of a region in terms of its per capita net domestic product. Much more work possibly with the help of causality tests and along the lines also of Datt and Ravilion(2002) needs to be done before more definite policy inferences can be drawn in this regard.

The question remains what type of intervention would help reduce regional imbalances. Among the specific policies that would be beneficial to a balanced regional growth in are the development of better communications between the core-urban center and remote rural peripheries in order to encourage agricultural productivity and lower transaction costs for enterprises in the periphery, and innovative financial instruments for financing public-private partnership infrastructure projects in under-developed regions. Some policy options for the development of backward areas are not controversial, for example, investment in education and skilled development including quality education and health facilities, better transparency and governance and the expansion of financial services. Encouraging less water-intensive rain-fed crops, livestock, and non-agricultural employment, Social support programmes for women and the elderly need to be encouraged. Development policies must focus on the peripheral regions with more autonomy to local planning and decision-making bodies. Local elected bodies are better positioned to identify and exploit local opportunities and to plan effective strategies.

TO SUM UP

It was observed from the above paragraphs that the backwardness of Telangana region is not due to lack of natural resources. The region is fairly rich in forests and minerals. The soils are responsive to the application of chemical fertilizers. Under the plans, efforts have been made to develop the region in various directions. Though some progress has been achieved, much more needs to be done if the historical lag in development is to be made up.

The analysis shows that the state's fluctuating growth rates could not keep pace with the national average. Agriculture and irrigation suffered neglect in plan expenditure. Almost all the districts in were in a lower state of development. The type of intervention would help to reduce regional imbalances, are the development of better communications between the core-urban center and remote rural peripheries in order to encourage agricultural productivity and lower transaction costs for enterprises in the periphery, and innovative financial instruments for financing public-private partnership infrastructure projects in under-developed regions. Social support programmes for women and the elderly need to be encouraged. There is a need for policy intervention in these peripheral districts in order to reduce regional disparities.

The potentialities of development vary in different parts of the region. The areas in the North and North-East of the region comprising parts of Adilabad, Karimnagar, Warangal and Khammam districts receive an annual rainfall of 40-45 inches and area covered with moist deciduous forests. The acceleration of the commercial exploitation of these forests and the establishment of forest based industries would greatly help in boosting up the income of the region. The strategy of development of these areas should also include tribal development schemes for the economic and social uplift of the tribal population living in this stretch of the region.

To the south of the forest region lies the mineral rich tract which comprises parts of Adilabad, Karimnagar, Warangal, Khammam and Nalgonda districts. The railway line between Vijayawada and Balahersha cuts across this tract which will be receiving extensive irrigational facilities under Pochampad Project in the North and Nagarjunsagar Left Bank Canal Project in the South. The infrastructure facilities for the location of resource based industries are extremely favourable in this tract. The annual rainfall in this tract is well over 30 inches. This tract a has great potential both for agricultural and industrial development.

Nizamabad district and portions of Medak district in the West of the Telangana region have good potential for development of agriculture. Already the agriculture in Nizamabad district reached a fairly high level of development, but there is still vast scope for increasing yields through the intensive application of improved technology. The region could also be developed industrially, the emphasis being on agro-based industries.

Hyderabad Urban, Hyderabad East, Hyderabad West and Medchal of Hyderabad district covering the Metropolitan City and its environs should have to be treated as a unit for developmental purposes. Already this tract contains a number of major, medium and small scale manufacturing units. This tract possesses the potential for being developed into a major industrial complex in the country.

In the South of the Telangana region lies the semi-arid tract covering Mahabubngar district and parts of the Hyderabad and Nalgonda districts. The rainfall in this tract varies from 21 to 30 inches. The forests in this area are either dry deciduous or scrub types. The mineral resources in this area are extremely limited. Soil erosion is a major problem in this tract. This area is the most backward in the Telangana region and poses many problems for its development. Any strategy of development of this area should aim at not only developing the limited agricultural resources and agro-based industries but also establishing non-resource based industries. In this semi-arid tract, the development of appropriate dry farming techniques is an essential prerequisite for ensuring efficiency of cultivation.

The above gives a rough picture of the potentialities of the development of the region. However, to concretize the development strategy, it is essential that the potentialities and prospects of development in the various sectors should be studied in depth and the micro and meso regions of development identified and the strategy translated into concrete schemes.

The above findings show that on record the coverage is quite good, but the real picture on the ground is something different. The need for policy measures for rural housing, water and sanitation access to housing, water, and sanitation has been definitely on the rise over time. At the same time, local government institutions in charge of operating and maintaining the infrastructure are seen as weak lacking in financial resources to carry out their functions. Therefore, it can be concluded that far from 'development' programmes—more precisely, welfare measures currently being implemented with the spread of development within the State persists.

The plan to help the backward regions will help reduce inter-regional disparities, and trigger another green revolution. Also, the backward regions, of Telangana can be developed. This will not only reduce inter-regional disparities but also act as a powerful force of national integration.

REFERENCES

1. Hanumantha Rao Ch. & S Mahendra Dev (eds), Human Development Report 2007 AP, Centre for Economic & Social Studies, Hyderabad, 2008.
2. Directorate of Economics & Statistics, District statistical hand book, , Hyderabad, 2007, 2008, 2011, 2012.
3. Galab, S., E. Revathi,and Prudhvikar Reddy, "Farmers' Suicides and Unfolding Agrarian Crisis in Andhra Pradesh", in D. Narasimha Reddy and Srijit Mishra (ed.), Agrarian Crisis in India, Oxford University Press, 2009, New Delhi.
4. Government of AP: Water Vision, Vols. I&II, Hyderabad, 2001.
5. Govt. of India, Census of India, District population tables, 1991, 2001, 2011
6. Hanumantha Rao, Ch.:Regional Disparities, Smaller States & Statehood For Telangana, Prof.B.Janardhan Rao, Memorial Foundation, Warangal, 2009.
7. Hanumantha Rao Ch. & S Mahendra Dev (eds), AP Development: Economic Reforms & Challenges Ahead, Regional Disparities: Causes & Remedies" , Centre for Economic & Social Studies, Hyderabad, 2003.
8. Mahanty, G:"Human Development in AP: A District Level Analysis". Indian Journal of Labour Economics, 43(2), 2000.
9. Rao, C.H.H., "Budgetary Surpluses of Telangana", Economic and Political Weekly, October 18, 1969.
10. Rao, C.H.H., (2006): "Growing Regional Disparities in Development in India—Post-Reform Experience and Challenges Ahead", published in, The Indian Economic Journal, Vol. 54, No. I, April-June.
11. Subrahmanyam, S. 'Regional Disparities: Causes and Remedies', in C.H.H.Rao and Mahendra Dev (eds.), Andhra Pradesh Development-Economic Reforms and Challenges Ahead, 2003.

AN ANALYSIS OF CHANGING LAND USE PATTERN EFFECT ON KALLADA RIVER BASIN, SOUTHERN INDIA AND KERALA BY USING GEOSPATIAL TECHNOLOGY

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ABSTRACT

Land use change is accelerating throughout southern India, Kerala and is the cause of many environmental problems. Kallada river is west flowing river which originates from the Kuluthupuzha, Shenthuruni ranges of Western Ghats, lies between 8^0 49′N to 9^o 17′ N latitudes and 77^0 16′ E to 76^0 24′Longitudes. It flows down to the Achenkovil basin on the north and Ithikkara basin on the south. The tributaries are Kalthuruthi river, Shenthuruni river and Kuluthupuzha river. The length of this river is 121 km with an area of 1404 sq.km. Kallada river basin is now under the edge of environmental degradation due to the complex and dynamic anthropogenic activities take place in the basin. Lowering Soil fertility due to conversion of land into other uses, excessive clay and sand mining, land and water pollution, lowering water quality etc. are the main problems of the Kallada river basin. The present study has brought out that the settlement rapidly increased from 2.73% to 13.1% during 1967 to 2012 and forest is decreased in the study area from 38.8% to 15%. The paddy field also converted into other uses and has decreased from 3.23% to 1.8% percentage. The Settlement rapidly increased from 0.17 to 7.9%. The study employs satellite data from LISS IV 5metre Resolution (2012),

Keywords: - *Land Use, Remote Sensing, GIS, Land Use Pattern and Change Analysis, Land Use Monitoring, River Basin.*

INTRODUCTION

Managing land use/Land cover changes in the river basin ecosystem of south west India is an extremely complex problem. However, success depends on having appropriate information on land use/Land cover in the form of maps and statistical data. Although primarily a hydrological unit, a drainage basin also represents a natural unit for physical, economical, industrial and social Planning and development (IYER, K.G and ROY, U, N 2005; REDDY, Y.V.R. et al.2008). Changes in any of the components of the basin many changes the overall environment of the basin. Today, anthropogenic impacts on land cover area reorganized as critical factors influencing global environmental changes (LAMBIN E.F. and GEIST, H.J.2006; NAGENDRA, H.et al. 2004). Land use/land cover inventories are essential for the optimal utilization and management of resources in a given basin. Land cover refers to different features covering the earth's surface including vegetation cover, water bodies, open scrub etc. It integrates the sum of human activities having an influence on the environment. The USGS has devised a land use/land cover classification system for use with remote sensor data (Anderson et al., 1976). Land use and land cover information should be presented on separate maps and should not be intermixed (Lillesand et al., 1979). With the latest advancements and the wide range of applications in the field of remote sensing, Geographic Information System (GIS) facilitates the adoption of new methodologies which prove to be highly efficient. Sahai *et al.*, (1985) used multidate, multispectral Landsat imagery of pre and post monsoon studies. Remote Sensing data can serve as a model input for the determination of river catchment characteristics such as land use /land cover, geomorphology, slope, drainage etc. GIS offers the potential to increase the degree of definition of spatial sub units, both in number and descriptive detail.

Holben (1986) studied that Normalized Difference Vegetation Indices (NDVI) increased as one proceeds from water through ice, snow, opaque clouds, bare soil, to green vegetation. (Wiegand et al., 1991) have argued that, at a specific site, the cumulative evapotranspiration and cumulative vegetation index should be highly correlated because the same green plant tissue measured by NDVI is due to absorbed active photo synthetic radiation. Reddy (1997) described that satellite data provides integrated information on rock types, land forms, geological structures, weathering, soil types, erosion, land use/ land cover, surface water bodies, distribution of ground water, slope details, soil type, rainfall, irrigated areas and their acreage etc., All these data, incorporated into the GIS package, it will form an excellent data base and becomes useful for judicious planning, proper development and effective management of water resources. Identification and delineation of Land use/Land cover, location, extent and their spatial distribution patterns are possible because of the synoptic view provided by the

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Satellites and their ability to resolve both macro and micro details on a single imagery. The different Multi-spectral and Spatial data can be merged with other satellite data for optimizing the LU/LC identification and discrimination.

STUDY AREA

Kallada river is west flowing river which originates from the Kuluthupuzha, Shenthuruni ranges of Western Ghats, lies between 8^0 49′N to 9^o 17′ N latitudes and 77^0 16′ E to 76^0 24′longitudes. Kallada river basin is bounded by Achenkovil basin on the north and Ithikkara basin on the south. The tributaries of Kallada river are Kalthuruthi river, Shenthuruni river and Kuluthupuzha river. These rivers joints at Parappar where the reservoir is constructed. Kallada River passes through Nedumangad, Pathanapuram, Kottakkara, Kunnathur and Kollam taluks and ends at Astamudi Lake. The length of Kallada river is about 121 Km and drains an areas of 1404 sq.km. Kallada River mainly used for irrigation purpose in Pathannamttia and Alappuzha districts. Point in the Kallada river basin Karimalaikodkal (1763mt AMSL) is the highest. Kallada river is a fifth order stream with gradient of 12.6mt/per km. Riverine alluvium, brown hydromorphic, Greyish Onattukara soil, Laterite soil, Forest loam and Coastal alluvium are the major soil varieties found in the Kallada river basin. Being a densely populated area, Kallada river basin is now under the edge of environmental degradation due to the complex and dynamic anthropogenic activities. Lowering Soil fertility, conversion of paddy field or crop land intoother uses, excessive clay and sand mining, land and water pollution, lowering water quality etc are the main problems of the Kallada river basin.

AIMS AND OBJECTIVES

The main focuses of this paper is Geo-environmental issues of the Kallada river basin with special emphasis on land use/land cover changes The specific objectives of the study are:

(a) To assess the changing pattern of landuse/ Landcover, in Kallada river basin.

(b) To evaluate the conversion of land in the study area.

MATERIALS AND METHODS

Data Used

To analyze the Changing land use pattern in Kallada river basin, Multi temporal satellite imageries and the survey of India topographical map. No 58C/12, 58C/16, 58D/9, 58D/13, 58G/4, 58H/1 on a scale of 1:50,000 were used to delineate basin boundary and to generate baseline information of the study area.

METHODOLOGY

The methodology adopted for detecting land cover changes between 1970 and 2012. LISS IV 5 meter resolution satellite images and topographical map scale. The topographical map were geometrically corrected using the UTM /WGS 1984 North 43 zonation projection system, and The images were geometrically corrected by taking the topographical map as the reference. Sub pixel image to image registration accuracy was obtained through reputed attempts. Sub set operation of satellite imageries and Topographical map was carried out by creating an area of interest (AOI) from the vector layer of the basin boundary, which was digitized from the survey of India toposheet. After generating the sub set of the imageries supervised classification using parametric rule and maximum likely hood operation was used to assess the Land use/Land cover dynamics in the Kallada river basin. Interpretation in which the supervised feature classification by setting up proto types (collection of Sample Point) for each feature class or land cover to be mapped. This procedure is most often used for the quantitative analysis of remote sensing data. The analysis was done through interpolation techniques and fish net generation for 1000 meter grid extension and each grid represents 1sqkm. Finally the grid was intersected with the thematic layer; this helped in understanding the number of thematic features contained in a single grid. Likewise the intensity of land use/land cover change map was constructed for the study area.

The generated data are brought into Arc GIS 10.2.1 and Erdas Imagine 9.1 for the processing manipulating and analysis.

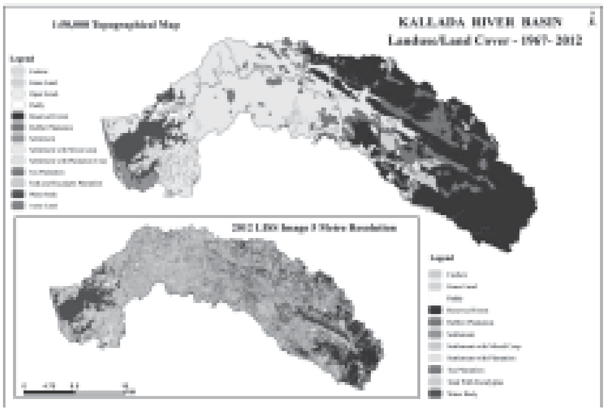
ANALYSIS AND FINDING

Land Use/ Land cover Change in 1967-2012

The study focused to analyses and monitor the Land use /Land Cover changes for the year 1967-2012 using LISS (IV) NRSC satellite and topographical maps. Land use changes were identified based on the visual interpretation of the satellite image following image processing techniques (supervised Classification). The Table 1 has revealed that settlement was rapidly increased from 2.73% to 13.1% in the year 1967 to 2012 and reserved forest also drastically reduced from 38.8% to 15%. During this period paddy field were

Table No:1
Land Use/Land Changes 1967- 2012

LU/ LC-	*1967* Area sq km	%age	*2012* Area sq	%age km
Cashew	0.86	0.06	55.1	3.9
Grass Land	12.54	0.89	115.6	8.2
Open Scrub	1.66	0.12	0.00	0.00
Paddy	45.34	3.23	25.7	1.8
Forest	534.07	38.04	215.9	15.4
Settlement	38.39	2.73	184.3	13.1
Settlement with Plantation Crop	13.58	0.97	110.2	7.9
Tea Plantation	37.49	2.67	58.9	4.2
waste Land	19.29	1.37	0.00	0.00
Water body	19.10	1.36	47.5	3.4
Rubber Plantation	104.52	7.44	105.8	7.5
Settlement with Mixed crop	550.76	39.23	357.8	25.5
Teak and Eucalypts Plantation	26.74	1.90	127.3	9.1
Grand Total	1404.33100.02	1404	100	



Sources: NRSC.

Fig : 1

converted into other uses its and areas rapidly increased from 3.23% to 1.8%. The settlement with plantation also changes from 0.97 to 7.9% with respectively in 1967 and 2012.

Land Conversion during 1967-2012

Following the table show that around (318.17Sqkm) of the forest lands are converted to settlement, mixed plantation, mixed crop and rubber plantation etc. Most of the paddy fields are reclaimed to settlement, mixed plantation and rubber plantation (19.64sqkm), including forest, paddy, and waste land and mixed crop also converted into Rubber plantation (1.28) in the study area. In the case of settlement, settlement with mixed crop, teak and eucalyptus plantation are existing from the other land use categories. According to the (1971-2011) Census report clearly shows that population distribution and household rate in the study area was gradually increased around 12,53,156 to 19,176,98 population distribution and 37,938 to 47,9631 household. The process of population expansion and household intensity increasing is degrading the existing land use or land conversion is at a take place, which sets up in the degradation of the basin. The process of urbanization has a considerable hydrological impact in the terms of controlling rates of erosion and the delivery of pollutants to river and in terms of influencing the nature of runoff and other hydrological characteristics (Andrew Goudie 2013)

Land Use Intensity 1967-2012

The intensity map (Fig:3) of Land use/Land cover change was prepared by using the temporal data obtained during the period of (1967-2012), the analysis was done through interpolation techniques and fish net generation for 1000 meter latitude and longitude grid extension of the investigated area. Finally the grid was intersected with the LU/LC layer; this helped in understanding the number of Land use classes as contained in a single grid. Table No: 4 reveals that only one percent 1% of the area has very high intensity in 1967, and more than 25% of the area has very high intensity during 2012. The half of the area (50.59%) has very low intensity of change in 1967 and only 5.73% of the area has very low intensity of LU/LC in 2012.Analysis the intensity of land use/ land cover change has been accelerating since 1967s in the kallada river basin. The intensity of land use change was scattered all over the river basin. While after four decades in 2012, the data shows significant changes in the intensity of land use. This marks a new trend in intensity of land use where the intensity of land use changes has spread from the river bank towards the entire basin. The intensity and pressure is mainly concentrated in the banks of the river.

Table
Land Conversion

Actual Land	*Existing Land Use*	*Area in SqKm*
Forest	Mixed Crop, Rubber Plantation, Settlement, Teak Plantation, Mixed Plantation	318.17
Paddy Cultivation	Mixed Crop, Rubber Plantation, Settlement, Teak Plantation, Waste land, Mixed Plantation.	19.64
Existing Land Use	*Actual Land*	*Area in SqKm*
Rubber Plantation	Forest, Paddy , Waste Land, Mixed Crop.	1.28
Settlement	Paddy, mixed plantation, mixed crop, paddy cultivation	145.91
Settlement with Mixed Plantation	Forest, Paddy, Waste land, Mixed Plantation	96.62
Tea Plantation	Forest ,Water Land, Mixed Plantation	21.41
Teak and Eucalypts Plantation	Paddy, Waste land, Mixed Plantation	100.56

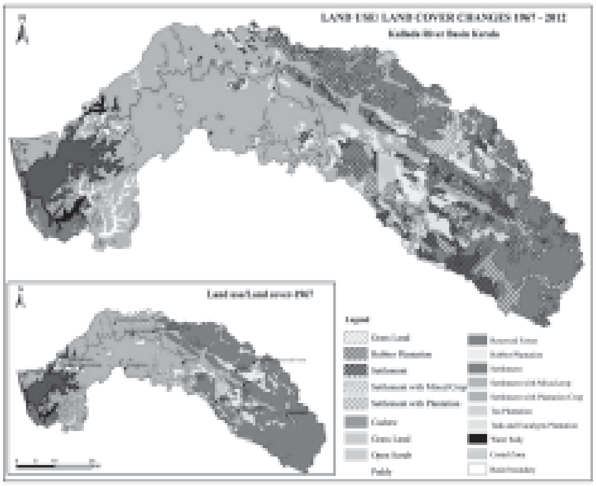


Fig. 2

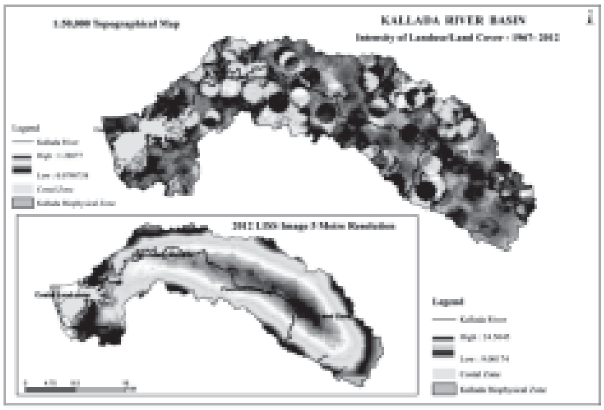


Fig: 3

Table No: 3
Land Use Change Intensity

Years	*1967*		*2012*	
Intensity Class	*Areas qkm^2*	*(%)*	*Areas qkm^2*	*(%)*
Very Low	710.29	50.59	66.45	5.73
Low	361.84	25.84	200.29	18.68
Medium	239.36	16.41	354.22	25.23
High	85.57	6.09	338.29	25.09
Very High	13.92	0.99	451.50	25.04
Grand Total	1410	100	1410	100

Sources: NRSC.

CONCLUSION

The focus of this paper is to analyses the effect of LC/LC Change in Kallada river basin for the last four decades. The evaluation of present stu clearly shows that anthropogenic activity are dominant factor for LU/LC change role due to the causes of changes land use pattern and effect on the basin. According to economic deterministic approaches based on the basic ideology of man's mastery over environment and continued to economic industrial expansion through application of modern technologies (Savindra Singh 2006). Remote sensed data, satellite image provides synoptic coverage of the entire basin it's in this study has clearly shows that population distribution, population Growth and no of household are gradually increased from 1971 to 2011 censes. The rapidly population growth has resulted in the depletion of natural resources (R.C Chandna 214). From the analysis Land use/Land cover changing pattern is reveals that most of the forest area is being converted to settlement, settlement with mixed crop, settlement with mixed plantation and rubber plantation. The current scenario of the rapid population growth, with growing demands and differing priorities in Kallada River. The resulting products of the exploratory analysis and classification were used to assess spatial pattern of Land cover/ Land use pattern and mapping of the study area. The urban expansion and population density are common phenomenon which is along the basin. The land use/ land cover changes in the most of the basin are unplanned so managing and checking these issues are big task for urban planner especially modification of river, river restoration, river management, flood along the river, land capabilities, site suitability, erosion and runoff. The study suggest that by environment spatial data base can be generated for basin area based on this data set monitoring and management of the kallada river basin easy be done and in a more meaning full way, furthermore it can become a policy tool for urban planner, irrigation department and governmental official to control and unplanned land use/land cover changes.

REFERENCES

1. Alphan, H., 2003. Land Use Changes and Urbanization in Adana, Turkey, Land Degradation and Development, 14, pp. 575-586.
2. Anderson, J. R., E. E. Hardy, *et al.* (1976). A Land Use and Land Cover Classification System For Use With Remote Sensor Data, U.S. Geological Survey.
3. Benenson, I. and P. Torrens (2004). Geosimulation: Automata-based Modeling of Urban Phenomena, Wiley.
4. Berry, M., B. Hazen, et al. (1996). The Land-Use Change Analysis System (LUCAS) for evaluating Landscape Management Decisions. IEEE - Computational Science and Engineering **3**(1): 24-35.
5. Cabral, P., M. Painho, et al. (2004). Spatio-temporal Analysis of Urban Growth Pattern in Lisbon Metropolitan Area. 24th Urban Data Management Symposium, Chioggia, Italy.
6. Brahabhatt, V.S., Dalwadi, G.B., Chhabra, S.B., Ray, S.S., & Dadhwal, V.K., 2000. Landuse/land cover Changes Mapping in Mahi Canal Command Area, Gujarat, Using Multi-temporal Satellite Data, J. Indian Soc. Remote Sensing. 28(4), pp. 221-232.
7. Cheng, J. (2003). Modeling Spatial & Temporal Urban Growth. Faculty of Geographical Sciences. Utrecht, Utrecht University**:** 203.
8. Flamm, R. and M. Turner (1994). Alternative Model Formulations for Stochastic Simulation of Landscape Change. Landscape Ecology 9(1): 37-44.
9. Gluch, R. (2002). Urban Growth Detection Using Texture Analysis on Merged Landsat TM and SPOT-P Data. Photogrammetric Engineering & Remote Sensing 68(12): 1283-1288.
10. Gong, P. and J. Howarth (1990). The Use of Structural Information for Improving Land-cover Classification Accuracies at the Rural-Urban Fringe. Photogrammetric Engineering & Remote Sensing 56(1): 67-73.
11. Herold, M., N. Goldstein, et al. (2003). The Spatio - Temporal Form of Urban Growth: Measurement, Analysis and Modeling. Remote Sensing of Environment 85: 95-105.
12. ICN (2004). Parque Natural Sintra-Cascais, Instituto da Conservação da Natureza. 2004. INE (2003). Instituto Nacional de Estatística.
13. Jensen, J. R. (1996). Introductory Digital Image Processing: A remote sensing perspective, Prentice Hall.
14. Kaufmann, R. and K. Seto (2001). Change Detection, Accuracy, and Bias in a Sequential Analysis of Landsat Imagery in the Pearl River Delta, China: Econometric Techniques. Agriculture, Ecosystems and Environment 86: 286-302.

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GROUND REALITIES OF DECENTRALISED PLANNING IN INDIA: MISSING SPATIAL APPROACH

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ABSTRACT

The emphasis laid on decentralised planning in India, has its history, starting from the times of Mahatma Gandhi, in pre-independent India. While post-independent India saw starting of decentralised planning since 1951, with Community Development Programme, which was the first step in independent India towards grass root planning. India lives in its villages, and therefore, the community development planning became synonymous with rural planning. With the hierarchy of levels which were introduced for integrated planning of a region, the decentralised planning became inevitable. The hierarchy of an administrative region is divided into Village, Block, District, State and National. The 73rd CAA, gives planners/scholars the constitutional right to prepare spatial plans, in contradiction to the sectoral plans which were prepared pre-1992 period. Though the Panchayati Raj system was introduced in 1957, in Third Five year plan, but no constitutional status was given to such system of governance.

In today's time, the Regional planning and the decentralised planning are carried out at all levels of administrative hierarchy. The preparation of the district plans require the integration and the consolidation of the village and block level plans. However, the ground reality has another picture. This paper will seek to analyse the decentralised and rural planning in India, taking a case study of village and Block level plans of Palwal Block, in Palwal District of Haryana state. A Block level plan required the consolidation of village level plans, however, these consolidations of plans within various sectors were missing and hence, the spatial approach of planning was again uncared for. The process which facilitates adoption of spatial approach includes: coordination between various institutional departments and people's own participation and a sense of responsibility in their own development. People's participation requires comprehension of the planning process by them, which requires training and time. Social biasness of the rural areas curtails the participation process of all individuals, and lead to social exclusivity. To overcome this exclusion, it is required that the social, economic, cultural and political sectors are given equal attention by the planners.

The traditional cartographic methods and the present technology of mapping and GIS makes it possible to overlay all the aspects together and bring out a spatial approach in the process of planning. This paper will be discussing following parts: history and problems of decentralised planning in India; consolidation of plans and approaches towards planning taking a case study of Palwal Block; people's participation and socio-economic scenario of the Palwal Block as a region; suggestions for better spatial planning through mapping tools and techniques possible in the current situation, taking example from successful plans of Kollam district of Kerala and other parts of India.

Keywords: *Decentralisation, Spatial, Sectoral, Social Exclusivity, Consolidation Of Plans*

INTRODUCTION

The era of globalisation has been heralded with the intention of the forthcoming economic development with building ties with the neighbouring countries and therefore availing resources in the native nation state for betterment of citizens. However, since the regime of economic growth featured by the free trade, entrepreneurship and capital accumulation is governed by the elite class of the society, there is unequal distribution of resources amongst the population. The trickle down or the spread effect hardly works in the real world scenario. Therefore, the Constitution of the India provides the public authorities or the government with the right to work for the betterment of the citizens and improve upon their quality of life. The initial thought of planning was based on such notions. Nevertheless, it is worth mentioning that the emphasis laid on the planning or the vision for development has been changing with the political powers altering. Since, the independence and the inception of the Planning Commission, the vision to develop our nation has been shifting, with focus on rural develop to industrial development followed by regional development, urban development or Slum Clearance, infrastructural and employment generation, Social and community development. Finally, we have reached the age where prominence of technological maturity, transparent governance along with people's participation in their own development has been of major significance. These aspects can be stated as some of the many steps initiated towards facilitation of the decentralised planning in India.

This paper makes an attempt to address some issues with the planning scenarios in India, as observed in the field. The predicament with which planning field

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has been dealing in our country is the mechanisation of the exercise and the tremendous power of the bureaucracy and the political elements over the developmental vision of the region. Though, as a Third World nation, it is meritoriously admitted that we have come a long way from the past, but the question to be asked is "where are we heading and what are we heading towards?" Does our planning exercise even have the consequences for which they are conceived? The credibility gap which exists between the theory and the praxis becomes evident once we are in the field. The subjectivity of the discipline lands us in controversy and sometimes unjustified arguments. Nonetheless, the basic goal is to improve the quality of life of citizens, which is responsibility of the government of the nation-state, and this provides the legitimacy to the federal system of the governance. Therefore, how can we improve and learn from our lapses is discussed in this paper and it is obvious that the scope of the improvement lies beyond the suggestions mentioned here.

History and Problems of Decentralised Planning in India

The decentralised planning traces back its history since the times of pre- independence, when Mahatma Gandhi laid emphasis on grass root level planning. However, the first initiative towards the rural decentralised planning was taken in the First Five Year plan with the launch of Community development Programme in 1952, covering 163,000 villages by the end of first five year plan and the entire country by the end of sixties. The hierarchy for rural planning was created at five levels:

Table 1
Institutional Structure for Rural Planning Under CDP, 1952.

National level	Planning Commission
State level	Development Commissioner
District level	District Collector
Block level	Bloc k development officer assisted by 8 extension officers
Village level	Village level worker

Source: First Five Year Plan (1956-61), Planning Commission, GoI.

The BDO was assisted by eight Extension Officers, one each for agriculture, animal husbandry, Panchayat, cooperation rural industries, rural engineering, social education and women and child welfare. The village level worker was supposed to cover 5000-6000 population, comprising 5-6 villages, where they had to persuade the villagers to become a part of the development programme initiated by the government. The CDP was launched with a fair intention of ensuring community participation and development and to enhance agricultural production with equal access to growth and justice. However, it failed to produce the desired results because of village level workers (VLWs) half-hearted efforts to engage the villagers and moreover, the political and elite class influence over the VLWs, just made the exercise of initiating people's participation, a mere formality. Development programmes approved at the central and state level were rigid; the consultation process remained merely an academic exercise (Maheshwari,1988)

With the Third Five Year Plan, the Panchayati Raj system was introduced as suggested by Balwant Rai Mehta Committee in 1957. The adoption of three tier system of local governance in order to decentralise the process of decision making was done at three levels viz, village, block and district, placing Gram Panchayat, Panchayat Samiti and Zilla Parishad respectively. Though this multi level planning framework was adopted, the main drawback was domination of socially and economically privileged part of the society in the process of decision making. The later five year plans till 1991, had more initiatives towards community development and various schemes such as DPAP, TADP, SAFDA, MFALDA, TRYSEM, DADP, IRDP, DWACRA, NREP, RLEGP were introduced.

The 1992 year was a watershed for the decentralised and multi level planning in India, with 73rd and 74th CAA. The 73rd CAA gave constitutional right to planners to prepare a spatial plan. Earlier approach to planning was merely sectoral planning, however, with 73rd and 74th CAA, emphasis was laid on consolidation of plans and therefore giving planning a spatial approach. The village plans were to be prepared by Gram Panchayat, ensuring people's participation through Gram Sabhas, these individual village plans were to be consolidated at Block level to prepare Block plans and the District Planning Committee was set up, which ensures consolidation and integration of all lower level plans apart from preparation of a District plan having Sectoral and Spatial approach. The 73rd CAA defines the three Fs i.e Funds, Functions and Functionaries, which would facilitate the multi level planning framework in the rural planning process. However, the implementation of 73rd CAA is still an issue in most of the regions. The act was announced to reduce the existing gap between the bureaucracy and the people. States like Kerala, Andhra Pradesh, West Bengal pose a successful example for adopting spatial planning approach. While still, most of the states have not even constituted DPCs in their Districts. Post eighth five year plan, the schemes to strengthen community development has been launched. However, no strict actions against the states, where 73rd and 74th CAA are not implemented, are taken. The monitoring and evaluation of policies and reforms are the missing approach which needs to be taken seriously. The role of NGO in spreading awareness, indulging people in planning and evaluation of projects running currently has been commendable in present times. Moreover, various technological initiatives by government taken have been discussed in later sections, which have brought a new face for the planning.

Consolidation of Plans and Approaches Towards Planning

The Constitution, in Article 243ZD provides for the 'consolidation' of plans prepared by the Panchayats at all levels and municipalities in the district, into the draft development plan of the district by the District Planning Committee. (District Planning Manual, 2008). The consolidation of plans goes beyond the idea of compilation of various village plans and urban municipal plans into one. It requires the merging of spatial as well as sectoral approaches, keeping in mind location of various services belonging to various sectors. Broadly, the approach that is adopted while preparing village development plan is sectoral approach, where various sectors such as economic, social, cultural and institutional sectors are studied and future prospects are analysed. Whereas in urban area or municipal plan, partially spatial approach is adopted where, landuse and land zoning is major area of interest, the location of services and other locational attributes are given special attention, however, in rural areas this approach is missing. Therefore, the consolidation of plans has merely become a compilation of different plans. The integration of plans requires spatial, sectoral, horizontal and vertical integration. For instance, spatial integration would require integration between distribution of and access to resources across the space, sectoral integration would require integration amongst various sectors such as health and education, and horizontal integration would require integration across space for horizontal expansion of the development, while vertical integration would require integration of schemes and policies from lower to higher level of governance.

Consolidation should be based on common stakeholders, externalities, location in space, institutional set up and the coordination between them. Apart from these factors priority set for the development shall also be set straight i.e a vision shall be envisaged which should also be considered while consolidating various plans. Besides, inter departmental coordination is a must for consolidation. The various steps concerned with the consolidation of plans are illustrated in District Planning Manual, released in 2008, however, the reality which is witnessed, shows a different picture. Let's take example of a District level plan which needs to be prepared under the supervision of District Commissioner who will look after the coordination of various departments. The preparation of various village plans is a responsibility of Gram Panchayat and preparation of city development plan is responsibility of Municipality. Taking Block as a unit of planning, as suggested by Sivaram Committee, preparation of various Block level plans is required under Block Development Officer. The ideal situation would require preparation of Block Development Plan in a manner where, Block level data for various sectors is analysed besides village level data for various different sectors and after that emergence of spatial pattern is given priority and the character of the region comes out and therefore the region is planned for the future accordingly, keeping in mind, the demographic trends. What is happening on ground in most of the states, districts, and blocks is mere compilation of village level plans to prepare Block level plan. And the district plan is prepared in the same way, by compilation of the block plans. The need to integrate the urban and rural areas demand and the externalities or the spill over effect of the projects taken up in the urban areas is required for the balanced development of the region.

The coordination between various departments for the preparation of development plan of a region is required but in reality the departments are shunning away the possibilities to contact the other departments and brush aside by merely preparing the individual level village plans or urban area plans and compiling them together. Quoting a scenario from the Palwal Block, where PWD was required to lay water pipes in villages, the available plan was compilation of individual village level plans of pipe layouts with no consolidated file obtainable. Nevertheless, though on paper, the record said that there was 100 % coverage of water in all the villages of the block, on our field visit, the reality was different. In this scenario, in few villages villagers were resistant to take water from the concerned department and were interested in exploiting ground water resources and in other villages, where water was available when power was supplied the overflow and wastage of water took place because of absence of taps. This states that the behaviour and the lifestyle of people also matters in the issue of development of the region. Therefore, just the provision of services will not deal with the problem; the requirement is to change the mindsets which require promotion of education and awareness. Moreover, the rural planning has shrinked to the level of preparing plans for various sectors and merging them together with a total sectoral approach and no spatial approach, hence, there exists a dubious nature of planning, where sometimes lack of services or services unable to cater to assigned number of population happens. Also, it is witnessed that, services which are serving lesser population than that of norms, is also the case very popular.

The creation of primary school at a distance of every 2 kms.,in Palwal, pose a developmental policy, where spatial approach is taken care of. However, provision of services at a particular diametric distance is just a superficial approach of spatial planning. The spatial planning shall meaningfully adhere to the resources and people in space, such as sharing of water and other physical and natural resources.

People's Participation and Socio- Economic Scenario of Palwal Block:

Sherry Arnstein (1969) defines citizen participation as: "Citizen Participation is a categorical term for Citizen Power. It is the redistribution of power that enables the have-not citizens, presently excluded from the political and economic process, to be deliberately included in the future." Hence, People's Participation as a concept entails the inclusive participation or engagement of every citizen in the process of decision making which promotes development of the society as a whole. Consulting the citizens before making any decision which would affect their lives, is just a form of tokenism, their active participation should include assigning them with the power to negotiate for their betterment along with full access to growth and justice.

In a country like India, where caste, communal and class differences are inflicted from times this civilisation is present, and have been aggravated in present times, becoming a sturdy instrument in acquisition of power. It becomes very difficult to deal with such cleavages and carry out inclusive planning. Rural India is still ruled by the caste system. Though, in areas which are in proximity to the cities and big towns, may have overcome the rules of commensality, but there still exists the caste hierarchy which surfaces at the time of contestation for power. In areas characterised by regional backwardness, where caste system still has a dominant hold, the conditions are worst. Out of 24 crores households in India, almost 70% are in Rural areas and 30% are rural landless households who are belonging to lower caste.(Socio-Economic Caste Census, 2011) These people are not included in the decision making process and hence are belonging to the lower rung of the ladder of participation.

In the decentralisation approach the process of people's participation is a phenomenon which has been emphasised on, since a decade or two. Taking example from Kollam in Kerala where people are actively involved in making plans for themselves, in villages, along with experts and skilled personals using efficient technology, it becomes important that we take the planning ahead after comprehending the regional specificities of the region rather than crawling on the same path for every region.

Palwal is a District in Haryana State and is a part of Delhi NCR region. Palwal city is located along the National Highway no.2 from Delhi to Mathura. The district has been separated from the District of Faridabad in 2008, and consists of five blocks, out of which the recent one Prithala Block has been carved out of Palwal Block in 2014, therefore now Palwal block comprises 85 villages and 73 Gram Panchayat.

The DFC, KMP and KGP are passing through Palwal block giving a boost to the secondary and tertiary sector.(Figure 1) Besides, Palwal is proposed as a regional centre in NCR plan 2021. Palwal lies within 60 km. from Delhi, 54 km. from Gurgaon and 30 km. from Faridabad. Palwal is predominantly agriculture based district, having its 81percent of land under agricultural use. (Statistical Abstract Haryana,2007-2008)

The district headquarter is in Palwal city and the district office is located in Palwal city. The city shows linear development along NH2 while the rural areas on the interiors of the region, are neither totally deprived as the villages of Eastern U.P, Bihar, Jharkhand or Orissa. The inclusion of Palwal in NCR region has given its development a boost, especially in institutes of technical education and townships. The city has a population of 2,35,663, while the block has a population of 3,30,000, the entire district accomodates 10,40,493 persons.(Census,2011) The city and the block has the highest weightage in terms of population in the district.

The caste composition of the villages in Palwal Block is such that notable presence of Thakur, Brahmins, Yadavs, Jats and SCs could be seen. Though other castes were also present but these formed the majority. Jats forms the dominant community in the villages, with mostly Sarpanch belonging to the higher caste in the village.

Since, the reservation of not less than 33% of seats for women is insured by 73rd CAA, in most villages female Sarpanch were seen to be holding the posts. However, it is worth mentioning that the females were Sarpanch just for the sake of holding the dominant position in the family, as the functions of the Sarpanch was carried out by the male members of the family, mostly the husband. Therefore, the foothold was maintained by a single household in

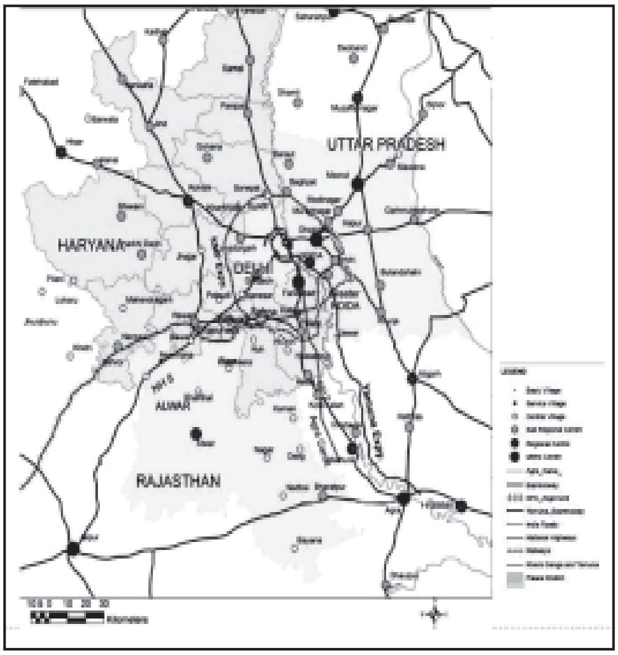

Fig. 1: Regional Setting of Palwal

the village for more than one tenure of Sarpanch. Interestingly, as we have heard of the term "absentee landlordism", there was also witnessed a similar phenomenon of " absentee governance", where the Sarpanch, would reside outside the village, principally in city of NCR and the job was looked after a male member of the family. The affluence of the villages in this particular region, was astonishing, the reason given was the agricultural development. However, not omitting the fact that in the same region, a stark difference was seen in terms of levels of development amongst the villagers, where upper landholding caste villagers had pucca houses, pucca roads, handpumps, while lower landless caste villagers, agricultural labourers were supported with lower level of means of life.

The idea to mention the above point is not to over romanticise the phenomenon of inequality in the rural areas based on caste divisions. Nevertheless, an attempt is made to comprehend the disparity caused by the governance structure and lack of implementation despite of existing constitutional provisions. The landowning castes have been in ruling power since times immemorial. However, with changing times, spread of education, opportunities to migrate outwards in the cities, have lead to a changes in the status of the lower caste groups, and this have been equally accepted by the upper caste community as well. The other side of the coin reveals a different scenario, where, caste barriers lay strongly, when distribution of resources comes into play and are governed by power structure. The distribution of services, as per duties of Panchayat, poses an unfair importance of caste amidst the superficially pluralistic rural society sited in Megacity cluster of India, in 21st Century.

The effect on planning of the above mentioned socioeconomic structure is such that, it hinders the maximum participation of the native people in the plan making, where, Gram Sabha meetings are dominated by males, that too chiefly from higher castes, with no women, because of prevailing Purdah system, still existing in the villages. The minimum criteria of Gram Sabha meetings to be executed is 1/10th of the population shall be present. This was mentioned as the maximum turnover by the Sarpanch of the village, with pride. Hence, the supposedly autonomous status of the panchayat is reduced to a body with funds availing from the state government, functions merely reduced to the level of provision of handpumps, construction of roads, drains and functionaries being the landowning community and that too males. Absence of innovations, research and development, monitoring and people's participation has lead to half hearted development in the villages of this region, which is purely because of affluence of people, who avail services from the outside of villages or the core region.

The planning at grass root level requires community participation through engaging different groups such as women, children, youth and old age people, as involved in IDDP of Kollam. The native people require understanding of the aim of the plan making and hence analytical spatial mapping tools such as transect walk, time analysis tools, which would further help in analysing activities and deducing the needs of the villagers, a seasonal calendar can also be of great help. Similarly, mobility mapping can be also used for visual representation of people's movement within and outside their community which can reveal issues and problems with socially differentiated mobility and access to resources. Since planning officials and surveyors require training to encourage people to participate in plan making, various NGOs shall be encouraged to take initiatives in using such mapping tools which can be easily comprehended by the villagers also. The basic hurdles on the way of such development and planning is socioeconomic structure of the rural areas, hence to overcome such rigidities, the monitoring by District level planning officials is needed, as done in case of Kollam.

The beauty of the Kollam IDDP and LDP lies in the combined use of people's native skill and trained personnel without omitting scientific technologies for the data collection and analysis. Also, the efficient institutional structure prepared for the IDDP and LDP comprises various committees having experts in them. One such Spatial Integration Committee was formulated for spatial linkages of various LDPs and consolidation of LDP in IDDP taking its inputs.

The decentralisation of funds has largely become a moot point in the planning scenario, as there is a large dependency of local bodies on state government for funds, the Kollam IDDP, had their local bodies access to 34-40% of states' funds which was devolved to local bodies, for implementation of projects.

Suggestions for Better Spatial Planning through Mapping Tools and Techniques

For better management, representation, dissemination and interaction between stakeholders and other administrative community, it becomes really important to maintain a spatial data infrastructure at all levels of administrative hierarchy. Different countries are developing means to manage their SDIs for better decision making, regionally as well as globally. In India, there is a crucial requirement of maintaining SDI data especially at local level. Various initiatives of government have been in this direction, one such effort is the establishment of National Spatial Data Infrastructure (NSDI) constituted by Department of Science and Technology. XII plan proposed to set up state SDI and therefore state geo portal are being set up in Haryana, West Bengal, Jammu & Kashmir and Uttarakhand. The coordination of NSDI and state geoportals with various departments such as census, SOI, GSI, NBSSLUP, CGWB, FSI, CWC, CPCB, IMD, NATMO is required to maintain a geospatial database. NSDI provides various geospatial information to the government, for various projects and planning purposes. Census has also taken initiative in cartographic representations till village and ward level household data. The national e-governance plan of Government of India, has a vision of making all government services accessible to the door step of common man using strategy of focussing on service delivery, centralised initiative and decentralised implementation and capacity building with the help of awareness and communication programmes. NSDI forms a major role in providing geospatial database to the implementation agency regarding agricultural land, property registrations, land records, environmental and traffic and transport planning, infrastructural development, health and school services and various information regarding municipalities.

However, the data sharing has always been from one government organisation to another (G2G), the public dissemination of the data has been highly restricted. Therefore, this has lead to just duplication of the datasets, wasteful use of time and lack of initiatives and time management amongst various orgnaisations. The geospatial datasets demand high towards high end, nevertheless there was always a lack of standardized data. "Available data was sporadic and was not useful for all purposes - it was often specific or in poor form, since each agency or department had looked at its own need in isolation whenever such data had to be created." (DSSDI, 2014, DIT, Govt. Of NCT Delhi, Price water house Coopers)

All the above initiatives listed and the commencement of era of Digital India indicates that there is a huge requirement of maintaining and sharing geospatial database and using that technology efficiently in planning. The planning of any area, a block for an instance, cannot be simply a compilation of the village plans, following considerations shall be kept in mind while we are consolidating village plans for preparation of block plan:

- Spatial pattern of settlement shall be taken in mind, taking consideration of existing transport network, water networks, landuse and density.
- Growth pattern and direction of the settlement shall be considered with economic activities and spatial coverage of facilities.

Preparing plan in an Indian context, various social groups in space shall be well thought-out, for inclusive planning. Their indulgence involves making them aware to various steps of planning and map making such as time analysis tools, mobility mapping. Preparation of the village plan will vary according to the size, social group, and proximity to the main city, economy and social infrastructure present in the village. Therefore, every village plan should not be merely prepared on the basis of the spatial distribution of the facilities available and lacking.

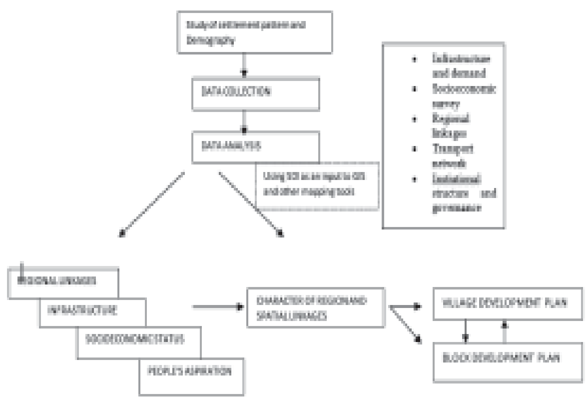

Fig. 2: Planning Exercise Suggested Using SDI

The Fig. 2 suggests the planning exercise to be done, at any level, using geospatial database as a tool, whereby analysis shall be done taking considerations of the current scenario, which gives the region a special character. The layering of various requirements for preparation of plans becomes easy if the sharing of geospatial datasets is carried out, like in various other western countries. The recent initiatives and the emphasis laid on the e-governance requires such stepladder to be followed, so that planning is just not reduced to a level of map making and collection of datasets.

CONCLUSION

The above aspects in block level planning will emerge when various village level individual plans are superimposed or laid out together. Therefore, for planning for provision of various services, spatial integration of various sectors is quintessential. However, this spatial approach, and that too only to extent is addressed in city planning or urban planning. We have been following the same old sectoral approach with addressing what is required according to the population norms and providing that at the available place. Unfortunately, we fail to comprehend that any activity which comes up in space is integrated with activities of several other sectors and will induce development and growth, if market forces allow. Hence, three major aspects in order of importance are transport infrastructure, economy or market forces and governance, are required to be adopted.

REFERENCES

1. Arnstein, Sherry R. "A Ladder of Citizen Participation", *Journal of the American Planning Association*, Vol.35, No.4, July 1969, pp 216-224.
2. Bardhan, Pranab. 2002, Decentralisation of Governance and Development, *The Journal of Economic Perspectives*, Vol.16, No.4, pp.185-205.
3. Bhuiyan, Dasarathi. 2013,Role of Panchayati Raj Institutions in Grassroot Planning: Some Issues and Concern, *Odisha review*, pp.41-46
4. Government of Kerala, State Planning Board and State Town and Country Planning Department, (2003) Integrated District Development Plan and Local Development Plan.
5. Government of India, 2008, Planning Commission of India, District Planning Manual
6. Kumar, Shiva *et al*; 2012, Improving Spatial Data Management for Development Planning in India, *Economic and Social Council*, UN, E/CONF/.102/IP.7
7. Maheshwari, S.R., 1985, Rural Development in India: A Public Policy Approach, *SAGE Publications*, New Delhi: 35-51.
8. Natural Resource Data Management Systems, Ministry of Science and Technology, Government of India, NRDMS Annual Report, 2012-2013.
9. Neale, C. Walter, 1985, Indian Community Development, Local Government, Local Planning and Rural Policy since 1950; *Economic Development and Cultural Change*, Vol33, no.4, pp 677-698
10. Thaha, Abdul and Mumtaz Thaha, 1979, A Manual on Integrated Rural Development (for village, block and district planning), *St. Joseph's Press, Trivandrum*
11. Tinker Hugh, 1959, Authority and Community in Village India, *Pacific Affairs*, Vol.32, No.4, pp.354-375.
12. Williamson et al; 2001, Developing Spatial Data Infrastructures: From Concept to Reality, *CRC Press*

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Cartography for Disaster Management

FLOOD SUSCEPTIBILITY AND RISK AREA DELINEATION OF VADODARA CITY

Ami Upendrabhai RAWAL[1]

ABSTRACT

The Government of India has envisioned the creation of 100 smart cities in the country. A smart city creates sustainable economic development and high quality of life by excelling in economy, mobility, environment, infrastructure and government. In the approach to the Smart Cities Mission, the focus is on sustainable and inclusive development. Efficient governance and the creation of a supportable society are the core concepts of a smart city. Some typical features of comprehensive development in Smart Cities emphasize on making areas less vulnerable to disasters.

Vadodara, also known as Baroda, is already on its way to becoming a smart city. This "cultural capital" of Gujarat is the third largest city in the state after Ahmedabad and Surat. The city of Vadodara is situated on the banks of the Vishwamitri, which originates in the hills of Pavagadh and joins the Dhadhar River and Khanpur River before emptying into the Gulf of Khambhat. This river system includes the Sayaji Sarovar on the Vishwamitri River and the Dev Dam on the Dhadhar Branch. This river system remains highly prone to flooding despite of having proportionately high number of flood control measures. The flooding of Vadodara by the waters of the Vishwamitri is an age old phenomenon. Vadodara has experienced major floods over the years with constantly decreasing intervals and increasing intensities. 1941, 1974, 1976, 1994, 1996, 2005, 2013 and 2014 were particularly trying times for the city.

There are many watercourses called "Kaans" which form the main storm water drainage for the city. The storm water from the entire city drains into a few of the major kaans', which collectively drain into the river. ***Thus the network of the river and kaans' forms the traditional storm water drainage system for Vadodara.****The process of haphazard urbanization has resulted in the reduction of the width of the kaans' and the river. An exponential increase in Illegal settlements and improper waste disposal has led to widespread artificial siltation and even total blockage of the storm water drainage system. These factors contribute to the reduction in the water carrying capacity of these natural drains. This is a major factor for the floods in Vadodara city. Additionally, the meandering nature of the Vishwamitri River poses a formidable challenge to counter the pressing issue of frequent floods.*

This paper is an attempt to critically analyse the reasons for flooding in Vadodara with the help of secondary data. The paper takes a Geo-spatial approach to disaster risk reduction for Vadodara city with the aid of good governance.

Keywords*: Disaster Risk Reduction, Floods, Urban Drainage Blockage, Smart City*

INTRODUCTION

Most big human settlements in the world have been cradled by rivers which are their lifeblood. Large cities of Gujarat are no different. The Vishwamitri River has faithfully nurtured Vadodara over the ages from a small settlement to the third largest city of Gujarat today. Since ancient times, Vadodara has been a service and administrative centre and an intermediate point on the logistical map.

The earliest record of Vadodara identifies it as Vadapadraka, which replaced the neighbouring settlement of Ankottaka as the main town. The city was once called Chandravati, after its ruler Raja Chandan, but was renamed Vadapadraka because of the abundance of Banyan trees on the banks of the Vishwamitri.Archaeological evidences suggest that Vadodara originated as a small village called Ankottaka on the eastern bank of the river Vishwamitri, a tributary of Dhadhar. The village existed between 2BC and 600AD. Excavations show that the inhabitants lived in well-built houses of burnt brick. Ankottaka was the seat of nonferrous foundry, moulding bronze sculptures known to be better than the Chola bronzes. Gujarati artisans were engaged in metal foundry before any other culture in the world.

Around 600 AD, a massive flood in the Vishwamitri washed away Ankottaka. The survivors took refuge in Vadapadraka, which was further west of the western bank of the Vishwamitri. The new settlement of Vadapadraka flourished around 600 AD, bringing the existence of Ankottaka to an end. Vadapadraka served as an administrative centre during Mauryan, Gupta and Chalukyan rule between 900AD and 1500AD.

Baroda experienced the first aspects of urbanization during the rule of Maharaja Sayajirao Gaekwad III (1875-1939 AD). The Maharaja had the foresight to realize that planned development had to be supported by infrastructural growth. He initiated the

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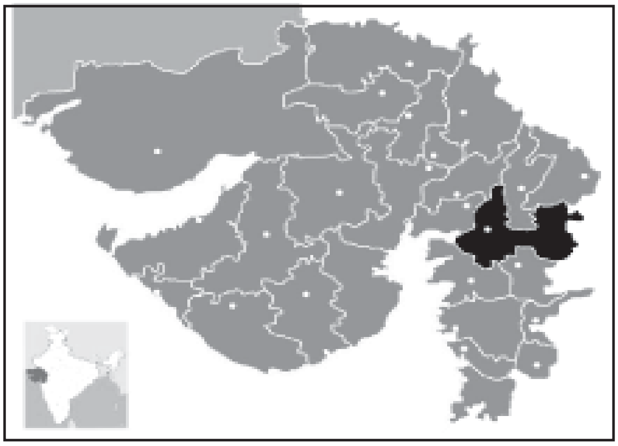
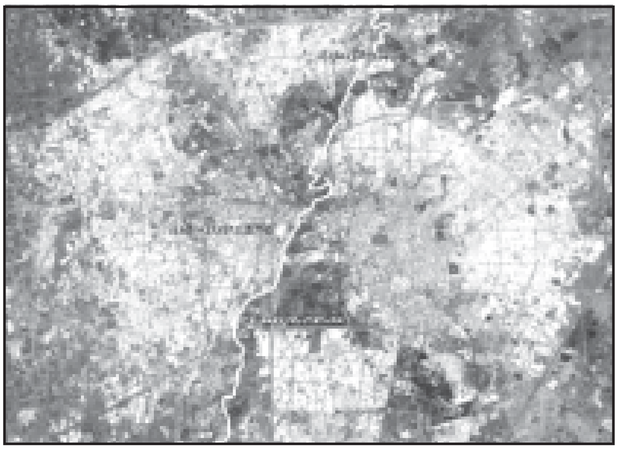
construction of an eastern dam across the river Surya at Ajwa. The city began to receive filtered water through pipelines in 1894AD.The water flow in the entire network was designed based on regional topography. Piped sewerage was first installed in 1896AD. The first water boosting station with an elevated reservoir and the sewage treatment plant were commissioned in 1952, although localized collection of sewage by pumping was already in practice. Surface runoff was directed to detention tanks interconnected by storm water drains. Surplus water from the tanks was directed to Sursagar, a centrally located artificial lake, via underground tunnels. Excess water from Sursagar was emptied into the river Vishwamitri.

The State of Baroda was the most pragmatic and developed state of British India.



Map 1 : Location of Vadodara district in Gujarat state.



Map 2 : Image of Vadodara City with Vishwamitri River

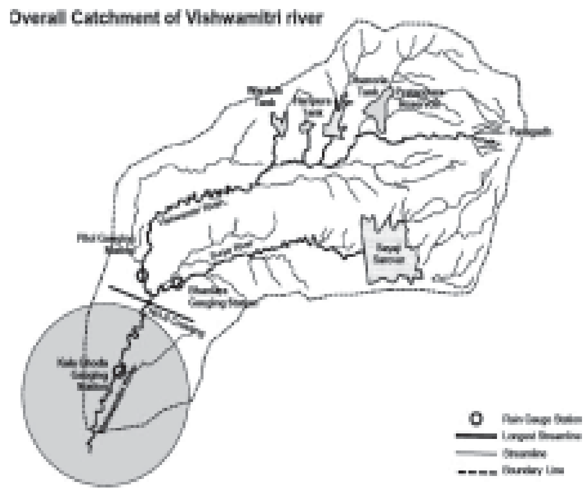
STUDY AREA

Vadodara is located at 22° 17′ 59′′ North latitude and 73° 15′ 18′′ East longitude, in the western part of India. The city is spread over 108.22 sq. km., at 35.5 m above mean sea level. As of 2011, Vadodara had a population of almost 22 lakh people. The city of Vadodara has almost equally grown on both the banks of the Vishwamitri, a seasonal river.

Vadodara city has a general slope from north-east to south-west. Vadodara has a flat terrain, with five rivers- Mahisagar a perennial river that flows at about 15 km west of the city; whereas the Mini, Surya, Jambuvai and Dhadhar flowing in the south. The Vishwamitri passes through the city, following the topography. Apart from this, there are smaller drains scattered around the city, comprising an important part of the natural drainage system.

The Ajwa dam, a 5 km long earthen dam, is built around 20 km upstream of the city. Water from the Ajwa dam meets the requirement of about 3,00,000 residents of Vadodara. Despite having a number of dams on the Vishwamitri and its tributaries the city remains subject to frequent flooding.

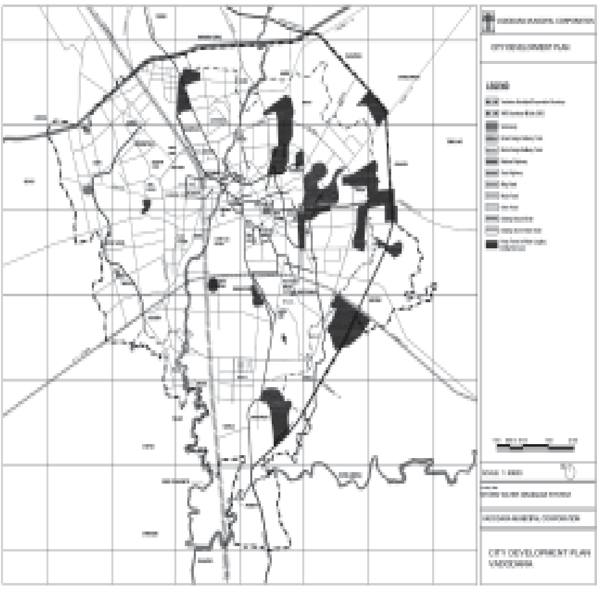
The average annual rain received in Vadodara is 30 inches, while it was 77 inches in 1878, 69 inches in 1917, and ~90 inches in 1927. Vadodara has also suffered major floods in years 1941, 1970, 1974, 1976, 1994, 1996, 2005, 2008, and 2014. These floods have caused catastrophic loss of lives and heavy damage to public and private properties. All public transport services had to be suspended and all major bridges over the river were closed down.



Map

In 2005, the floodwaters, damaged/destroyed houses causing loss of life and extensive damage to property washed away peri-urban settlements. The heavy rains left many of the major dams full while the medium and small dams were overflowing. Most of the excess water got drained into the Vishwamitri River. A sizable number of crocodiles from the river entered residential areas, increasing the gravity of the situation. The situation turned menacing when heavy rainfall in the catchment areas of Ajwa Dam necessitated opening of spillway gates to release water. The river was flowing well above the danger mark, and much of the city was waterlogged.

The 2014 floods were also quite destructive. During the 2014 floods, almost 20% of the city was waterlogged. Areas on the riverbanks and along local watercourses were worst affected, with almost 8 feet of water above mean levels. The following map shows the storm water drainage system with areas prone to water logging in monsoon.



Map 4

There are 10 major watercourses; out of which five are rivulets called "Kaans"(sing.), and five are artificial water tanks; which form the main storm water drainage for the city. The storm water from the entire city drains into a few of the major kaans, which in turn drain it into the river. Thus, the network consisting of the river and kaans' forms the storm water drainage system of Vadodara. The storm water drains of the city cover about 48 % of the total area and cater to about 48 % of the total population. The city has 199 km of storm water drains of which 97 km is underground piped drainage located in the walled city. The well planned and sturdily built storm water drains are laid out below the footpaths, directed symmetrically outwards from the centre of the old city area to the river. Five major natural drains (kaans') aid in carrying the entire storm water from the city and draining it into the Vishwamitri.

DISCUSSION AND ANALYSIS

The flooding problem in Vadodara is due to a number of significant factors. Some of them are discussed below.

Rampant and unplanned development on and around the kaans' has caused some undesirable changes. Unauthorized construction of residential and commercial complexes has caused the kaans' to change their orientation and gradient. Encroachment by slum-dwellers at multiple locations has reduced the section of these natural drains. Widespread dumping of medical and domestic wastes in the rivulets has made them shallow. All these factors greatly contribute to the decreasing net water holding capacity. The problem alleviates in the monsoon season.

Due to inadequate water holding capacities, the neighboring areas become flood prone whenever it rains. Also, solid waste dumping causes low water percolation, increasing the time taken by the floods to recede. Even small spells of rain can lead to heavy water logging in such areas.

As part of the development of the city, many low lying regions are elevated and constructed upon. This has reduced the net attenuation of storm water. The runoff water has fewer places to flow towards, leading to even higher water logging in such areas.

Silting of the natural drains leads to a sharp reduction in the water holding capacity and intensifies the problem of flooding. Almost all major and minor kaans' have flat gradients, making them more prone to silting than covered drains. Access to some drains for maintenance is restricted by development over the manholes. Also, many junctions have direct body connections, making it difficult to clean them. The area of Vadodara has increased threefold in the last three decades, but commensurate development in storm water drainage has not taken place. The areas with chronic flooding problem are shown in map 3.

The walled city has the highest population and built-up land density. In spite of the same, the walled city faces negligible water logging, even during floods. This indicates the engineering acuity and foresightedness of the Maharaja and world renowned town planners, including Patrick Geddes.

CONCLUSION

Vishwamitri river is prone to floods since the historical past. Due to its penchant for flooding, the ancient settlements around the river faced many difficulties. The inhabitants of Ankotakka had to evacuate their well established village and distance themselves from the Vishwamitri to prevent further loss of life and property.

Even in the recent past, floods in Vishwamitri are a common phenomenon. The scientific and technological advances of today's era are unable to shield us from this natural disaster. Haphazard growth and ill planned public infrastructure has aggravated the issue of water logging, especially during monsoon season.

Vadodara features on the list of proposed Smart Cities of India. Some typical features of comprehensive development in Smart Cities emphasize on making areas less vulnerable to disasters. For this, the administration needs to focus on sustainable and inclusive development.

The need for considering topography as an important aspect of town-planning was fully understood by the former rulers and decision makers of Vadodara. In today's time, the consideration of natural processes, systems, and geographical aspects is inevitable to construct a Smart City in the true sense.

REFERENCES

1. Suvarna Shah, J. N. Patel (2009) Morphometric Analysis of Vishwamitri River Basin Gujarat State, India , International Journal of Earth Sciences and Engineering ISSN 0974-5904, Vol. 02, No. 04, August 2009, pp. 331-339
2. H. K. Shastri , D. B. Desai, Prof. G.S. Parthsarthy (2005) Blockage of natural drains due to urbanization and its afterfits, ISPRS, Commission VI, Working Group IV/10
3. History of Vadodara city. http://www.barodaonline.com/city.html
4. Usha Bilipchandra Joshi, Eco-city Plan Generation using RS-GIS: A Case Study of Vadodara, Ph.D thesis
5. Vadodara Municipal Corporation, (2014) Infrastructure Assessment of Vadodara City, Report
6. VMSS, (2014), Vishwamitri Riverfront Development Project, Report
7. Google Earth
8. Wikimedia commons

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A GIS-BASED MODEL FOR FLOOD RELIEF CAMP SITE SELECTION IN DHEMAJI DISTRICT, ASSAM

Krishna DAS[1] and Ashok Kumar BORA[2]

ABSTRACT

Flood is a recurring phenomenon in Dhemaji district of Assam during monsoon season due to abundant rainfall. Many inhabitants of the district are affected and displaced due to flood hazard. During flood it is really very difficult to quickly select ideal sites for establishing the flood relief camps. Therefore, in this paper, an attempt has been made to select suitable and ideal sites for flood relief camps well in advance in the district with the help of Geographic Information System (GIS) modeling. A vector-based site suitability assessment has been made under GIS environment in order to select suitable relief camp sites during flood. Relief (elevation), slope, river, road network are the main aspects taken into consideration for relief camp site selection. The database for relief and slope are extracted from the ASTER DEM data of Dhemaji district, whereas, river and road network layers are generated from the Google Earth online interface. Ideally, the flood relief camp site should be located at a distance from rivers, on land with fair elevation and slope, and at a close location accessible by major roads. Following the ideal criteria, the suitable flood relief camp sites have been selected through proximity, overlay and extraction functions using ArcGIS software packages. Around 17 percent of area to the total geographical area of the district scattered here and there has been found ideal and suitable for the establishment of flood relief camps. From these selected suitable sites, again around 5 percent of area to the total geographical area of the district has been identified as prominently suitable sites for flood relief camp in terms of best access to communication, health services etc. This study carried out with geospatial technology has shown long-term implication for efficient management of flood relief and rescue activities meant for the displaced and flood affected people during hazard emergency period.

Keywords: *Flood Relief Camp, Vector-Based Assessment, Suitable Sites, Dhemaji District*.

INTRODUCTION

Dhemaji district is one of the most flood affected districts of Assam as per flood hazard index calculated by National Remote Sensing Centre (Flood Hazard Atlas for Assam state 2011). Abundant rainfall during monsoon, numerous perennial rivers, geographical location etc. may lead to frequent inundation and recurring flood in this district every year. During last year, flood hazard affected around 700 villages in the district with 3 lakhs affected population (Flood Report of Dhemaji district 2014). Therefore, in this paper, an attempt has been made to prepare a Geographic Information System (GIS) based model to select suitable flood relief camp site in order to shelter the displaced and affected people during flood.

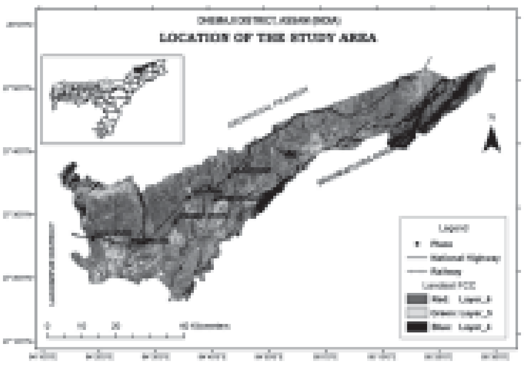

Fig. 1: Location of Dhemaji District, Assam

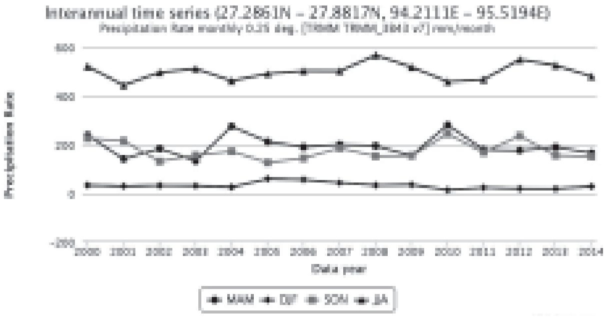

Fig. 2: TRM-M Rainfall Estimates (Seasonal) over Dhemaji District, 2000-2014

THE STUDY AREA

The study area is confined to Dhemaji district of Assam (India), located in the easternmost part of the state covering a geographical area of 3237 km^2. The extension of the district is from 27°16´55´´ N to 27°52´19´´ N latitudes and 94°12´29´´ E to 95°26´38´´ E longitudes. The district is bounded by Arunachal Himalayas to its north and east, Brahmaputra river to its south and Lakhimpur district to its west. Subansiri, Jiadhal, Moridhal, Sissi, Gai, Simen, Telam are some major rivers of the district. Dhemaji district shelters a population of 6,86,133 persons as per 2011 census with a density of 212 persons/km^2. The district has 1,319 villages and 4 towns with a total household of 129,504 numbers.

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OBJECTIVES

The main objectives of this study are-

(a) to find out suitable site for flood relief camp in the study area using GIS approach; and

(b) to determine the prominently suitable site for flood relief camp within the selected suitable site based on certain criterion.

DATA BASE AND METHODOLOGY

Relief (elevation), slope, river networks and road networks are the main aspects taken into consideration in order to select suitable flood relief camp (*Fig-3*). Ideally, the site for flood relief camp should be on plain topography with favourable relief and fair slope, at an ideal distance from perennial rivers and close to major road networks in order to access to services. The elevation and slope layers of the study area are extracted from ASTER DEM data. Similarly, perennial rivers and major road network layers are extracted from Google Earth online interface. To prepare a site suitability model under GIS environments, the four criteria relief, slope, distance from rivers and close to major road networks have been weighted orderly from low weight to high weight and dataset layer for each criterion has been processed using ArcGIS software package.

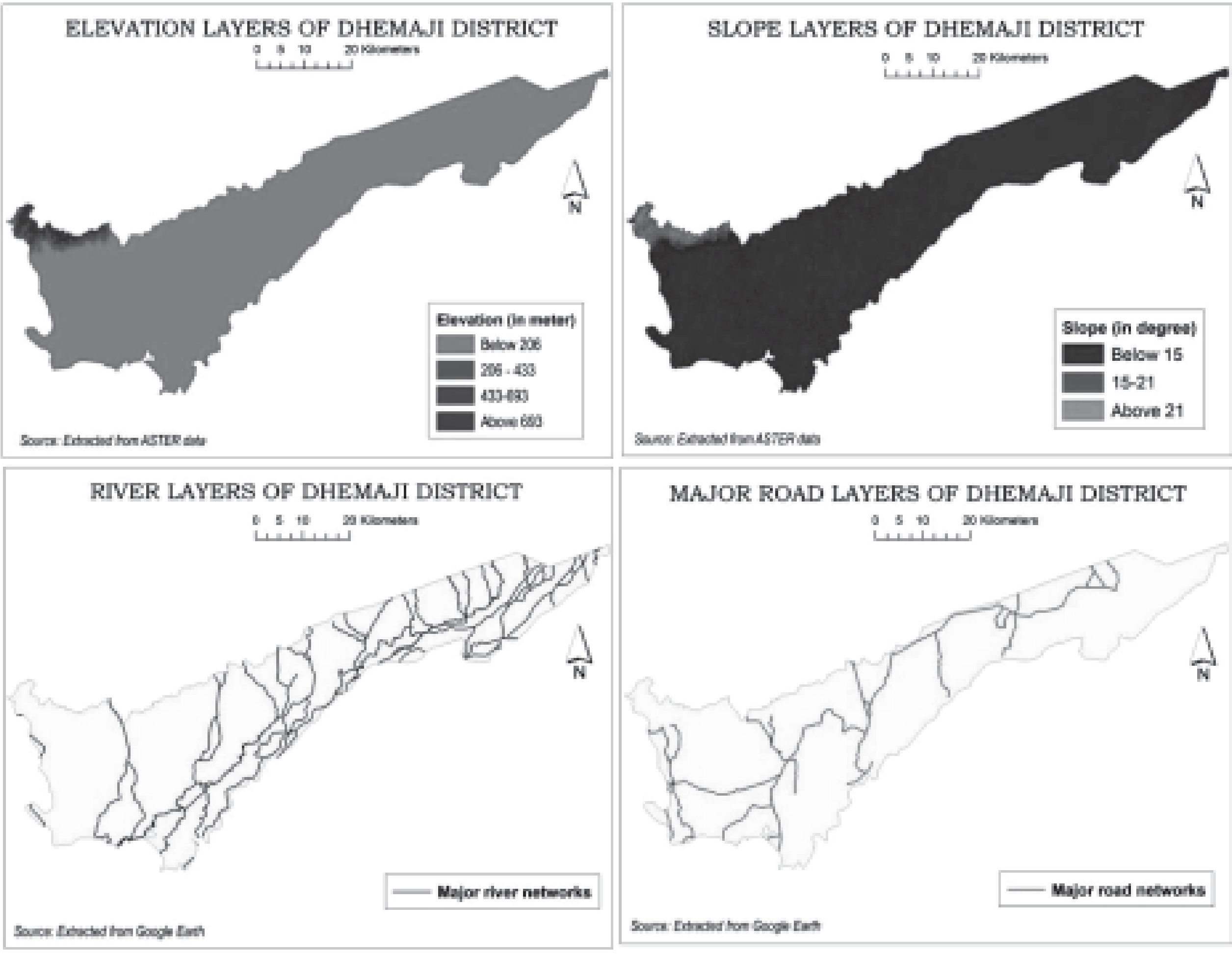

Fig.3: Dataset Layers as Used in the Study

Spatial analysis, vector analysis methods (like proximity, overlay techniques) are used to get the final results of suitable flood relief camp site. Criterion-wise the datasets are processed in GIS using same projection system (WGS84UTM46N) as-

i. Relief (elevation) layer has been classified into four ideal classes and below 206 meter is taken for suitable site selection;

ii. Slope layer has been classified into three ideal classes and below 15 degree is taken into consideration;

iii. A buffer of 1 km of width from the river networks has been hypothetically generated to consider flood extent and this buffer is taken for site selection; and

iv. Finally, a buffer of 1 km of width along the major road networks has been hypothetically generated to find out the closeness to roads and taken for site selection.

The weighted order of these criteria from low to high is i.<ii.<iii.<iv (*Fig-4*).

After the final suitable flood relief camp site selection, again, within the suitable site some prominent suitable flood relief camp site has been identified based on mobile/wireless communication as a prominent criterion. For this purpose, 1 km buffer has been generated in the mobile tower locations layer in order to determine the strength of network signal coverage (*Fig-5*).

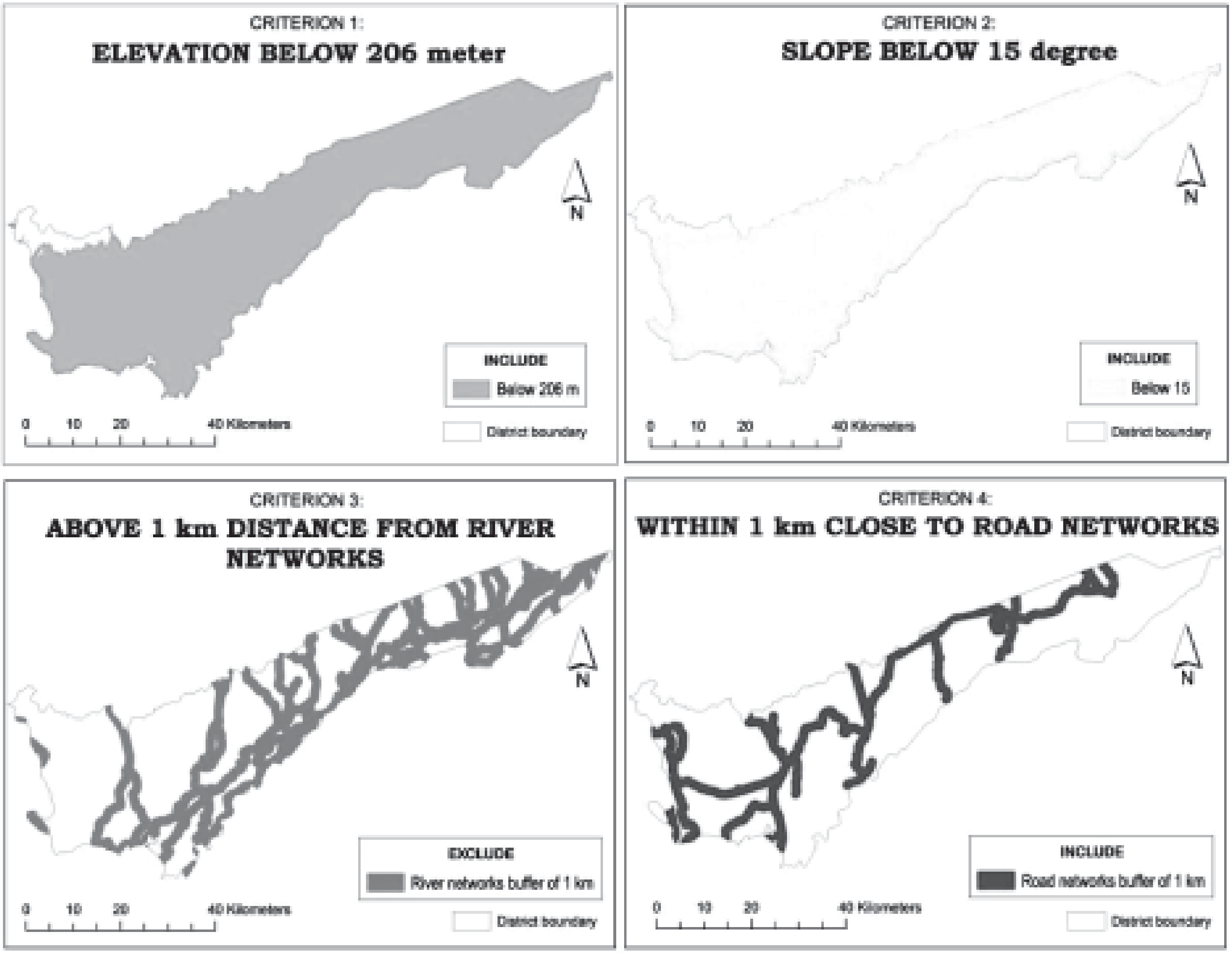

Fig.4: Criteria for Suitable Site Selection

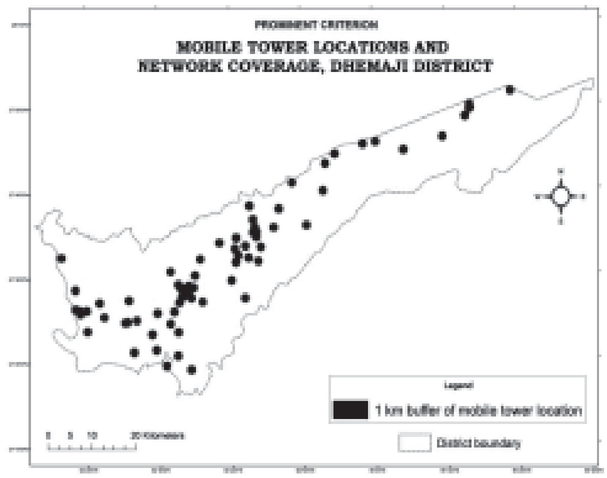

Fig. 5: Prominent Criterion for Prominently Suitable Site Selection

DISCUSSION AND ANALYSIS

Based on the four criteria, suitable flood relief camp sites have been generated and mapped using vector-based analysis under GIS. The highly weighted criterion, i.e., close to major road networks, is taken into consideration for the reason that the affected people in the flood relief camps will able to get better access to commodity, goods, transport, health and education services. The final suitable flood relief camp site in the study area has been observed from the prepared final site suitability map at 541.74 km^2 distributed randomly (*Fig-6*). As many as 250 villages and 3 towns have been identified that are either completely or partly come under the boundary of suitable flood relief camp site.

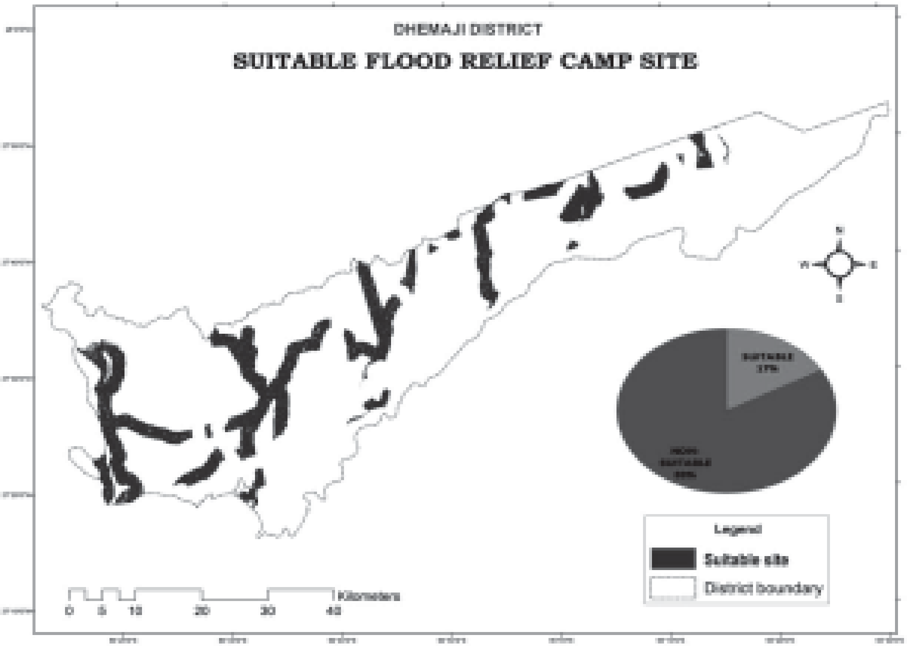

Fig. 6: Suitable Flood Relief Camp Site, Dhemaji District

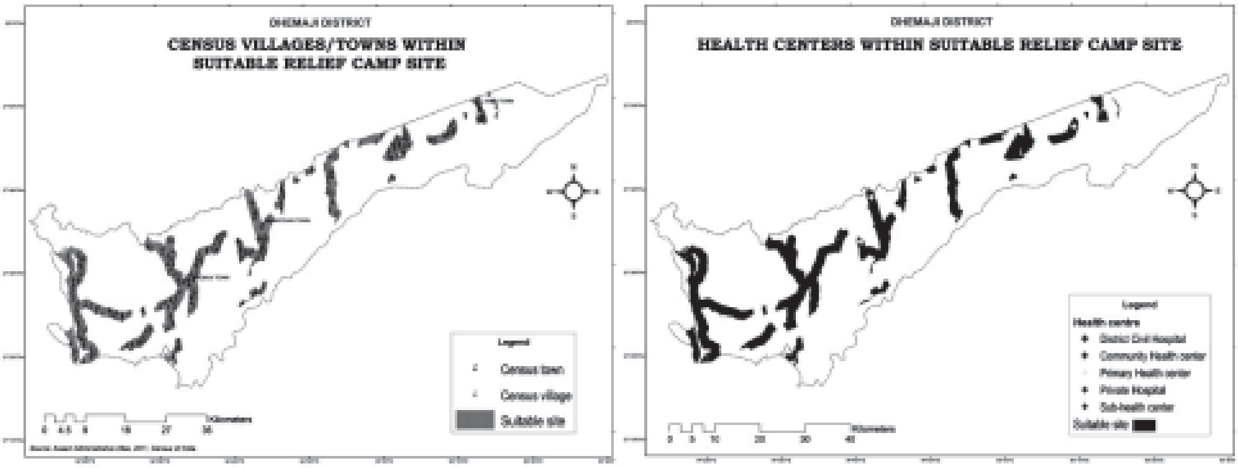

Fig-7: Location of Villages/Towns and Health Centers within Suitable Site

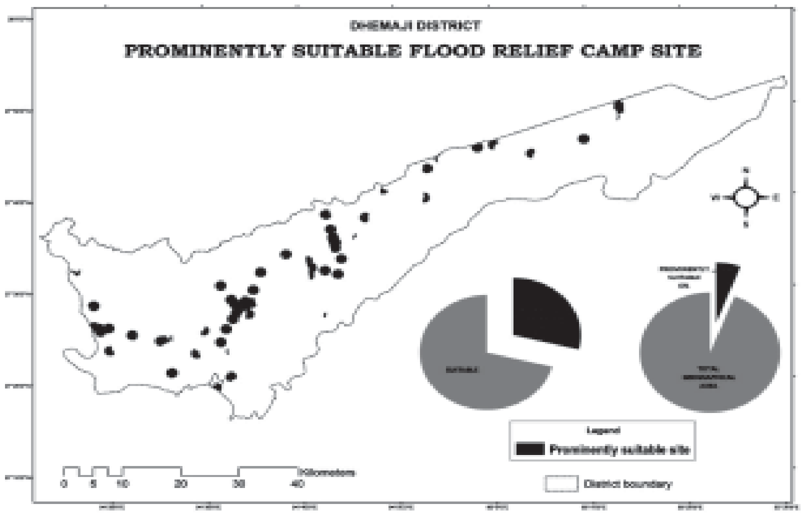

Fig-8 : Prominently Suitable Flood Relief Camp Site

A total of 42 health centers including district civil hospital (1 no.), community health center (3 nos.), primary health center (6 nos.), private hospital (3 nos.) and sub-health center (29 nos.) are found within the suitable flood relief camp site (*Fig-7*). Considering mobile communication as most effective mean during hazard time, some prominently suitable flood relief camp sites have been identified within the suitable flood relief camp site. The observed area for prominently suitable flood relief camp site is found to be 34.32 km^2, which is around 29 percent to the total suitable flood relief camp site area of the district (*Fig-8*). In this study, GIS based model for suitability analysis is found as a useful method for flood relief camp site selection.

CONCLUSION

The proposed (observed from the study) suitable flood relief camp site will help to establish ideal and temporary flood relief camps in Dhemaji district during flood hazard period. Around 17 percent of area to the total geographical area of the district has been identified suitable for flood relief camp site. Similarly, 6 percent of area to the total geographical area of the district is under prominently suitable site for flood relief camps. The identified suitable flood relief camp sites have also prospects for rescue operation of affected people using helicopters and other land transport-ambulance services. The study has provided a sound implication for speedy selection of suitable flood relief camp site with the help of geospatial technology in the hazard-emergency time.

REFERENCES

1. Al-Shalabi, A. et. al (2006): "GIS Based Multicriteria Approaches to Housing Site Suitability Assessment", *XXIII FIG Congress,* Germany.
2. Asare-Kyei, D. et. al (2015): "Modeling Flood Hazard Zones at the Sub-District Level with the Rational Model Integrated with GIS and Remote Sensing Approaches", *Water,* Vol 7, pp. 3531-3564.
3. Census of India (2011): "Administrative Atlas of Assam", Government of India.
4. Dawood, G. M. et. al (2011): "GIS-Based Spatial Mapping of Flash Flood Hazard in Makkah City, Saudi Arabia", *Journal of Geographic Information System*, Vol. 3, pp. 225-231.
5. District Administration of Dhemaji (2014): "Flood Report of Dhemaji district", Government of Assam.
6. Givechi, S. et. al (2013): "Site selection of temporary housing after earthquake by GIS and AHP method Case study: Region 6 of Shiraz", *Urban - Regional Studies and Research Journal*, Vol. 5, No. 17, pp. 29-52.
7. Kumar, M., and Shaikh, V. R. (2013): "Site Suitability Analysis for Urban development Using GIS Based Multicriteria Evaluation Technique", *Journal of Indian Society of Remote Sensing,* Vol. 41(2), pp. 417–424.
8. National Remote Sensing Centre (2011): "Flood Hazard Atlas of Assam State- a geospatial approach", Government of India.
9. Sinha, R. et. al (2008): "Flood Risk Analysis in the Kosi River Basin, North Bihar using Multi-Parametric Approach of Analytical Hierarchy Process", *Journal of Indian Society of Remote Sensing,* Vol 36, pp 335–349.
10. Yeganeh, N. and Sabri, S. (2014): "Flood Vulnerability Assessment in Iskandar Malaysia Using Multi-criteria Evaluation and Fuzzy Logic", *Research Journal of Applied Sciences, Engineering and Technology*, Vol 8(16), pp 1794-1806.
11. Assam State Disaster Management Authority (2014): *http://sdmassam.nic.in/gis.html* Lauren, S. (2015): "Site Selection for Refugee and IDP Camps to House Population Displaced from Nigeria", *https://sites.tufts.edu/gis/files/2015/.../Spink_Lauren_DHP207_2015.pdf*
12. National Aeronautics and Space Administration (2015): *http://giovanni.sci.gsfc.nasa.gov/giovanni/*

CHANGING RIVER COURSE OF SUBARNAREKHA WITH SPECIAL REFERENCE TO FLOOD DISCHARGE – A CASE STUDY USING GEOINFOMATICS

Kishor DANDAPAT[1] and Gopal Krishna PANDA[2]

ABSTRACT

River course changes with respect to time and space play a significant role in stream flow dynamics. When a river leaves its existing course and takes a new course to maintain its flow it is termed as shifting or change of course. Changes in the course of a river can be attributed to geologic, geomorphic, climatic and hydrographical factors or to human interference. Significantly, course of a river is almost liable to change during the extreme floods in the river basin. The lateral erosion of the river banks leads to a decrease in agricultural lands bordering the river banks and decrease in the areas of the river island which in turn reduces the agricultural production. The rambling and trailing of channels in the studied region have been studied through systematic analysis and interpretation of diverse channel configuration and multi channel orientation using multi-temporal topographical maps and satellite images for a period spanning nearly 42 years(1972-2014). For this specific purpose Subarnarekha River has been selected which is virtually a zone transition between exhibiting rolling topography of Chhotonagpur plateau and low lying alluvial plains in South Bengal, in Paschim Medinipur district, state of West Bengal. The prime objective of the study is to reveal the spatio-temporal sequences of course changes, longitudinally and the factor and causes of such changes. For this particular extraction, a base map has been generated with the help of SOI topographical maps and satellite images of the specific area and Google earth's, Arc Gis is used for final product generation and Sinuosity Index and Lateral Entrenchment Ratio also used.

Keywords: *Multi-temporal, Older Alluvial and Lateritic, Diverse Channel Configuration, Google Earth, Arc GIS.*

INTRODUCTION

Drainage system is a dynamic system of the earth which always keeps on changing in response to the changes in the earth-atmosphere system. River always under gone through change in its shapes and alignment by continuous changing their hydrodynamic and morphodynamic processes, depending upon the slope, terrain characteristics, structural parameters, climatic variation, vegetation cover etc. with due course of time. According to the model of landscape evolution, river change its course of flow in response to the above factors. The river course shifting in all most all the river around the world. In India, the greatest channel shift occurred in Kosi River which shifted about 120 km towards east. In geonomic orientation the shifting course of river Subarnarekha is causing large scale disaster in terms of flooding in Paschim Medinipur District, West Bengal, India.

OBJECTIVES

Shifting the river bank is a serious problem of those people who are setting in bank side of the river. Loss of fertile agricultural lands, loss of vegetated cover areas and damaged the earthen embankment disrupt the social structure. So, now a days it is very important for the management of changing fluvial process and river dynamic activities which are related to human investment. Thus the objective may be summarized as follows :

- To find out shifting of the river course.
- To analyze the nature of change occur during the study period.
- To find out changeable factors behind it.
- To point out the management ways.

DATABASE AND METHODOLOGY

- In this study Landsat 5(TM), Landsat 7(ETM+), Landsat 8(OLI), Google Earth and

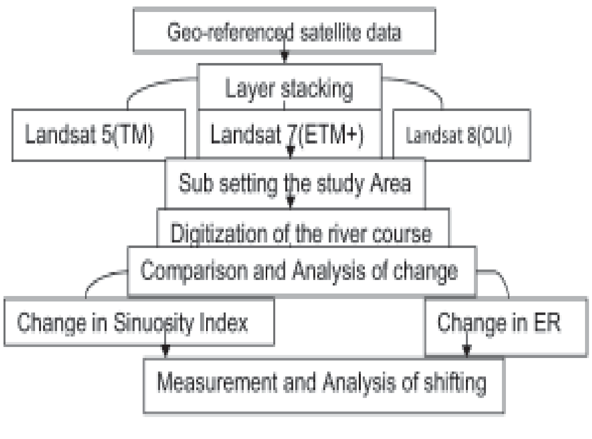

Fig. 2. Methodology Flow Chart

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Topographical map (1:50000) were used to prepare a change alignment map of Subarnarekha River.

- A high resolution CARTOSET DEM is also used
- The district boundary and the drainage map of the district have been prepared on the basis of NATMO planning series map.

STUDY AREA

The Subarnarekha River is situated older alluvial and lateritic region of Paschim Medinipur District, West Bengal, India which is virtually a zone of transition between rolling topography of Chhotonagpur plateau and low lying alluvial plains in South Bengal. The study area extends in between 86p 452 E to 87p 202 E and 21p 502 N to 22p 102 N.

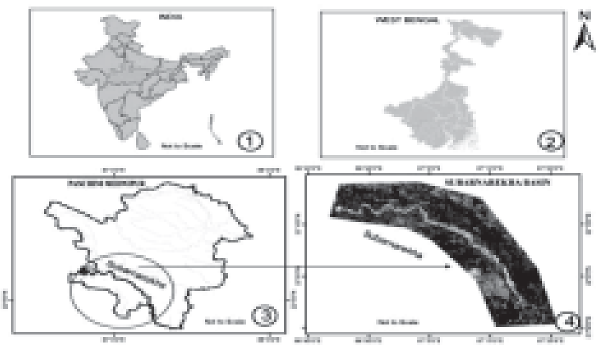


Fig.1. Location map of the Study Area (1.India 2.West Bengal 3.Paschim Medinipur 4.RGB view of Subarnarekha River)

MAJOR PARAMETERS TO ESTIMATE THE CHANGE OF RIVER COURSE

Sinuosity Index (SI)

It is the measure of deviation of the river from its ideal path of movement between two points. Rosgen classification (1994) of stream is considered here. Mathematically it is calculated by the following formula-

SI = CL/SL.. (i)

Where,

CL = actual channel length between source and mouth

SL = straight line length between the same points.

If SI = 1 there is no shifting of the channel and it is any value more than 1 the channel is shifting.

Table.1
Sinuosity value of Subarnarekha River at All Segment

Unit	*1972*	*1993*	*1999*	*2008*	*2014*
I	1.65	1.77	1.60	1.51	1.63
II	1.10	1.90	1.71	1.51	1.63
III	1.11	1.45	1.28	1.33	1.27
IV	1.70	1.65	1.54	1.39	1.34
V	1.17	1.22	1.13	1.03	1.12
VI	1.16	1.24	1.16	1.27	1.16
VII	1.06	1.29	1.13	1.21	1.25
VIIII	0.05	1.25	1.12	1.11	1.15
IX	1.05	1.34	1.14	1.12	1.25

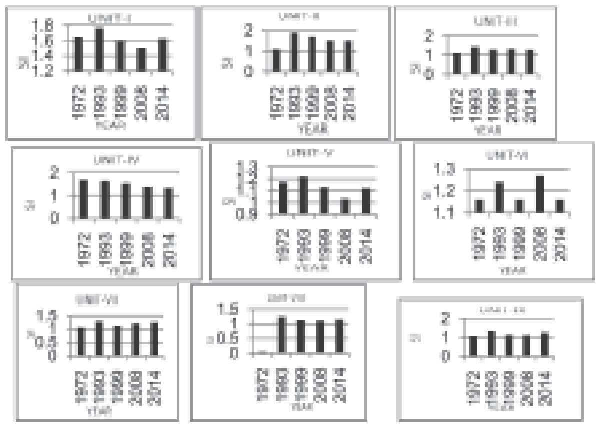


Fig.3. Showing the Sinuosity Index of Subarnarekha River at all segment.

From the above study of changes in sinuosity index the following aspect are found to exist in the nature of alignment of the river are-

i. Unit I and II of the river appears to be meander as the SI value of these two segment over the study period remains 1.5.

ii. Unit IV also a meander but at present study area shows a declining trend in SI. Thus it gradually straightens it course during the study period.

iii. Unit V, VI, VII, VIII and IX of the river shown a rising trend in SI during the study period.

So, overall reflectance of the study area is that the river course gradually changes over the time in response to the high flood discharge and other associated flood intensifying condition like, terrain characteristics, Geo-morphological characteristics, human interference etc.

Lateral Entrenchment Ratio (ER)

It helps to identify the amount of bank shifting of a river. It is the ratio between lengths of the two banks of a river to identify the amount of bank shifting of a river, as expressed under-

ER = LL/LR .... (ii)

Where, LL = Length of the left bank

LR = Length of the right bank

If the value remains 1, it means there is no bank shifting of a river. If it is >1 that means channel is shifted towards its left bank. If ER <1 that means the channel has shifted towards the right bank at the given segment of the river.

Table. 2
ER value of Subarnarekha River at All Segment

Unit	*1972*	*1993*	*1999*	*2008*	*2014*
I	0.89	0.85	0.88	0.87	0.88
II	0.96	0.94	0.87	0.84	0.93
III	1.08	0.99	0.99	0.93	1.06
IV	1.10	1.09	1.16	1.15	1.11
V	1.07	1.14	1.11	1.15	1.06
VI	1.01	1.00	1.04	1.10	1.12
VII	0.94	1.02	1.05	0.99	0.98
VIII	1.06	0.98	0.98	1.10	1.04
IX	0.98	0.97	1.00	1.01	1.00

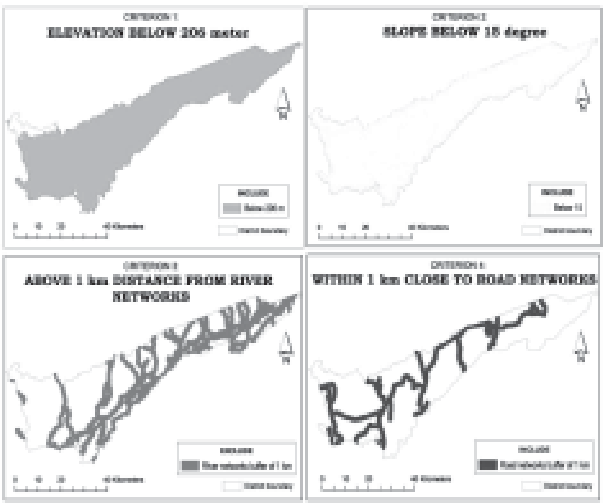


Fig.4. Showing the ER value of Subarnarekha River at all segment.

From the above analysis of changes in Lateral Entrenchment Ratio the following aspect are found-

i. Unit I and II of the river shows that there is shifting of river bank from left towards right.

ii. Unit IV, V and VI of the river bank shifted from right towards left.

iii. Without above units (I,II,IV,V,VI) all the units of the river bank are shifted either left to right or right to left during the study period.

So, over the study period (42 years) river bank shifted either towards right or left, not a single one unit of the river bank which are not shifted.

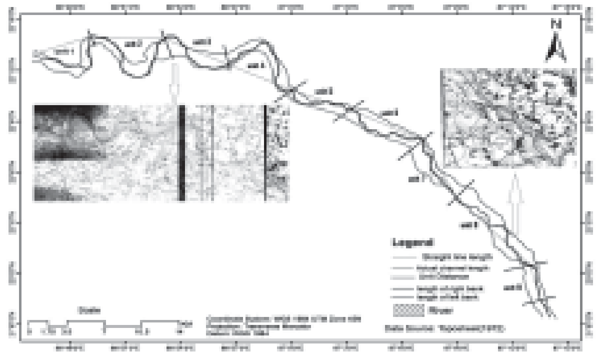


Fig.5. Subarnarekha River segment 1972

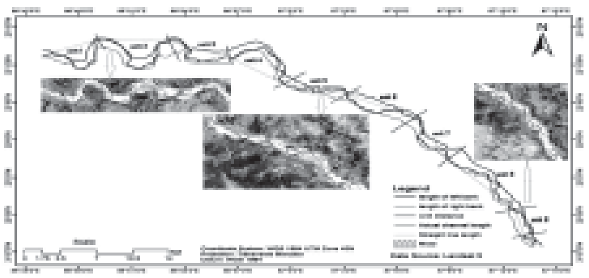


Fig.6. Subarnarekha River segment 1993

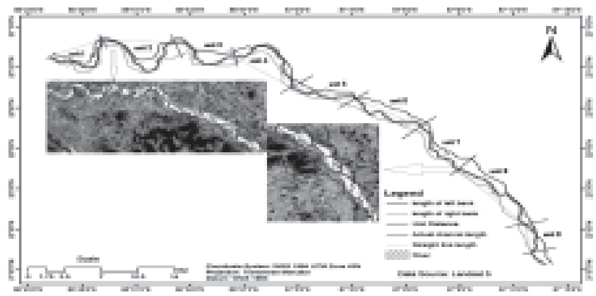


Fig.7. Subarnarekha River segment 1999

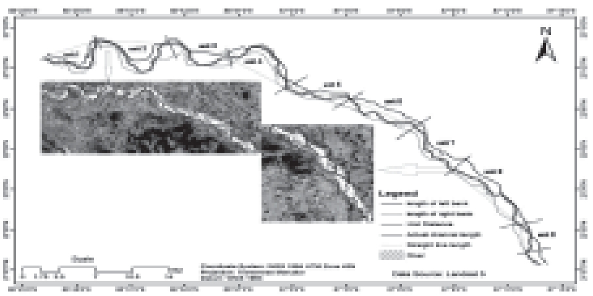


Fig. 8. Subarnarekha River segment 2008.

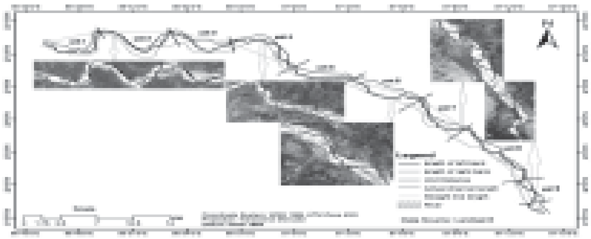


Fig. 9. Subarnarekha River segment 2014

River Course Shifting with Direction and Distance From 1972-2014

Table.3

Major Shifting with Distance and Direction

Units	*Reach Distance(m)*	*Major shifting(m)*	*Shifting Direction*
Unit - I	1025	233	N
	1938	752	S
	1975	147	N
	3517	245	N
	4050	922	S
	6045	464	NW
	7969	331	NW
Unit – II	10041	223	N
	15057	140	SW
	15357	921	NE
Unit - III	22740	355	SW
	25821	622	NW
	29344	971	NW
Unit – IV	32981	525	SW
	34538	1198	NE
	39523	576	SW
Unit - V	41456	922	SW
	45033	527	SW
Unit - VI	49063	566	N
	52083	338	S
	54169	841	N
	54962	418	SW
	57096	855	W
Unit - VII	59859	551	W
	61266	580	SW
	62431	635	NE
	65616	1658	S
Unit - VIII	67497	319	NE
	70135	891	NE
	74239	799	SW
	74813	492	SW
Unit - IX	78116	1068	SW

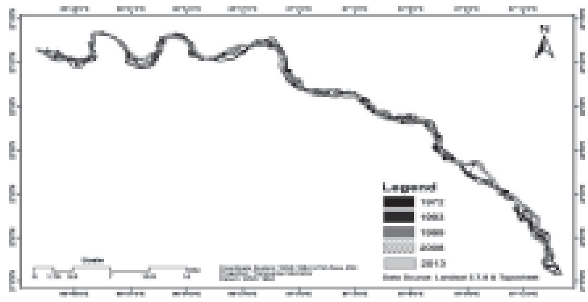


Fig.10. Shifted Channel of Subarnarekha River during the Study Period.

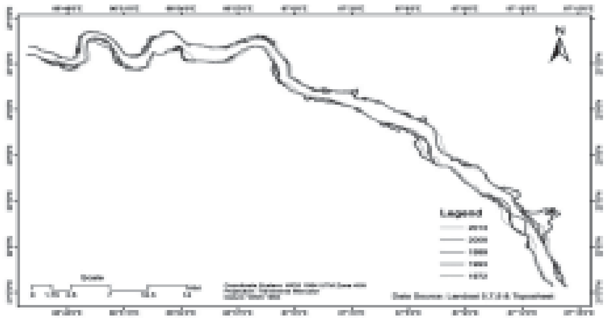


Fig.11. Shifted Bank of Subarnarekha River during the Study Period.

Responsible Parameters

Different parameter is responsible for shifting the river course like, morphological, hydrological, meteorological, sediment structure etc. Flood discharge is most important parameter among the various parameters for shifting the course.

Flood Discharge

Flood discharge is that the volume of water per unit time that passes a specified point on a stream. The discharge varies from 30 to 80000 cubic feet per second in Subarnarekha River.

Flood discharge during monsoonal season is very high and its create a great havoc on the society by flooding vast area as well as river bank erosion. Flood discharge > 70000 cfs create high flood because this time gauge height exceed extreme danger level (EDL). And during the whole year water flowing in closed to the bank and when high flood discharge come the slide occur and continue river change their channel as well as bank. Flood discharge probability of occurrences calculated by this formula-

Fa = 100(2n-1)/2y ....(iii)

Where, n = rank of each event

Y = the total no. Of events

And return period calculated by this following formula-

100/Fa ....(iv)

Where, Fa = probability of occurrences.

Table.4.
Flood Discharge and their Fa and Return Period

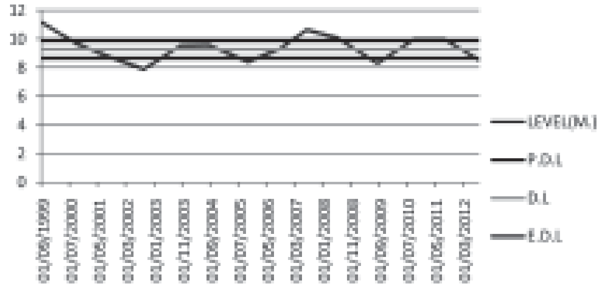
Year	*Flood Dis-charge (cfs)*	*Year*	*Flood Dis-charge (cfs) from largest to smallest*	*Rank*	*Probabi-lity of occur-rence (Fa)*	*Return Period*
1988	62110	2008	79574	1	1.85	54.00
1989	56611	1997	78214	2	5.56	18.00
1990	51921	1999	77837	3	9.26	10.80
1991	64254	1994	74592	4	12.96	7.71
1992	46978	2006	72922	5	16.67	6.0
1993	68972	1996	72642	6	20.37	4.91
1994	74592	1995	71112	7	24.07	4.15
1995	71112	2013	71018	8	27.78	3.60
1996	72642	1993	68972	9	31.48	3.18
1997	78214	2005	68928	10	35.19	2.84
1998	45678	2014	68212	11	38.89	2.57
1999	77837	2007	66526	12	42.59	2.35
2000	49978	1991	64254	13	46.30	2.16
2001	30948	2011	62323	14	50.00	2.00
2002	41574	1988	62110	15	53.70	1.6
2003	61987	2003	61987	16	57.41	1.74
2004	59427	2004	59427	17	61.11	1.64
2005	68928	2012	58424	18	64.81	1.54
2006	72922	1989	56611	19	68.52	1.46
2007	66526	1990	51921	20	72.22	1.3
2008	79574	2000	49978	21	75.93	1.32
2009	37348	1992	46978	22	79.63	1.26
2010	45924	2010	45924	23	83.33	1.20
2011	62323	199	45678	24	87.04	1.15
2002	58424	2002	41574	25	90.74	1.10
2013	71018	2009	37348	26	94.44	1.06
2014	68212	2001	30948	27	98.15	1.02

Source: Irrigation and Water Ways Dept. Government of West Bengal.

Hazard Function

From the flood discharge data showing the hazard function using Easy Fit software, the hazard function is the ratio of the probability density function to the survival function. The hazard function is used in reliability applications to describe the instantaneous failure rate at any point in time. Hazard function is-

H(x) = f(x)/s(x) = f(x)/1-F(x) ....(v)



Source: Jhargram irrigation and water ways office (Station: Asui-Dhrampur)

Fig.12. Showing the gauge height during flood season

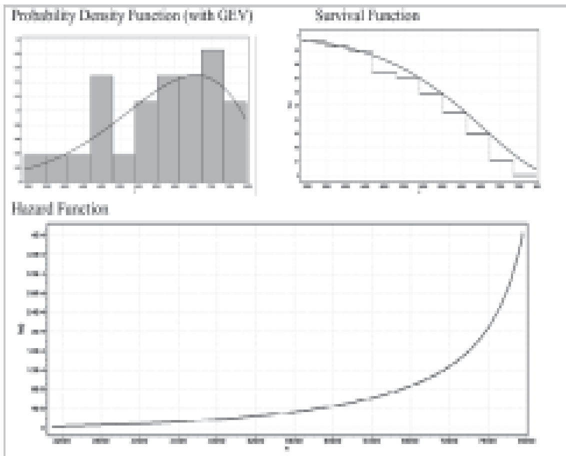
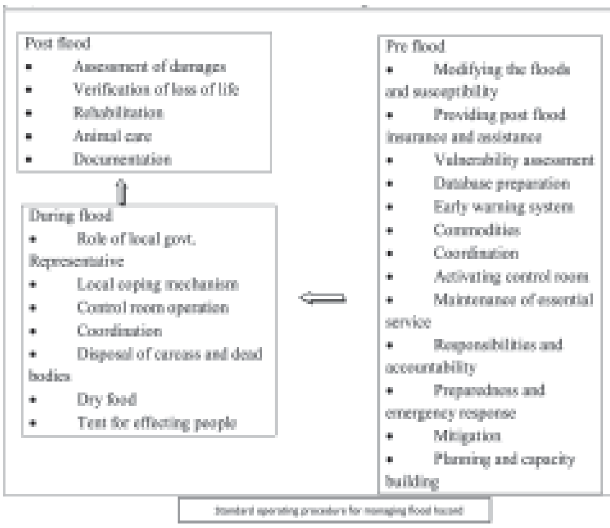


Fig.13. Showing the Hazard Function by the help of Flood Discharge

Flood Induced River Bank Management Aspect

Apart from an effective disaster response system, it is important to have a good flood prevention and mitigation system to achieve objectives of vulnerability reduction. The erosion has taken an alarming magnitude because of low level of



technological adjustment and ill directed planning. Geomorphologist thinks that a river is a living reality that needs space. The behavior of a river can be defined in terms of the rhythm of environmental system. But the absence of proper attention to the basic delta building geomorphologic processes is the cause of unexpected accelerated rate of bank erosion. The engineer's view is that the construction of embankments, spurs, etc. are the immediate solution when it is becoming a national disaster.

Component of Floods Preparedness Plan

A flood preparedness plan (FPP) which is integral component of the multi-hazard disaster management plan, is an action oriented document detailing specific actions to be under taken prior to floods, which set the ground for effective execution of emergency response and recovery activities during and after floods. The components of a FPP are-

i. Assessment of probable needs.

ii. Institutional mechanism for implementation of FPP.

iii. Activating early warning and disaster response system.

iv. Resource mobilization and allocation.

v. Communication within and outside the community.

vi. Sectoral components.

Effectiveness of Control Measures in High Risk Zones (HRZ)

The high risk villages of the study area are Samsunderpur, Asui-dhrampur, Chirchota, Kuthighat, Baliya, Bansjora, Aradangri, Varnal and Bahakulin and also the moderate danger villages, the following measures adopted to control erosion and flooding-

i. Construction of short spur to divert flow from attacking the bank line.

ii. Construction the permanent concrete wall at the major erosional places.

iii. Immediate plantation necessary in minor erosional bank line.

iv. Falling apron in the place of week bank line.

v Construction of retired embankment to avert flooding as and when the foreward embankment was danger.

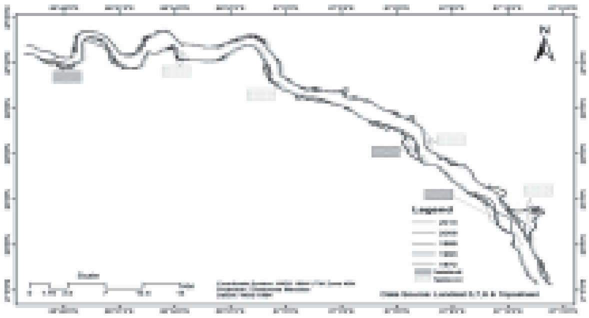


Fig.14. Proposed map to prevention the shifting the river bank.

SUMMARY AND FINDINGS

During the study period thalweg of Subarnarekha River has shifted at an average rate of 30 meters per year and also lateral entrenchment ratio changed. Every year during rainy season the thalweg of the river shift to a great extent. River bank are mostly composed of older alluvial and finer sand with alluvial, that is why river bank is shifted very much. So

i. The river course of Subarnarekha has changed over time in the studied region.

ii. The nature of change is visible in the longitudinal and transverse direction.

iii. It seems to be related to flood discharge and hydraulic action besides human interference in shifting of bed materials and setting of brick kilns in the river bed.

iv. River course shifted 3 to 30 meters per year.

REFERENCES

1. Banerjee, S.N. & Chakraborty, p. (1983), Some Observations on Recent Trends of Shifting of the Ganga between Rajmahal and Ahiron, journal of the Geographical society of India, 24, pp. 318-321.

2. Chakraborty P. and Choudhury.S: Ganga Padma River: Bank Faliure and Changing Courses- Down the Ages.

3. Mukhopadhyay.S and Mukhopadhyay.S., Bank Erosion of River Ganga, Eastern India-A Threat to Environmental System Management.

4. Ray S.C. (2004), A Study Report on Control of Left Bank Erosion of River Ganga between Rajmahal and Farakka by Irrigation and Water Ways Department Government of West Bengal.

5. Rudra.K. (1996), Problems of River Bank Erosion Along Ganga in Murshidabad district of W.B., Indian journal of Geography and Environment, 1, pp. 25-32.

6. Rudra.K. The encroaching Ganga and Social Conflicts: The Case Study of West Bengal, India, Independent Broadcasting Associates, Littleton, MA, pp. 40.

7. Ebisemiju, F.E. (1994), the Sinuosity of Alluvial River Channels in the Seasonally Wet Tropical Environment: Case Study of River Elmi, South Western Nigeria. Catena, vol. 24, pp. 13-25.

8. Leopold, L.B., and Wolman, M.G., (1957), River Channel Patterns: Braided, Meandering and Straight. United States Geological Survey Professional Papers, 282, pp. 39-85.

9. Panda,P.C., and Bora, H.N., (1992), A Study of Sinuosity Index of Siang River and its Major Tributaries: Arunachal Pradesh. Environmental Management, 1, pp. 97-101.

10. Rachna, R., Mulchandni, N., Bhandari, (2004) Channel Shifting of a Highly Sinuous Meandering River in Alluvial Plain, Vishwamitri River. Mainland Gujarat. Current Science, 86(12), pp. 1647-1653.

11. Schumm, S.A. (1963), Sinuosity of Alluvial Rivers on the Great Plains. Geological Society of American Bulletin, 74, pp. 1089-1100.

12. Schumm, S.A., and Khan, H.R. (1972), Experimental Study of Channel Patterns. Geological Society of American Bulletin, 83, pp. 1755-1770.

STATUS OF NATURAL DISASTER PREPAREDNESS IN HARYANA : A GEOGRAPHER'S CONCERN

Kuldip Singh KAIT[1]

ABSTRACT

Many regions of the country are vulnerable to natural disasters and are becoming increasingly vulnerable. Haryana has also witnessed an increase in the number and extent of natural disasters during the last two decade. While thousands of people suffer hardship of the natural disaster, things appear to be getting worse in two ways: natural disasters appear to be becoming more frequent and effects more severe. It becomes all the more critical as the poor are most likely to suffer from major disasters and the least likely to be ensured against loss. The unique geographical position and behaviour of the monsoon in Haryana makes this region vulnerable to different forms of natural disasters which includes floods, droughts, hailstorm, cloud burst, heat and cold wave and earthquake, besides a host of other disasters like pest attack, cattle epidemic and food poisoning, industrial & nuclear disasters, accident related, urban and village fire, major building collapse, road and rail accidents, festival related disasters, and so on. The cost of weather related disaster, however, exceeds all forms of other disasters and has been increasing over the period. The question therefore is, whether the disaster situation is improving over time and are the numbers of disasters showing any declining trend over the years. In order to meet the challenge posed by the various forms of disasters, a system of enormous scope must be undertaken. There is a requirement of preparedness measures, which are less costly than prevention. The state government has taken various measures to deal with the problem. But whether the preparedness of the state machinery is satisfactory to deal with such crisis is the question. In the current paper, an attempt has been made to do a temporal analysis of the natural disasters in Haryana, its effect and the preparedness of the government to deal with such emergency situations.

Keywords : *Natural Disaster, Monsoon, Geographical Positions, Challenge, Preparedness*

INTRODUCTION TO NATURAL DISASTER

A natural disaster may be defined as the effect of natural hazards which leads to human, environmental or financial losses. The costs of natural disasters — lives lost, homes destroyed, economies disrupted — have skyrocketed in this century, as the world's population has grown. Some of the natural disasters are geological while many of them are due to the changes in the climatic conditions. Such natural disasters are floods and droughts. By understanding how and where these natural events occur, and by providing real-time information about floods, earthquakes, and other hazards, we can respond effectively when disaster strikes.

Till recently the approach to Disaster Management has been reactive and relief centric, a paradigm shift has now taken place at the national level from the relief centric syndrome to holistic and integrated approach with emphasis on prevention, mitigation and preparedness. These efforts are aimed to conserve developmental gains as also minimize losses to lives, livelihood and property. In the current paper, an attempt has been made to do a temporal analysis of the natural disasters -floods and droughts in Haryana, its effects and preparedness of the government to deal with such crisis situations.

H.J. Critchfield (1987) defined Floods as –

- River floods result whenever the channel capacity is exceeded by the runoff. Excessive runoff or rainfall or snowmelt is the fundamental cause, but the channel may also be affected by barriers to flow (such as dams or ice jams), sudden changes of direction of the stream, reduced gradient, siltation of the stream bed, or sudden release of water due to a broken dam.".
- "Deficit that results when soil moisture is insufficient to meet the demands of potential evapotranspiration".

A View of Flooding in Eastern Haryana Plain

Flooding in Yamunanagar District of Haryana

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Floods have been a recurrent phenomenon in Haryana from time immemorial. Many part of the state of Haryana are prone to flooding. The devastating floods hit Haryana many times. In 1977, 78, 80, 83, 88,93and 1995, 1996 floods occurred in Haryana. Floods have been causing extensive damage not only to standing crops but also loss of lives and cattle.

The floods in Haryana can occur because of some natural reasons such as its physiographic situation which makes a depressional saucer shape zone around the Delhi-Rohtak-Hisar-Sirsa axis and it has a poor natural drainage system and sometimes the heavy precipitation becomes a major contributing factor in causing flood as such in case of Rohtak flood, 1995. The state receives an average rainfall of about 650 mm. The average annual rainfall varies from less than 300mm in the western and south western parts of Sirsa, Hisar and Bhiwani districts along the Rajasthan border to over 1100mm in the north-eastern Shivalik hilly tracts of Panchkula and Yamunanagar districts along Himachal Pradesh border The problem of floods is further accentuated by the existence of human-made barriers like the networks of roads and canals, which obstruct the natural flow of water and sometimes Drainage systems back up because they cannot cope up with the volume of water or are blocked by rubbish and garbage. On the other hand indiscriminate use of water for irrigation and development of low-lying areas and depressions has also created problem of drainage congestion and water logging which create a havoc of flooding.

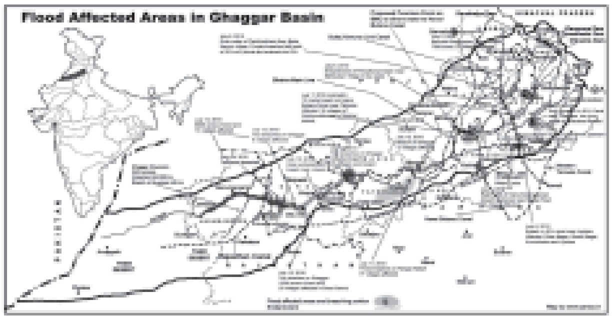
Flooding, in Haryana, generally takes place in the marginal areas along the Yamuna while the problem of poor drainage exists in some of the south western districts as well. Another cause for flood has been the water logging in the irrigated area and changes in river regimes due to increased ground water levels.

At present, the problem in Haryana is mostly of drainage congestion and water logging. Rainfall pattern during the kharif crop growing season (June–September) for the period 2006 to 2010 has been analysed for this seminar paper.

Out of 5 years, 3 drought years and 1 flood year have been identified i.e. 2006, 2007, 2009 and 2010 respectively. While erratic monsoons and drought are intertwined, a host of other reasons, mostly manmade, aggravate drought or create drought-like situations in the country. Over the past decades, individuals, communities and the government have all pursued lopsided water management policies, leading to the water scarcity situation we face today.

Ghaggar and its tributaries breached embankments one after another along its stretch and flooded vast areas. Heavy discharge and human interference in the natural flow of river water along with the lack of maintenance of embankments and canals are supposed to be the causes for such a massive loss of life and property of the common people residing in the Ghaggar basin.

In this paper, 2010 flood has been attempted for analysis. In the first and second week of July 2010, Punjab and Haryana experienced massive flood disaster in the Ghaggar River basin as shown in the Map.



Drought

H.J. Critchfield (1987) classified drought into:

(i) Permanent drought associated with arid climates;

(ii) Seasonal drought, which occurs in climates with distinct annual periods of dry weather and drought due to precipitation variability.

(iii) It is also to be noted that droughts does not begin with the onset of a dry spell, it occurs when plants are inadequately supplied with moisture from the soil.

Drought in Eastern Haryana Plain

Drought in Western Haryana Plain

Therefore drought is defined in terms of the water need of a particular crop growing under a specific combination of environmental condition.

In order to understand the occurrence of drought in Haryana, it is important to have an understanding of the various physiographic zones of the state. By and large, Haryana is a plain area except the foothills of the Shiwalik system in the northeast and of the remnants of the Aravalli system in the southwest. On the basis of local topography and distribution of sandy and calcareous sierozemic soils, Haryana is divided into Eastern, Western and Southern Plains.

Eastern Haryana Plain covers the districts of Ambala, Panchkula, Yamunanagar, Jind, Kurukshetra, Kaithal, Karnal, Panipat, Sonipat, Rohtak and Jhajjar. This plain is bordered by low hills of the Shiwalik system in the north-east to south-west, in which most of the rivers flow. A large number of rain-fed torrents flow down the outer slopes of the Shiwalik and spread much gravels and pebbles in their beds. Of these streams, the Ghaggar, the Markanda, the Chutang and the Saraswati are the important ones.

Western Haryana Plain, the arid region of the state covers Hisar, Sirsa, Fatehabad and Bhiwani districts. The scattered remnants of Aravalli dot the area. The land is thirsty and is clothed by steppe vegetation and with sand dunes of various slopes and sizes. Wind erosion is active and water table is deep in this area.

Southern Haryana Plain is rocky in nature covers the districts of Mahendergarh, Rewari, Gurgaon, Mewat, Faridabad and Palwal. It differs from the western plain because of the presence of the Aravalli offshoots and its slope towards the north and undulating character. This part is also dotted with sand dunes of varying sizes. A number of small rivulets carry water from Rajasthan. Among them the Sahibi, the Krishnavati, the Indoris, the Dohan and the Landoha are worth mentioning.

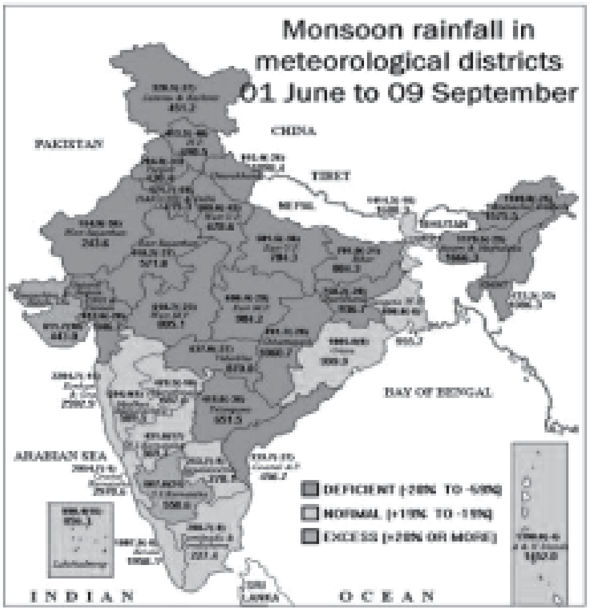
The drainage pattern of the state is based on the north east to south west slope and except river Yamuna flowing along the eastern boundary of the state, and river Ghagghar which is structure controlled and flows along well-defined tectonic lines all others are rain fed. The southerly to southeasterly direction of flow of the river Yamuna indicates a basement high.

The topographical low passing through Delhi-Rohtak-Hisar and Sirsa appears to coincide with basement high and the gradual shift in the drainage system indicates some neo-tectonic activity in the region. This has led to the most important ecological problem of the state i.e., the rapid desertification due to migration of sand dunes in the south and southwestern parts.

The climate of Haryana is semi-arid monsoon type, essentially a transitional one between that of the arid desert of Rajasthan and the moderately humid western Gangetic plain. Due to its interior location, the state fails to get the full benefits from the monsoon rains and there is generally shortage of rainfall over its greater part coupled, with the high summer temperatures and high evaporation.

Reckless over-exploitation of surface and groundwater, for instance, has been one area of deep concern. Because of multiplicity of factors along with fluctuating rainfall, Haryana has experienced droughts and drought like situations in 2006, 2007 and 2009. Prior to analysing the impacts of drought in the state, it would be interesting to note the occurrence of droughts in Haryana is due to the variability in rainfall in the years.

The 2009 drought in Haryana was due to the weak and erratic monsoon. Kharif crops withered away and large tracks of land in the state remained barren and unsown.



To deal with drought like conditions in future the state government decided to dig lakes and construct reservoirs for providing irrigation facilities to the thirsty land.

Direct and Indirect Impacts on the Economic, Social and Environmental Fabric of the Region

1. Depending on its reach and scale it could bring about social unrest.
2. A shortage of raw material supplies to agro-based industries.
3. Reduced rural demand for industrial / consumer products due to reduced agricultural incomes.

4. Potential shift in public sector resource allocation from investment expenditure to financing of drought relief measures.

Impact on crop production

In 2009, the kharif crops have been sown in only 26.57 lakh hectares as against 28.92 lakh hectares in the corresponding period in 2008.

Impact on Fodder and livestock

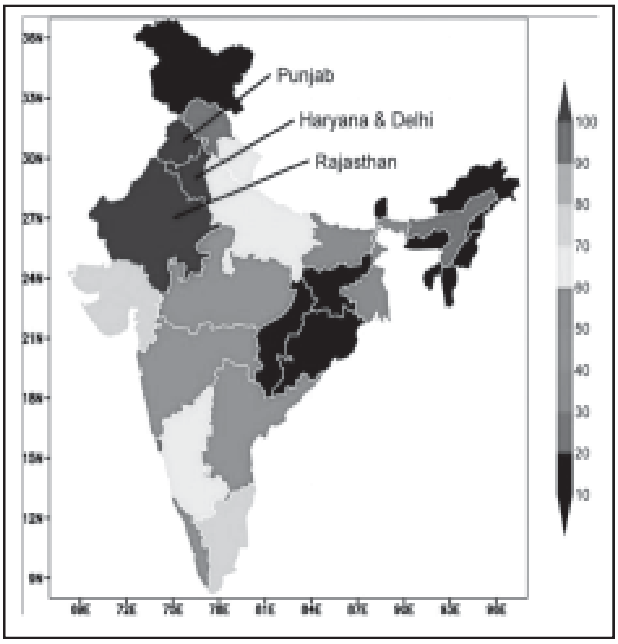
1. Another impact of the drought situation is fodder deficiency. With no agriculture, and limited buffer stocks of fodder, there is generally steep hike in fodder prices, which leads many into debt.
2. Further, much of the available fodder becomes contaminated. Due to the non-availability of water and fodder, people abandon their unproductive cattle.
3. Some migrate to the cities and other states with their animals and many a times the livestock is lost.

Impact on Agriculture-related Activities

1. In the year 2002, the impact of drought was felt on the largest cattle fair of the northern region, held in Haryana during June-September.
2. The sale of livestock fetched the farmers only about Rs 10 crore against over Rs 35 crore in the normal rainfall years.
3. Even though 2000-2001 was a partial drought year, cattle worth about Rs 19.50 crore was sold in these fairs.
4. The cattle breeders bear the brunt though the government revenue earned in the shape of registration of cattle sale in these fairs also declines.

Impact on Economy

1. The cascading effect of the drought on Haryana's predominantly agro-based economy is felt in the distress sale of milch animals' in South and Western Haryana Plain.
2. The reason - milk yield of even the best of the murrah breed declines as a result of drought.
3. The milk vendors would buy milk from the farmers and sell the same to consumers, in twice the prices, that too adulterated milk.
4. The price of dry fodder shoots up making dairy farming a grossly losing proposition.
5. Haryana along with neighbouring Punjab, the hub of the Green Revolution has been sucking up groundwater resources relentlessly. It is both the cause and consequence of droughts in the state.
6. As the latest figure of rainfall deficiency in Haryana stands at 74 % the state is facing a unique problem that of a thriving borewell industry. The deep borewell industry is booming as farmers dig deeper to tap ground water. But gravity research satellites of National Aeronautics and Space Administration (NASA) point out that the drop in groundwater level is alarming in Haryana (Map). Across the state the depth of the water table has gone down from 60-70 feet to 80-90 feet to 120 feet and now to 300-400 feet for deep bore submersible pumps.



7. Everyone who has three to four acres has put a submersible pump and it has been estimated that there is a tube well for every four acres of farmland which add up to almost 2 million tube wells for about 10 million acres of land in Haryana. NASA satellite imagery also shows that 109 cubic km of groundwater has been lost in just six years (2002-08) alone. The paradox therefore is whether to worry about the levels of ground water reservoir or worry about rural prosperity and food security.

State Preparedness And Response To Floods:

1. Flood Management in Haryana involves layers of participating departments/organizations. The three levels are State, District and the Local.
2. The State level departments are involved in policies, decisions, resource allocations, prioritization of activities and budget allocations and monitoring through the Emergency Operation Centre, Revenue & Disaster

Management Department, Government of Haryana, Chandigarh.

3. The process of flood management is participatory and catchment-wide, with communities being proactively involved.

4. The Haryana State Flood Control Board recently approved 66 schemes to be implemented by the Irrigation Department and 20 schemes by the Public Health Engineering Department and 67 irrigation schemes had already been completed in 2010.

5. Chief Minister of Haryana has categorically directed that the schemes be implemented district-wise, focusing on construction of water bodies to harness water and recharge the water table and senior officers should visit the sites and involve people before finalising the projects.

6. Under the Ganga Flood Control Commission the Union Ministry of Water Resources had already approved flood control works worth Rs.173.93 crore to strengthen the right bank of the Yamuna.

7. Besides the usual disaster management strategy adopted, the Haryana government has also planned to use state-of-the-art techniques of remote sensing satellites to monitor drought in the state. This Advance Wide Image Field Sensor data from the country's resource satellite would be used to assess the drought situation.

8. In order to perform the above tasks effectively, capacity development is an integral part. It is not only skill development but goes beyond as it includes human resource development, besides equipping individuals with understanding, skills and access to information.

RECOMMENDATIONS

Having discussed the causes, consequences and responses of the government, it may be Recommended that the

1. Gullies, manholes and storm water carriers must be cleared from silt before the rainy season.

2. Flood warning system must be installed and properly maintained by the trained personnel.

3. A separate agency or department could be created with technical staff from the concerned disciplines, so that the water logging problem in the area may be tackled in proper way.

4. Government should create hassle free drought management database with gradual accumulation of expertise to tackle such situations.

5. There needs to be more investment in both structural and non-structural mitigation. As it is based on organization rather than civil engineering, the latter is often more cost-effective than the former.

6. But for such efforts to succeed, it is strongly recommended to adopt rigorous standards for emergency planning, management, and training.

REFERENCES

1. Chritchfield, Howard J. (1994), "General Climatology", Prentice Hall, 1991.
2. http://chandigarh.gov.in/cmp2031/disaster.pdf
3. http://coralreef.noaa.gov/aboutcrcp/strategy/reprioritization/wgroups/resources/climate/resources/cc_futures.pdf
4. http://en.wikipedia.org/wiki/Drought
5. http://en.wikipedia.org/wiki/Drought_in_India
6. http://en.wikipedia.org/wiki/Flood
7. http://english.360elib.com/datu/Q/EM173447.pdf
8. http://gwadi.org/sites/gwadi.org/files/Singh_L11.pdf
9. http://hdma.gov.in/sdocs/floodmanual.pdf
10. http://hid.gov.in/Docs/Paper%20on%20Floods.pdf
11. http://nidm.gov.in/idmc2/PDF/Presentations/Flood/Pres6.pdf
12. http://panchkula.nic.in/pdf/App_to_DM.pdf
13. http://planningcommission.gov.in/plans/mta/11th_mta/chapterwise/chap21_water.pdf
14. http://r4d.dfid.gov.uk/PDF/Outputs/EnvRes/India-AnnexB-CountryReports.pdf
15. http://reliefweb.int/sites/reliefweb.int/files/resources/Disaster%20Risk%20Management%20in%20South%20Asia%20-%20A%20Regional%20Overview.pdf
16. http://revenueharyana.gov.in/html/disastermgt/haryana_hazard_profile.pdf
17. http://rohtak.nic.in/disaster_plan.htm
18. http://www.amu.ac.in/newevent/event/9861.pdf
19. http://www.ga.gov.au/scientific-topics/hazards/flood/basics/causes
20. http://www.ignou.ac.in/upload/Disaster%20Preparedness%20and%20Mitigation.pdf
21. http://www.nasa.gov/topics/earth/features/india_water.html
22. http://www.ndtv.com/india-news/early-

monsoon-rain-causes-floods-in-haryana-alert-sounded-525683

23. http://www.sciencedaily.com/releases/2009/08/090812143938.htm
24. http://www.sristi.org/english/dmis/dmplanning.html
25. http://www.tcpharyana.gov.in/ncrpb/FINAL%20SRP%20FOR%20WEB-HOSTING/15_Disaster%20Management.pdf
26. http://www.udayindia.in/english/content_13july2013/cover-story3.html
27. http://yamunanagar.nic.in/ynr/dwd/DDMA.pdf
28. https://archive.org/stream/indiacountrystud00heit/indiacountrystud 00heit_djvu.txt
29. https://www.getprepared.gc.ca/cnt/hzd/flds-en.aspx

PLANNING FOR DISASTER OR ENVIRONMENTAL MAP? THINK BEFORE YOU START

Nidhi KHANNA[1]

ABSTRACT

Environmental Maps and Disaster Maps are used and made very commonly today. On one side, amount of available information and reproduction of maps based on it has become easier; quality of such maps is another side of story. Map prepared by masses today don't even fall in the category of "Map". It is due to the lack of cartographic knowledge and their fundamental principles. Cartography indeed has come a long way in the period of Remote Sensing (RS) and Geographical Information System (GIS). But some conventions based on well-developed experiments and theories; are to be followed in all circumstances. Problem arises when we follow the convention; even then incoming information contradicts our previously stored information. Environmental Maps and Disaster Maps are such examples. They are negative in theme, and their connotative meaning leaves larger impact, than denotative one. Since the time of classical period of cartography, we have learnt that Value as a graphic symbol is most effective and efficient in conveying the ordered quantitative data. We use grey tone, texture and even the colour with their inherent value to depict such ordered data on the map. Following and using this convention for long has established as a rule in cartography and is stored in our mind as 'Schemata'. During the 'Visual Information Processing of the Map Image', 'convergent operations' take place where; incoming information is matched with the previously stored information to match, detect, identify and recognise the incoming visual image. When we use or extract the information saved in our memory, it is called top to down mechanism and when input of visual image goes into our brain through our eyes is called bottom to up mechanism. Convergent operations take place at the stage of 'Attentive Processing'. Conventionally higher value is for more quantity, and we find more as good. It works in case of wheat production, per capita income, number of hospitals, mineral production, etc. But in case of negative themes, it generates issue. If we represent more deforestation, high frequency of cyclone, large slums, high death toll due to famine, high intensity of earthquake, etc. with darker the value, we unintentionally perceive them to be good; while our incoming information conveys them to be not so good. This contradiction and confusion crates the interruption in information processing and delays the time taken in making inference. With the use of colour scheme that is based on associations and semantics, we can overcome this hurdle. Thus, for better output of our information processing system we need to improve the input of map Image by improving the map design with the use of appropriate colour scheme. So think before you choose colours for your Maps.

Keywords- *Conventions, Denotation, Connotation, Value as graphic symbol, Visual Information Processing, Attentive Processing, Convergent Operation, Interruption in Information Processing and Semantics.*

INTRODUCTION

Environmental issues are most sought after topic today. With one planet, only 30 per cent land, roughly 15 per cent liveable space, nearly 7 per cent all types of forest cover and only 2 per cent of fresh drinking water available to support 7.3 Billion people; the scenario looks really scary. Environmental issues can be categorised in three broad categories of Disasters, Degradation and Pollution. With the "Clean Air, Clean Water" crusade launched in America in 1960's; attention was drawn towards environmental issues for the first time. It took about twenty years, when I.G.U (International Geographic Union) and I.C.A (International Cartographic Association) in 1980, identified and emphasized the role of maps in evaluating, comparing, educating people, creating awareness and planning about environmental issues. It took off eventually in 1990's with the technological revolution created by the automation. Cartography saw a paradigm shift from conventional methods to digital, automated and interactive cartography afterwards.

Change in cartography was stimulated by the availability of georeferenced data coupled with rapidly evolving Geo-Information Technologies. End product of all sophisticated technologies is maps. Ultimately we need to map the information that we have collected, analysed or extracted from various sources. Cartography as a field is leading in linking all types of visualization modes; like Geographic Information System(GIS), Visualization in Scientific Computing (ViSC), and Visualization in Virtual Reality (VR). Due to its multidisciplinary endeavour, it can better coordinate as Geographic Visualization medium. A decade ago, maps were supposed to be the static one only. Enough literature and research is there for the visualization and cognition of these maps, but we need to teach and train general user for highly dynamic 2D or 3D, and interactive maps. In 1994 MacEachren defined and concluded that

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cartographic visualization is nothing else but the study of "How maps are used?" He explained his views with the Visualization Cube. (Fig.1).Later, he emphasised that hyperlinks, superimposition of layers and generalization of these dynamic maps needconstant research (MacEachren 1998). Taylor (1991) feared quite early that although Visualization is the combination of Cognition, Communication and Formalism (new computer technologies);gradually Computer Formalism is becoming dominant at the cost of Cognition and Communication (Fig.2).

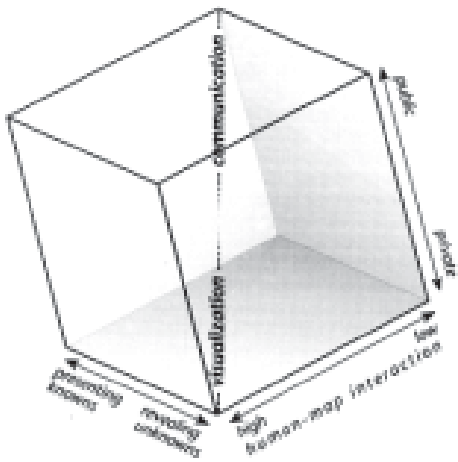


Fig.1. Visualization cube of MacEachren

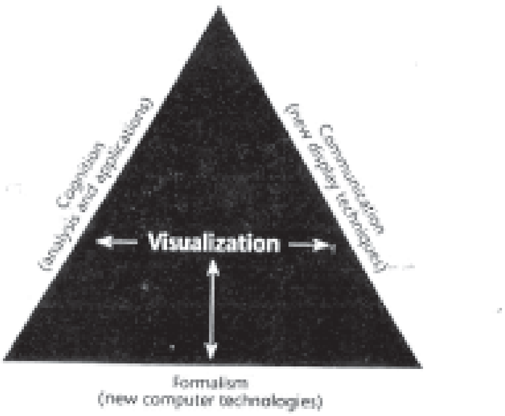


Fig. 2. Visualization Triangle by Taylor

Cartographic Conventions

Credit of giving cartographic symbolization, a defined and established approach goes to Bertin (1983) who evaluated major graphic variables on the basis of four perceptual properties; like Association, Selection, Order and Quantity. He discussed shape, size, value, colour, orientation and texture; that are used in maps as graphic variable. His findings were based on Experimental Psychology and they became convention in cartography for using graphic variable. He concluded that, for the optimum representation of the ordered and quantitative data, symbols should be efficient enough to be arranged and ordered immediately and spontaneously; without consulting legend, so that the hierarchy is clear and comparison is immediate. Size, value and texture were declared as most easily ordered graphic variable. He found size as most suitable variable for representing the numerical ratio between the two signs and differentiates the natural statistical steps. Colour was excluded from the list of symbols that can represent the ordered and quantitative data efficiently. Colour has three dimensions namely Hue, Value and Chroma (based on Munsell colour model 1941); and they are treated and studied as an independent variable in cartography.

Langer (1951), Robinson and Petchenik (1976), Schlichtmann (1985) and Eastman (1985) discussed a lot the 'nature of maps' and 'map symbolism'. It was found that, maps are neither completely discursive nor presentational. They are unique in nature, objective and purpose. It is different from discursive symbols because in any other language words appear one by one in linier progression and they have fix meanings in all the references and contexts. For maps, situation is different, as it is presentational in nature but different from rest of them of this category. In maps, graphical variables are used as words to represent the desired information but the meanings of these symbols are neither fix nor predefined. They change with each new map. Kolancy (1969) called map language the system of symbols and rules for their use. Ratajski (1973) emphasized 'correctness' of map language in the design reading stage and while discussing model of cartographic transmission. Various studies emphasize the applicability of linguistic model of syntactics, semantics and pragmatics to graphic sign system; since both are branches of semiotics.

Although maps do not have linier progression and appearance of these variables like discursive symbolism; but they certainly have hierarchy or depth cue, through which most important things are placed on upper most level and least one at the lowest. Bertin established that we can create depth cue in maps with the help of these steps like; 1) to decrease the size of any known object, 2) to decrease the value of known contrast, 3) to decrease the texture of an object, 4) to decrease the saturation of the known colour and 5) to deform the orientation and shapes. Here saturation of colour is actually the Chroma.

In 1985 Schlichtmanntook map as a communication system and said that, as any natural language have some words, their meaning, and grammatical rules through which information communicated by the presenter or writer is understood by the user after decoding the meanings of written words and thus he extracts the information. Same happens with the map image. Map design also has some rules its own vocabulary of sign system, their meaning and presentational method. Although the map symbolism don't follow the linier sequence of appearance but they surely has the hierarchal appearance in non-linier simultaneous format. So neither they are accessed nor processed in linier format so they are totally different from the other presentational symbolism. Hierarchy of presentation is created according to the importance and thus lesser important feature reseeds to the subsequent lower layers.

In 1980's coloured printing was a costly affair but today with the available technology and easy printing options, we cannot think of a map without colour. Colour use in cartography has come a long way since Robinson studied Colour for the first time in 1967, when he studied the Psychological aspects of colour in cartography. Field of colour research was enriched by the contributions made by D. Cuff, (1972a, 1972b, 1973a, 1973b, 1974a, 1974b), Patton and Crawford (1977), Mersey (1990) and Brewer (1989, 1990, 1992, 1994A, 1994B, 1995, 1996, 1997) etc. They all concluded that "value based series are always most ordered whether it is single hue with value steps or the inherent value arrangement of colour. Thus again it build up a convention that darker the value more the quantity and good or healthy the aspect. Some negligent attempts were made to highlight the role of thirds dimension that is Chroma (Cuff, D. 1972) but such attempts failed to establish it as an important graphic variable.

Requirement of Effective Map Design

For any novice user it is important to understand the communication system of map. Basic map communication model, suggested by Robinson and Petchenik (1975) is sufficient for the understanding of communication process through maps. (Fig. 3)

Fig. 3 Map Communication System suggested by Robinson and Petchenik (1975)

When we take map as a communication system, all three stages becomes equally important. Source is the cartographer or map maker, who can give best input for effective communication. Channel or signals of map are its graphic variable and symbolization methods that should be studied deeply. Recipient is the target population or end user whose ability, knowledge and interpretation skills are deciding factor. For an effective and successful communication, each part has its role. But, by and large we can easily say that if the input to any system is better, automatically better output can be achieved. If we want to improve the map design, we need more literature related to planner dimensions and properties, abilities and limitations of each variable; being used in map. Same is true for the user end. For efficient, correct and speedy generalisation through maps, a trained user is always better performer. Thus, large knowledge base is required to develop such expert systems that can help in using appropriate symbolization tool and technique for maps. Here comes the role of Design Research.

Problems Related to Environmental Issues

The paper here is to highlight the problem in case of using conventional data representation method in case of environmental maps; because environmental themes are totally different in nature and their impact. Environmental data are not as simple as the data of wheat production and number of black population in a region. It is related with the problematic aspect of present world. Up to mid of last century, environment was not a theme to map. It became an issue of concern around the world quite later. Its issues are threatening and alarming in nature, which can affect our life in a larger way. Large amount of environmental data is being monitored, maintained, collected and stored today. It is evident that there is big problem and threat to man, otherwise man would not have bothered to consider it even now. Learning and teaching of environment and its component started only after the adverse effects of industrial revolution started showing up. Thus environmental issues are not like economic, production and census data; that are purely quantitative in nature. These issues affect not only our health, wealth, and emotional status but have threatening impact too. So this cannot be treated as rest of the quantitative data, while designing the maps. It creates many problems if they are designed with the existing convention and especially if it is a colour. Their connotative meaning can create problems while processing the map image during convergent operations that we will discuss later.

First we take "environmental degradation" and their causes. Higher degree, higher amount, higher production or higher status of the human economic activities such as mining, agriculture, industry, commerce, urbanization and dense populated area of big market; all of them destroy the natural environment and create imbalance in environmental equilibrium. In the positive sense, areas of high density, high urbanization, high industrialization, high mining and highly dense agriculture are the centres of growth points but in negative sense these are the activities which alter the natural environment. They are the areas where problem of environmental degradation and crisis is most severe. They are the areas of high pollution, high deforestation, high land degradation and high social evils. From the point of view of environmental education, awareness and policy formation, negative aspects of these themes is important for mapping. If they are represented with same rule and convention of normal quantitative data representation, they will give wrong notion and will lead to wrong interpretation and wrong generalization. Existing convention so far will lead to the positive aspect of these phenomena in environmental maps and will not serve the purpose of creating a sense of threat and danger because of the conventional map design. Any environmental Atlas will be incomplete if it does not identify the most degraded areas and the causes and reasons behind it. So these parameters cannot be ignored and if they are mapped, the colour scheme for them should not be selected on the conventional rules and guidelines.

Problem in case of Hazard mapping is not very different because higher frequency, higher magnitude and higher impact in sense of damage are not good, healthy and positive sign. Man has always struggled with these natural disasters like volcanic eruptions, earthquakes, floods, cyclones and droughts. They interrupt the man's efforts in the direction of progress, development and prosperity and most surprising thing the perception of Hazards vary from culture to culture, place to place and from age, as perception plays a significant role in hazard management and relief operations. Here again some conventional colour associations can play a dominant role and again the existing sequential progression of value or Hue value can denote the sense of goodness, which will be totally wrong and cannot give the right interpretation.

Third and most important aspect of environmental mapping is the 'pollution mapping'. Land pollution, air pollution, water pollution, sound pollution and social pollution; all of them are causes of threat to mankind. Selecting suitable colour scheme for them is very tough and difficult task for this theme. Like environmental degradation, higher rate of soil erosion, deforestation, soil pollution and salinization, contamination of water resources and higher concentration of harmful gasses. Selecting suitable colour scheme for them is a challenging task. These aspects should never give the sense of goodness, idea of healthiness and any positive notion. Higher values of all these phenomena are not an ideal condition and if these attributes of environmental condition will be presented with the value sequence, where darker connotes to be good, this will definitely lead to the problem of denotation and connotation conflict during the visual information processing of maps.

So it is a double- edged problem for the mapmakers or cartographers. They have to follow the design convention of visual hierarchy and yet needs to change the representation method to convey the meaning which is correct in both the ways. To avoid the any problem during the convergent operation in human information processing, we need semantically correct colour scheme. To achieve this task, they have to keep in mind that whatever mode or sign or the symbol they are using, should be easy to be understand by the interpreter in order to fulfil the requirement of efficient communication.

Problem during Visual Information Processing of Map

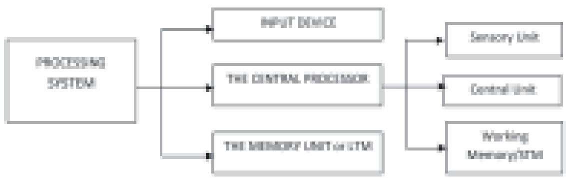
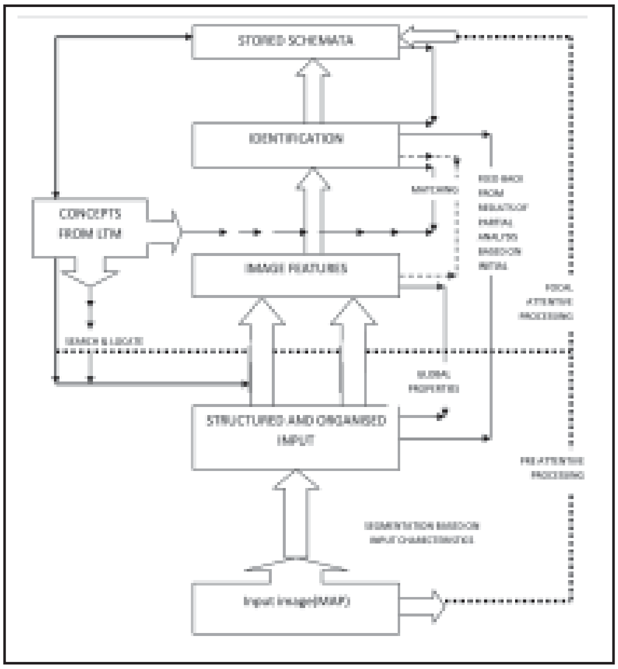


Fig. 4. Main components of Visual Information Processing

If we look into visual information processing of map in a simple way; our eye works as an input device to our processing system. At this stage only eye fixations and quick scanning is done. No image is made at this stage. It is shortest stage of nearly half a second. This stage is called Iconic Memory Stage. Our brain is the main processing unit, where information is processed in many stages. This is the stage where main processing is done. Most significant role is played by Short Term Memory here. Thus, this stage is termed as Short Term Memory Stage. Pre Attentive and FocalAttentive, two staged processing is done at this stage. Incoming available information is segregated, compared, allocated, associated and matched with the previously stored information in LTM as Schemata. This process of exchanging upcoming information with already stored information is called Convergent Operations (fig. 5).When help is taken from the schemata or LTM, it is known as Top to down mechanism and when upcoming information is being analysed, it is termed as Bottom to up mechanism. What we finally interpret, and generalize through map is the final output of this processing; which is finally stored in our permanent memory (LTM). This stage is termed as Long Term Memory Stage. This LTM or Schemata works like a library, which is randomly accessed by our brain for help while processing the new information. Whatever we see and experience in our day-to-day life is gradually stored in our mind. Over the period of time, repetition of any information or fact forms a strong convention in our schemata. Thus, entire processing of map image, or any visual image is completed.

Any kind of interruption, noise, or hindrance in processing causes delay in information retrieval and sometimes even the accuracy is affected. Keats (1982) has mentioned such information processing barriers in his work. He identified barriers of both the sides, from the map maker and from the map user side. If the required information is not available, or inadequate, or too expensive to use or if the user requirement is not known; map makers job becomes difficult. Similarly map user is unable to get desired information if the suitable map is not available, or not selected, or the information conveyed through map is difficult to interpret and perceive.



Source (Taken from unpublished thesis work of Vineeta John 2001)

Fig. 5 Convergent Operations during Visual Information Processing

Discussion again turns towards the semantics of sign system and their use in maps. First we have to make or choose semantically correct graphic variables, than we can think of teaching and training the users.

CONCLUSION

Thus selection of colour schemes for environmental maps has to be semantically correct, conventionally sound and able to communicate the desired effect; not just the information. In an experiment done by Yarnal, Mackay and Coulson (1982) it was found that the map users in general were found to make more use of the trails than those not using maps. Particularly noticeable was the effect of colour. When maps were designed correctly then map alone were able to stop the visitors from going the prohibited area of the Yoho National Park, Canada.For choosing suitable colour scheme we should look upon other presentational symbolism, that is Art or Painting. There are differences between a work of art and a map, yet few similarities are also there. As desired mood, emotion, or effect is generated in paintings with the skilful use of colour; same can be achieved in maps as well. Long back, cartography was an artist's job. Ronald Rees (1980) has discussed this relation and said. "Important branches of geography and are rooted in common ground". Than in 1984, relation between art and painting with cartography was re-established by Huge Prince. Colour with all three dimensions can evoke any emotion and mood. Same thing can be followed in case of environmental maps. With the association based hue selection, correct type of colour scheme and desired amount of chroma and value; we can create desired impact while remaining in the limits of syntactical rules and conventions of cartography. Khanna, N. (2010) had studied colour schemes for environmental maps on the grounds of semiotics. For this, she has used **Semantic Differential** test scales for evaluating the preference and performance of various colour schemes. She studied Uni-dimensional, Bi-dimensional and Tri-dimensional colour schemes along with Spectral Colour Scheme. She used an earthquake map showing seismic hazard zones in India based on its intensity on Mercalli Scale. Total seven colour schemes on same map were evaluated. When area with least possibility of seismic threat was shown as favourable or positive one and area with highest seismic possibility was treated as dangerous and unfavourable for man; it worked well. Effect of high saturation and low values with appropriate hue, delivered the desired effect. This effect of good- bad, clean-dirty, healthy-unhealthy, favourable-unfavourable, etc. can be created and evaluated too. Only careful and appropriate colour scheme is required that can be easily evaluated and judged on semantic differential.

FUTURE RESEARCH

In today's world when internet is flooded with numerous interactive and customised map options it is very important that their utility and usability should be studied and checked. When each map has multiple layers of information, it becomes more challenging to test their performance because now things come up in various combination and increase map complexity. Do our masses are ready to handle maps with loads of information? Are these maps performing their task? Is the purpose of preparing these maps being served? And do the map maker, who are more technology oriented than cartography; bother about such questions?

REFERENCES

1. Bertin. Jacques (1983) "The Semiology of Graphics" W.J. Berg (Trans) *University of Wisconsin Press, Madison XI*
2. Brewer, Cynthia A., (1989) "The Development of Process Printed Munsell Chart for Selecting Map colours," The *American Cartographer* Vol. - 16 No.-4. Pg. 269-278.
3. Brewer Cynthia A. (1990) "Colour Chart use in Map Design."*Cartographic Perspectives*. Vol.-4 Pg.-3-10.
4. Brewer Cynthia A. (1992) "Review of Colour Terms and Simultaneous Contrast Research for Cartography"*Cartographica* 29 No. 3/4 Pg. -20-30
5. Brewer Cynthia A. (1994 A) "Colour use Guidelines for Mapping and Visualization" In *visualization in Modern Cartography*, ed. A.M. MacEachren and D.R.F. Taylor Pg. - 123-147. Oxford: Pergamon Press.
6. Brewer, Cynthia A., (1994 B) "Guidelines for Use of the Perceptual Dimensions of Colour for Mapping and Visualization" In *Colour Hard Copy and Graphics Arts* III ed. J. Bares PP - 54-63, Bellingham, Wash: *International society for optical Engineering.*
7. Mac Eachren. A.M., Brewer, C.A. & Pickle L.W. (1995) Mapping Health Statistics: Representing data Reliability, Proceedings 17th*International Cartographic Association Conference* Barcelona Rep Pg. 311-319.
8. Brewer C.A. (1996 A) "Guidelines for Selecting Colour for Diverging Schemes on Maps". *Cartographic Journal* 33 No.-2. Pg.-79-86.
9. Brewer. C.A., Mac Eachren, A.M., Pickle L.W. & Herrmann. D.J. (1997) "Mapping Mortality: Evaluating Colour Schemes for Choropleth Maps,"*Annals of the Association of American Geographers* 87 (3) Pg. 411-438.
10. Brewer C.A. (1997) "Spectral Schemes: Controversial Color Use on Maps" *Cartography and Geographic Information System* Vol. 24(2) Pg. 203-220.
11. Brewer C.A. (1997) "Evaluation of a Model for Predicting Simultaneous Contrast on Color Maps" in *Professional Geographers* 49 (3) Pg. 280-294.
12. Cuff, David J. (1972 A) "The Magnitude Message: A Study of the Effectiveness of Colour Sequences on Quantitative Maps" The Pennsylvania State University Unpublished Doctoral Dissertation.
13. Cuff David J. (1972 B) "Value Versus Chroma in Colour Schemes on Quantitative Maps" The *Canadian Cartographer* Vol.- 9, No.-2, Pg. 134-140
14. Cuff, David J. (1973 A) "Shading on Choropleth Maps: some Suspicions Confirmed", *Proceedings of the Association of American Geographers* Vol.-5, Pg.-50-54.
15. Cuff, David J. (1973 B) "Colour on Temperature Maps"*The Cartographic Journal* Vol. -10, No.-1, Pg. 17-21.
16. Cuff, David J. (1974 A) "Perception of Colour Sequences on Maps of Atmospheric Pressure"*The Professional Geographer* Vol.-26 No.-2, Pg.-166-171.
17. Cuff, David J. (1974 B) "Impending Conflict in Color Guidelines for Maps of Statistical Surfaces"*The Canadian Cartographer* Vol. 11, No.-1, Pg. 54-58.
18. Eastman, J.R. (1985) "Cognitive Models and Cartographic Design Research", *Cartographic Journal* Vol. 22(2), Pg. 95-101
19. John, Vineeta (2001) "Analysis of the Efficiency of Information Retrieval from Graduated Circle Maps in the Presence of Redundant Graphic Variable in Symbolization" - Unpublished D. Phil thesis, University of Allahabad, Allahabad.
20. Keates, J.S. (1982)"Understanding Maps". By *Longman Press London & New York.*
21. Khanna, N. (2010) "Study of environmental map deign with special reference to colour use"- *Unpublished D.Phil. thesis, Dr. Bhim Rao Ambedkar University, Agra*.
22. Kol'acny, A. (1969) " Cartographic information-A fundamental concept and term in Cartography, *The Cartographic Journal,* 6, Pg. 47-49
23. Langer, S.K. (1951) "Philosophy in a New Key,"*New American Library, New York.*
24. Mac Eachren Alan M. (1994) "How Map Work: Representation Visualization and Design". *New York: Guilford Press.*
25. Mac Eachren, Alan M. (1998) "VISUALIZATION - Cartography for the 21st century, *Overview of International Cartographic Association.*
26. Mac Eachren, A. M. And Taylor, D. R. F., Ed. (1994). *Visualization in Modern Cartography*. Oxford, UK: Pergamon.
27. Mersey, Janet E. (1990) "Colour and Thematic Map Design - The Role of Colour Scheme and Map Complexity Communication" in *Cartographica* MONOGRAPHS-41 Vol.-27, No.-3
28. Patton, J.C. And Crawford, P.V. (1977)" The Perception of Hypsometric Colours", in the *Cartographic Journal* Vol.-14 No.-2. Pg. 115-127.
29. Prince Hugh (1984) "Landscape through Painting" in *Journal of Geography* Vol. 69 (1) Pg. 3-18 Ratajski L. (1973) "The research structure of theoretical

cartography" *International Yearbook of Cartography* 13, 217-228.

30. Rees, Ronald (1980) "Historical Links between Cartography and Art" in *Geographical Review*, Vol. 70, Pg. 60-78

31. Robinson, A.H. And Petchenik, B.B. (1975) "The Nature of Maps: Essays toward Understanding Maps and Mapping"Chicago, London: University of Chicago Press, 1976. Xi, 138 p.

32. Robinson, A.H. and Petchenik, B.B. (1976) "The map as a communication system: *The Cartographic Journal*, vol. 12, no. I, pp. 7-14. Reprinted in: *Cartographica*, 1977 monograph 19, pp. 92-110.

33. Schlichtmann, H. (1985) "Characteristic Traits of the Semiotic System of Map Symbolism" *Cartographic Journal* 22, p. 23-30.

34. Taylor, D.R.F. (1991) R.F. ed. *Geographic Information Systems: the microcomputer and modern cartography" Oxford*, Pergamon Press, p. 1-20

35. Yarnal, C.M., Mackay & Coulson, M.R.C. (1982). "Recreational Map Design and map use: An experiment" in *the Cartographic Journal* Vol. 19(1) p. 16-27.

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SALINITY STATUS AND IT'S ASSOCIATION WITH DEFORESTATION IN UTTAR PRADESH

Ratan PRIYA[1] & Arvind CHAUHAN[1]

ABSTRACT

The study is attempted to access the pattern of land degradation in Uttar Pradesh. Salinity/alkalinity is one of the factors, which is cause to land degradation. Worldwide about one third of the land degradation is in high risk of land degradation, which is mostly human induced. As for as it is concerned, high salinity and alkalinity convert the land into electrical conductivity and the residual alkalinity. As a consequence, this debases land in more fragile gradually. As can be expected this result into land degradation. Thus, the present paper have studied the pattern of salinity and alkalinity in UP. District-wise analysis has been done. Descriptive Statistics is done to analyze pattern of salinity and alkalinity, one characteristic of land degradation, in UP by using cross-tabulated data, which is provided by NAAS and ICAR. In order to examine the temporal variations in area under salinity and alkalinity, data have been used of three time periods 2000, 2005-06 and 2008-09. The change in land use pattern over the period of time has confined that out of total geographical area of 24 million hectare, 62% area is cultivated. It is consist of 17,500 thousand ha net shown area and approximately 1000 thousand ha the current fallow. The net shown area increased from 16,200 in 1950-51 to 17,500 thousand ha due to expansion of agricultural practices. About 1800 thousand ha (6%) of the area is under fallow, either by the reason of lack of irrigation facility or salinity and alkalinity. Raebareli, Unnao and Kanpur are mostly affected area by salinity and alkalinity. To reduce or combat the problem of these areas, there is need some watershed development program and improvement in it, which helpful to compress the soil productivity in watershed area, river-bed area. Furthermore, there is needed to act out improvement in irrigation system.

Keywords: *- Salinity, Alkalinity, ArcGIS, Land Use Pattern.*

INTRODUCTION

On the one side, the population is going dramatically to be larger day by day. Naturally, the demand for food is also accumulating accordingly. But on the other ways, all the irrigated areas are more or less affected by salinity and alkalinity. Under these circumstances, the production of soil is gradually decreasing (FAO, 1999). There are so many factors, which cause to land degradation i.e. gullied, ravenous, soil erosion, water erosion, alkalinization, flood, draught and desertification etc. Salinity is one of the severest problems, which is needed to encounter. Less grassland or forestland and increasing saline areas are outcome of expanding demand for agricultural land (Wang, Seki, Miyazaki & Ishihama, 2009). According to Li, Wang & others (2009) salinization and alkalinization might be a result of natural and human activities, for example geologic, climatic, topographic, hydrologic factor by nature and demographic pressure and overgrazing due to human interference. Salinity and alkalinity reduce the fertile capacity of grazing and agro practice land. Both are determined by time and space also. For instance, concentration and precipitation of salts mixed water causes to alkalinization and less vegetation responsible for increasing the pace of evaporation and runoff. These are resulted into decline in the rate of infiltration. Koshal (2012) accounts that water logging is major impact of less infiltration. In that case fertility of land has been reaching infertility stage.

OBJECTIVE OF THE STUDY

The above description emphasis that there is need to study on extent of salinity in Uttar Pradesh. Firstly, the study would like to focus on what is the trend of overall land degradation in Uttar Pradesh. Secondly, the pattern of salinity and alkalinity is estimated by using GIS technique. This is needed to study in this area because it comes under humid climate and experience four seasons. In the same way, this state also spread over the Gangetic plain. Hence it might be interesting to study how this is suffering from salinity because study area has so much facility as follow: plainly region, monsoon affects, irrigated areas and especially high production due to availability of fertile land. Furthermore, it is also studied in this paper is how unforested areas are correlated with salinity.

STUDY AREA

Uttar Pradesh, a state of India, is situated in North. It has established in 1 April 1937 as the United Provinces, Later named as Uttar Pradesh. Uttar Pradesh, 236,286 Km^2 geographical areas, is fifth and first state according to area wise and population-wise respectively. This area is irrigated by Ganga, Yamuna

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and other tributaries. Uttar Pradesh is surrounded by Bihar in the east, Madhya Pradesh in south, Rajasthan, Delhi, Himanchal Pradesh and Haryana in west and Uttaranchal in North (UP Govt.). It also makes international boundary with Nepal in northern side. Uttar Pradesh lies between latitude 23^o 52' N to 31^o 28' N and longitude 77^o 06' E to 84^o 37' E. It is clearly noticeable that three type of physiographic detected in the region- Himalaya in the north side, parts of plateau in south and the great plain of Gangetic lays almost three fourth part of the state. Therefore, there is a hardly change in elevation. On the whole, the state comes under subtropical, monsoonal and continental climate. Winter season usually is mild and dry, conversely summer season is hot and uncomfortable in the region. The state receives 88% rainfall from monsoon. The areas near Himalayan foothills consist maximum rainfall (>1400 mm), where as the districts adjoining Rajasthan receive minimum rainfall less than 600 mm (Fig.1).

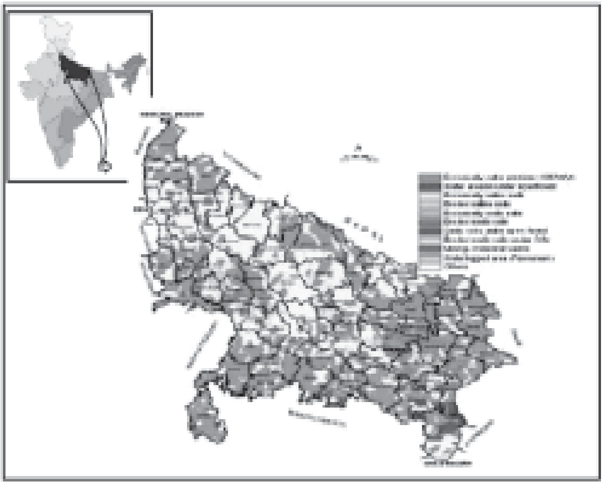
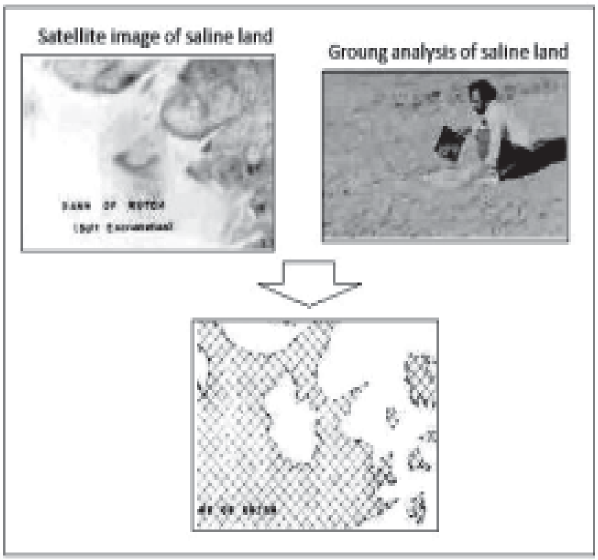


Fig. 1 Study Area

The change in land use pattern over the period of time has confined that out of total geographical area of 24 million hectare, 62% area is cultivated. It is consist of 17,500 thousand ha net shown area and approximately 1000 thousand ha the current fallow. The net shown area increased from 16,200 in 1950-51 to 17,500 thousand ha due to expansion of agricultural practices. About 1800 thousand ha (6%) of the area is under fallow, either by the reason of lack of irrigation facility or salinity and alkalinity (Wasteland Atlas, 2010).

DATA BASE

Descriptive statistics is done to analyze the extent and pattern of one characteristics of land degradation in Uttar Pradesh by using cross-tabulated data, which is provided by NAAS and ICAR. For achieving this objective, extent and pattern has distributed in district level. This is demonstrated by map, which is prepared through ArcGIS 10 software. Firstly all district-wise data of salinity calculated as % out of total geographical area. District-wise Status and spatial distribution of degraded and wastelands of Uttar Pradesh are provided by Indian Council of Agricultural Research and National Academy of Agricultural Sciences, New Delhi. These organization followed remote-sensing technology, and identify land-use and physical condition of the surface features for mapping non-agricultural areas (presently non-arable) on 1: 50,000 scale using satellite image of late rabi season with adequate field checks (Fig. 2). Some examples is given, by which satellite imagery of salinity identified as following-



Source : Forest cover data for 2008 has been taken from Forest Survey of India.

Fig. 2 : Method Adopted by NAAS & ICAR

METHODOLOGY- LINEAR REGRESSION MODEL

To determine the impact of deforestation on salinity linear regression model has been run. Out of total districts only 17 districts, which are having more than 2% saline area out of total geographical area, have been selected for estimation. In this model saline/ alkaline areas are dependent variables and unforested areas are independent variables. Thus the equation for this framework is :

$$Y_1 = \beta_{0+} \beta_1 X + U$$

RESULT AND DISCUSSION

The land degradation is very dominant in study area. The linear trend shows that overall land degradation is decreasing in between 2000 to 2010. Fig. 3 demonstrates with help of linear forecast trend line that land degradation is going to decline in forward years. Where as if it is attended on two time period moving average, then it has been detected that

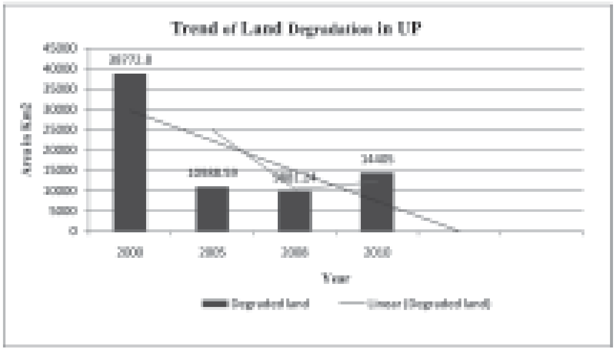


Fig. 3 : Trend of Land Degradation in Uttar Pradesh.

between years 2000 to 2008 there is sharply depletion in land degradation and after year 2008, land degradation shows steadily raise.

Likewise land degradation, salinity also shows declining trend in between period of year 2000 to 2010. But it is intresting to notice that total degradation has accounted gradually raise after year 2008, instead salinity has displayed fairly reduction after year 2008 (Fig. 4). But the pace of decreasing salinty is became slow durind year 2008-10. Soil salinity is increasing due to irrigation and drainage pattern (Bilgili, 2012). Mostly this area comes under irrigation and riverbed. However, the pattern of irrigation accords facility of canals in whole area but it is woefully inedequated and varries in different areas. As a consequence, salinity has been increaes due to continued recirculation and reuse of marginal-quality of water without any disposal of saline water from outside system (Tyagi, 2003).

Forest is also an important factor to control the

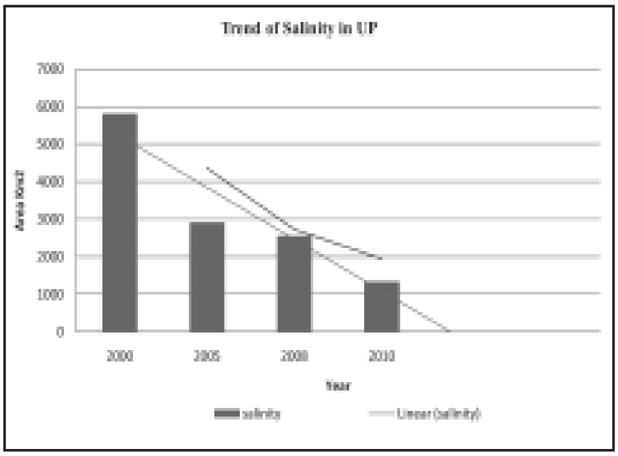


Fig. 4 : Trends of Salinity in Uttar Pradesh

salinity. Thus, it is best to evaluate the trend of forest cover in study area. In Uttar Pradesh forest cover demonstrate accretion in time period. In 1997, 10751 km^2 areas have come under forest cover. It is increased by 16583 Km^2 in 2011. In similar ways, forest cover has slightly increased during 1997-2003. But during 2003-2009, reduction in small amount is

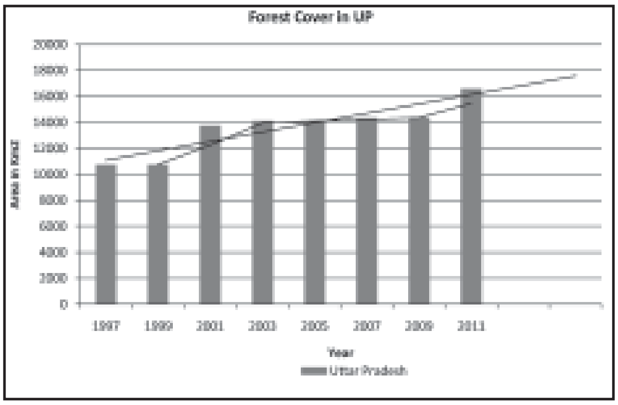


Fig. 5 : Trend of Forestation in Uttar Pradesh

recorded. After that rapid amplification of forest has been detected. Of course, overall gradual increase has informed during 1997-2011. Equally, salinity has also annotated gradual decline. So there might be relation between forest and salinity. Clearly it is to be alluded that forestation is helpful to reduce the degradation (Raina, Kumar & Singh, 2009).

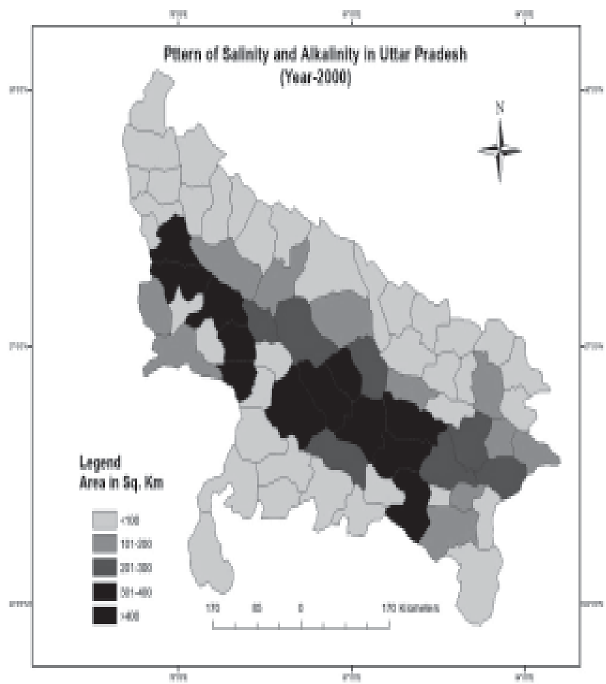


Fig. 6 : Pattern of Salinity in UP

The salinity and sodic surface is mostly depending on irrigation water quality. Irrigation with alkaline water has caused to low fertility capacity of top soil (Cauhan, Chauhan & Minhas, 2007). Fig. 6, 7 & 8 have reported that middle area of Uttar Pradesh in Gangetic plain is extremely affected by salinity and alkalinity. If we look according to area (km^2), then in year 2000, 5 districts are extremely affected; named Mainpuri, Kanpur, Unnao, Raebareli and Pratapgarh. But it is interesting to note that the no. of district most

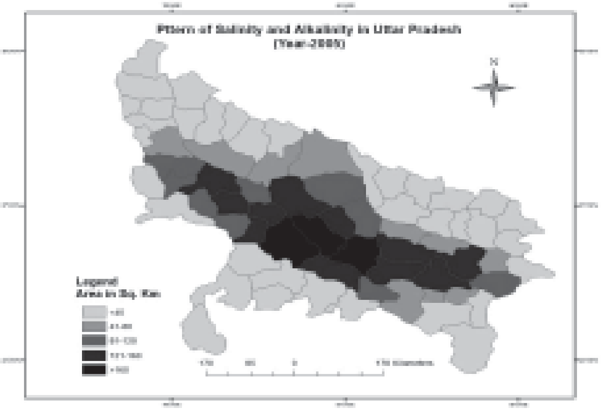


Fig. 7a : Pattern of Salinity in UP

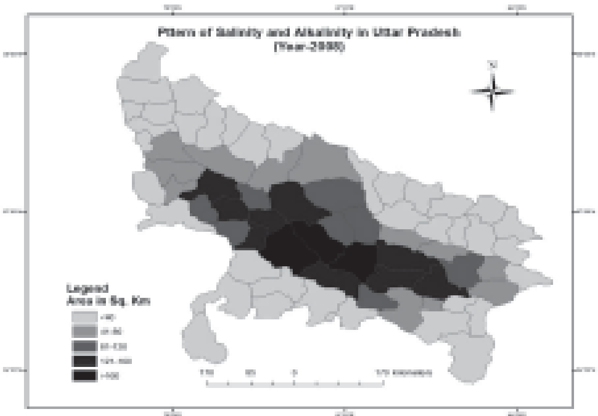


Fig. 7b : Pattern of Salinity in UP

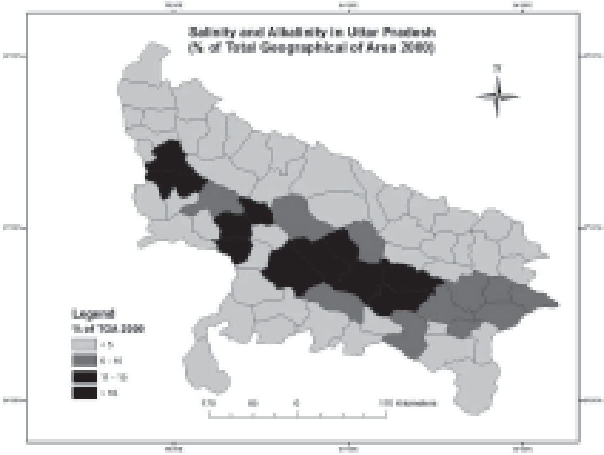


Fig. 8

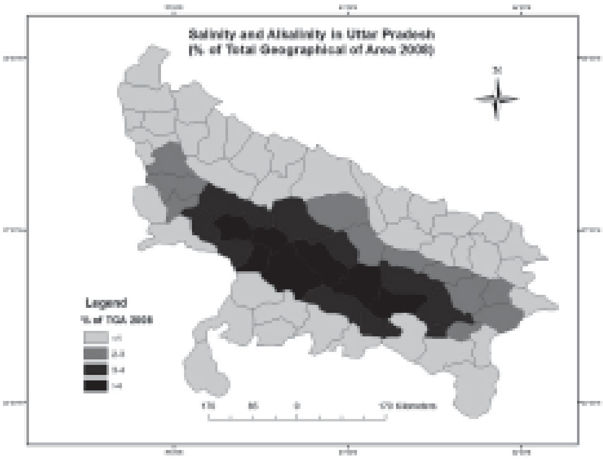


Fig. 9

degraded with salinity is reduced. On contrary there is increase in no. of district moderately affected by salinity. The reason behind it is increasing in amount of irrigated areas (Bingili, 2012). Although, this area is agricultural area, but some industries are grown, which disposed their contaminated wastes into the riverbed. As a consequence, water of these rivers is having characteristics of sodic and water from the rivers are used for irrigation in the field. So, as there is spread in irrigation, the salinity and alkalinity is also increased in the surface areas.

If we look at salinity and alkalinity % of total geographical areas (TGA), then Pratapgarh and

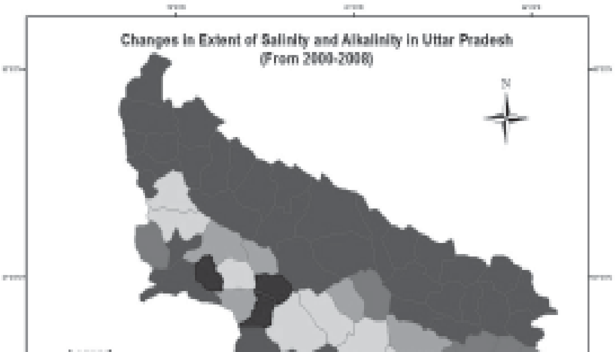


Fig.10

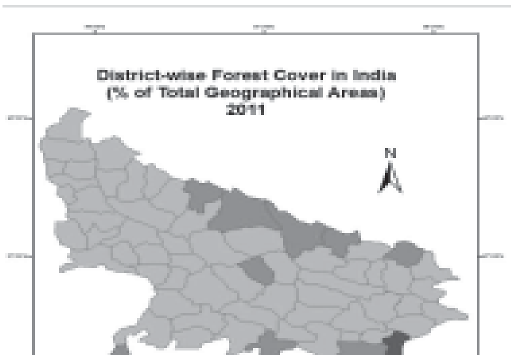


Fig. 11

Mainpuri is highly influenced (more than 16 % of total geographical area) district in 2000. Unnao, Raebareli and Bulandshahar are moderately degraded (more than 10 %) by salinity/alkalinity. As aggregate is concerned above that salinity has demonstrated gradual decease, so in 2008 % of salinity out of TGA round Gangetic plain has declined. Kannauj, Auraiya, Raebareli, Unnao and Mainpuri are suffered by salinty in great degree (fig. 9 & 10), but the amount of % is very low (more than 4 % and less than 6 %). There is trend of increase round Gangetic area. Because of during year 2001-2008, there also increase in canals. Although the amount of salinity has decreased, but the salinity is spreading around the areas, which is really need to attention.

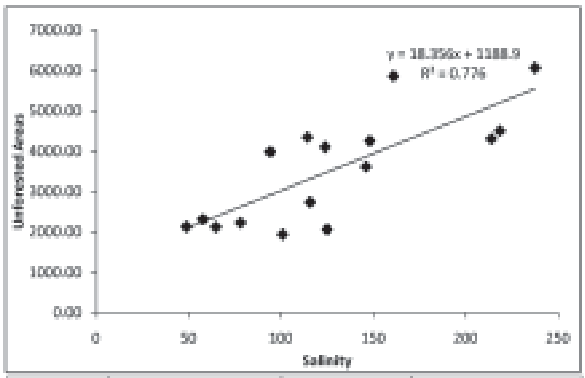
Fig. 11 explains that Bulandshahar, Aligarh, Mainpuri, Kanpur, Unnao, Raebareli and Pratapgarh are showing negative changes in salinity/alkalinity. Kannauj, Auraiya, Hathras and Firozabad are showing very high positive growth.

This map concludes that the areas, which previously have very low salinity, but after passing years there is very high increase in salinity. Thus, it is extremely problematic that most of the area of UP is converting in saline land. It is demanded that there should be taken some steps for reduction of salinity and restoration of land fertility.

Salinity and Its Relation with Forest Cover

Having less vegetation cover is a major problem in Uttar Pradesh. It should be noted that according to Forest Survey of India Utter Pradesh have only 16583 km^2 with forest areas, which is merely 6.86 % of TGA. As it is known that the Salinized land need to improve to be made more productive. Again Figure-11 has alleged that most of the districts are having forest cover less than 11% of TGA. Some districts close to foothills of Himalayas have featured with forest cover less than 22% of TGA. Apart from this, Chandauli is only district, which has forested areas more than 22% of TGA and Sonbhadra is a district, which have more than 33% areas covered with forest out of TGA.

As Kathakali S. Bagchi & Mini Phillip have submitted that alkalinity builds up very quickly if usar soil are left fellow, thus the forest cover or vegetation brings or helps to mitigate the problem of salinity. This message has prompted towards the second objective. This paper found that salinity and unforested areas are highly correlated. It intends if there will be increase in unforested areas then saline areas also will be increased. R is 0.776; it indicated that forest cover is a major factor, which highly responsible for salinity. R^2 is 0.602 and t-value and F-value are 4.599 and 21.152. These values are significant at the level of 0.001. Hence, there are many other factors, which influence the salinity in soil, but deforestation is one of the major factors. Therefore, initiative to motivate the afforestation must be done by organization.



R	R Square	t value	F value
.776	.602	4.599*	21.152*

* Significant at the level of 0.001. So the null hypothesis is rejected.

CONCLUSION

It is very satisfactory that most degraded by saline area is showing reduction trend, but in contrast low affected areas are showing very high increase in salinity. Evapotranspiration also causes to increase in salinity. It is follows that human activities like deforestation, extensive irrigation, recycling of saline ground water, irrigation return flow and application of agricultural fertilizers are also contributing in increase in salinity (Rao, 2007). This can be reduced by combining use of alkali and good water quality canal waters. If it is possible then treatment should be provided to the water, which is used for irrigation (Cauhan et al., 2007). Government must try to reach forested cover areas at least 33% of TGA. Nitrigenous grass species (like Kaenal grass) in rotation with salt tolerant hardy forage species i.e. Barseem, Shaftal, Para grass etc. should be grown. These steps are going to helpful for minimizing the risk of salinity and alkalinity in Uttar Pradesh.

REFERENCES

1. Bilgili, Ali V. (2012). Spatial Assessment of Soil Salinity in the Harran Plain using Multiple Kriging Techniques. *Environ Monit Assess*, 185, 777-795. DOI 10.1007/s10661-012-2591-3.

2. Chauhan, S. K. Chauhan, C. P. S. and Minhas. P. S. Effect of Cyclic Use and Blending of Alkali and Good Quality Waters on Soil Properties, Yield and Quality of Potato, Sunflower and Sesbania. *Irrigation Science*, 26, 81-89. DOI 10.1007/s00271-007-0074-z

3. FAO. (1999). Soil Salinity Assessment Methods and Interpretation of Electrical Conductivity Measurement. FAO Irrigation and Drainage Paper, California, USA.

4. FSI. (2011). *India State of Forest Report 2011*.

5. ICAR & NAAS. (2010). *Degraded and Wastelands of India- Status and Spatial Distribution.*Indian Council

of Agricultural Research, Krishi Bhawan I, Pusa, New Delhi. M/s Royal offset printer, New Delhi.

6. Koshal, A. K. (2012). Satellite Image Analysis of Saline Areas through GPS, Remote Sensing and GIS. *Indian Geospatial Forum.*14th Annual International Conference and Exhibition On Geospatial Information Technology And Application.

7. Machender, G. Dhakate, R. Reddy M. Narsimha. and Reddy, I. Panduranga.(2013) Hydrogeochemical characteristics of surface water (SW) and groundwater (GW) of the Chinnaeru River basin, northern part of Nalgonda District, Andhra Pradesh, India. *Environ Earth Sci*. DOI 10.1007/s12665-013-2665-8.

8. Nayak, Sanatan. Land Degradation in Uttar Pradesh: Causes, Extent and Intensity.

9. Raina, P. Kumar, M. and Singh, M. (2009). Mapping of Soil Degradation Hazards by Remote Sensing in Hanumangarh District (Western Rajasthan). J. *Indian Soc. Remote Sens.*, 37, 647-657.

10. Rao, N. Subba. Factor Controlling the Salinity in Ground Water in Parts of Guntur District, Andhra Pradesh, India. *Environ. Mont, Assess*, 138, 327-341. DOI 10.1007/s10661-007-9801-4.

11. Sengupta, Nirmal. (2002). Traditional vs Modern Practices in Salinity Control. Economic and Political Weekly, 13, 1247-1254. retrieved from http://www.jstor.org/stable/4411928.

12. Singh, V. K., Bikundia, D. S., Sarswat, A. and Mohan, D. (2012). Groundwater quality assessment in the village of Lutfullapur Nawada, Loni, District Ghaziabad, Uttar Pradesh, India. *Environ. Mont, Assess*, 184, 4473-4488. DOI 10.1007/s10661-011-2279-0.

13. Tyagi, N. K. (2003). Managing Saline and Alkaline Water for Higher Productivity. Water Productivity in Agriculture: Limits and Opportunities for Improvement. Eds. J. W. Kijne, R. Barker and D. Molden.

14. Wang, Li, Katsutoshi, S., Miyazaki, T. and Ishihama, Y. (2009). The Causes of Soil Alkalinization in the Songnen Plain of northeast China. *Paddy Water Environ*, 7, 259-270. DOI 10.1007/s10333-009-0166-x.

PANCHAYAT LEVEL MAPPING OF FLOOD AND AGRICULTURAL DROUGHT PRONE AREAS IN KANNUR DISTRICT, KERALA

Savitha VIJAYAN[1], T. NEELAKANTAN[2], B.SUKUMAR[3] & Ahalya SUKUMAR[3]

ABSTRACT

The United Nations defines a disaster as a serious disruption of the functioning of a community or a society. Disasters involve widespread human, material, economic or environmental impacts, which exceed the ability of the affected community or society to cope using its own resources. Activities designed to minimize loss of life and damage – for example by removing people and property from a threatened location and by facilitating timely and effective rescue, relief and rehabilitation are important aspect of disaster management. Preparedness is the main way of reducing the impact of disasters. Community-based preparedness and management should be a high priority. When natural hazards like flood and landslides happens suddenly causing damage to life property it becomes disaster. Preparedness needs spatial information of all natural hazards. Agricultural drought and flood are natural hazards. Drought is a slow process and the flood is a sudden incident. Even though drought is a slow process, if it is neglected it would make serious damage in future. Agricultural drought is a kind of drought where soil moisture is lacking at least for a month or so. In this paper an attempt is made to identify flood and agricultural drought prone areas at Panchayat level in Kannur district using GIS. Natural hazard map of Kannur district prepared by CESS in 1:50,000 scale and Agricultural drought prone area map prepared by CESS in a project for Kannur district were used as base. These two hazard prone areas were digitized along with Panchayat boundaries. By making over lay method, areas under these hazards at Panchayat level were calculated. These values were used to prepare thematic map distribution map showing flood and agricultural drought prone areas by choropleth method to get a clear spatial distribution. There are 81 panchayat in the district. Total flood prone area in the district is 437.55 sq. km. From the study it is found that the total flood prone area of the district is more in Payyannur panchayat (25.66sq.km) followed by Thalassery (12.55sq.km), Cherukunnu (12.05sq.km) Ezhome (10.96sq.km), Thaliparamba(10.63sq.km) Kalliassery (10.07sq.km) and Pappinissery (9.96sq.km). The total agricultural drought prone area of the district is 443.58 sq.km. Peringome Vayakkara (33.47sq.km) Panchayat ranks first among the Agricultural drought prone area followed by Eramam Kuttur (28.34sq.km), Pariyaram (22.13sq.km), Chengalayi (21.65sq.km)and Kankole Alapadamba(20.15sq.km).Measures should be taken to reduce the flood vulnerability during south west monsoon season and drinking water scarcity during summer season with the help of local administration.

***Keywords**: Flood, Agricultural Drought, GIS*

INTRODUCTION

The United Nations defines a disaster as a serious disruption of the functioning of a community or a society. Disasters involve widespread human, material, economic or environmental impacts, which exceed the ability of the affected community or society to cope using its own resources. Activities designed to minimize loss of life and damage – for example by removing people and property from a threatened location and by facilitating timely and effective rescue, relief and rehabilitation are important aspect of disaster management. Preparedness is the main way of reducing the impact of disasters. Community-based preparedness and management should be a high priority. When natural hazards like flood and landslides happens suddenly causing damage to life property it becomes disaster. Preparedness needs spatial information of all natural hazards. Agricultural drought and flood are natural hazards. Drought is a slow process and the flood is a sudden incident. Even though drought is a slow process, if it is neglected it would make serious damage in future. Agricultural drought is a kind of drought where soil moisture is lacking at least for a month or so. Unplanned urbanization changes the drainage characteristics of a natural catchment area. Increasing Urbanization has leads to significant alteration in the natural system of an area. The alteration will leads to Water logging, Impermeability of surface area etc. The increasing trend of disaster shows that the developed countries are most devastated in property and developing countries affected in loss of life.

In Kannur district most of the urban areas are located along both sides of the National Highway. Even small scale floods may leads to considerable damages to the life and property. Both natural factors like heavy rainfall during South West monsoon and human factors such as modification by reclamation of drainage channels lead to floods in the district. Since Kannur district is famous for its agriculture and

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related activities, drought is serious problem that directly affect the production and productivity of crops. The lack of soil moisture for more than two months will affect the entire agricultural activities of an area like Kannur district. A combination of spatial, technical and organizational measures can be able to reduce the vulnerability. Geographical Information System contributed a major part in deriving accurate and authentic information on disaster management and mitigation.

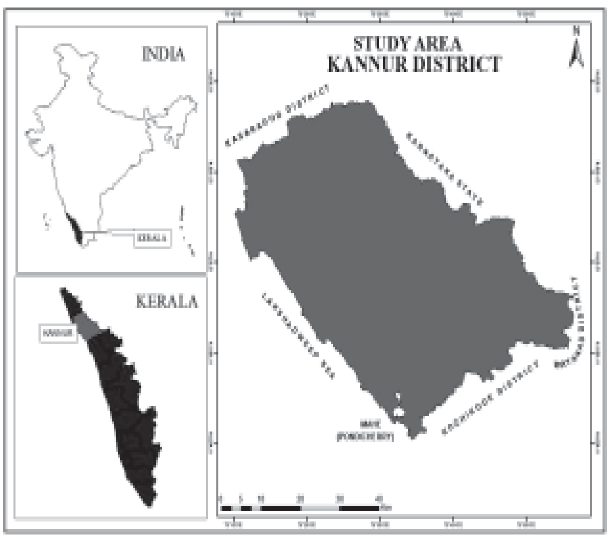
Disaster related studies in the district especially Floods and Drought were studied by CESS (2009), Sukumar et al (2009), Savitha et al (2009) and Jyothirmayi et al (2009).

AIM AND OBJECTIVE

The aim and objective of the paper is to identify panchayat wise flood and agricultural drought prone areas in Kannur district.

DATA BASES AND METHODOLOGY

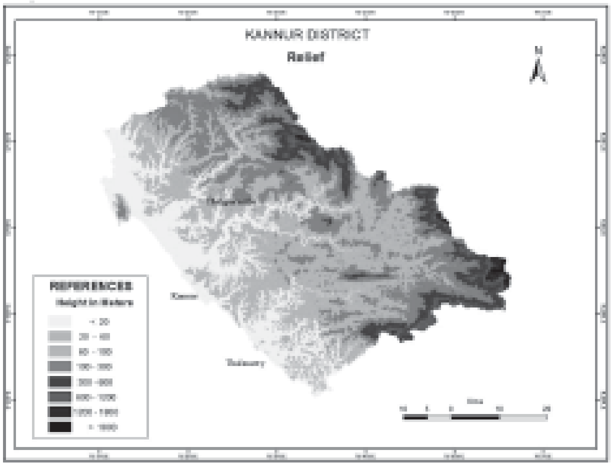
The study mainly focuses on the panchayat level distribution of flood and drought prone areas. This research paper has been carried out mainly with the help of secondary sources. Agricultural drought prone area map and Natural Hazard map of Kannur district prepared by CESS in different projects was used for the hazard analysis. Survey of India Topographical map was used for the preparation of base map. Various Census reports from 1981 to 2011 and other Government reports, Books, Journals were also used for the analysis. Thematic maps such as Relief, Slope, Soil, Drainage, Drainage density (Maps1, 2, 3, 4, 5), Flood prone area (Map.7) and Drought prone area maps (Map.8) were prepared in GIS environment to assess the flood and drought prone areas.



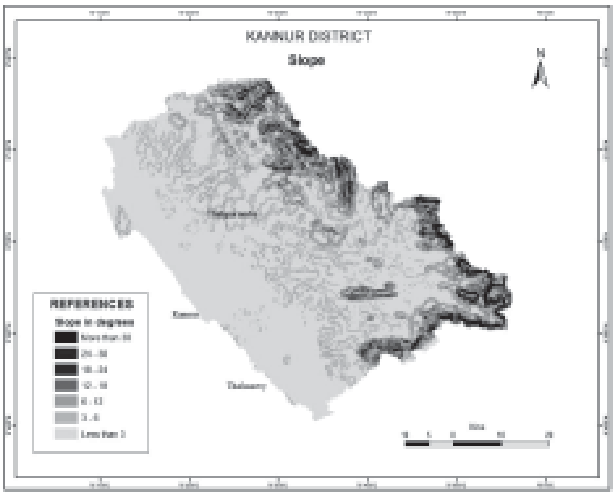
Map 1 : Study Area

STUDY AREA

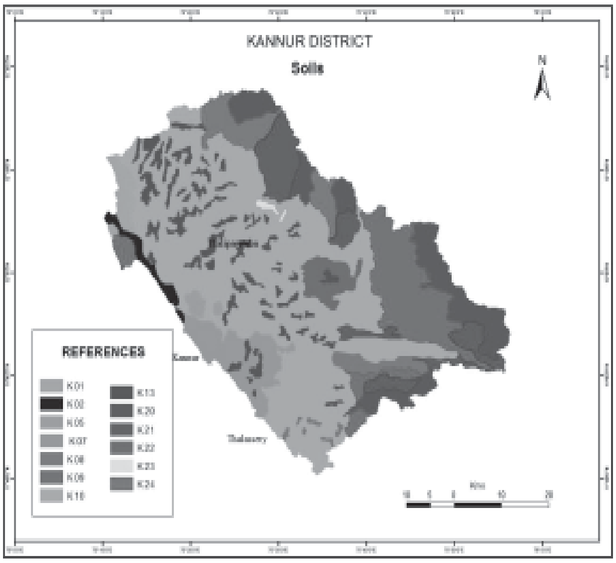
Kannur District is one of the northern most districts in the state of Kerala. The district lies between latitudes 11° 40' to 12° 48' North and longitudes 74° 52' to 75° 56' East (Map.1). The total area of the district is 2961 sq.km. The district is has three taluks namely Thaliparamba, Kannur and Thalassery. According to the 2011 Census, Kannur district has a population of 25, 23,003. The district has a population density of 812 persons per square kilometre. The population growth rate of the district for 2001-2011 was 4.84 %. More than 50% of the population resides in the urban agglomerations. The total urban population of Kannur district is 16, 40,986. There are 67 towns in the district which is one of the highest in Kerala. There are 6 statutory towns, 61 census towns and 1 Contonement. The statutory towns are Kannur, Thalassery, Payyannur, Thaliparamba, Kuthuparamba and Mattannur.



Map 2 : Relief



Map 3 : Slope



Source: Soil Survey Department

Map 4: Soil

Reference to Soil Map

K 01 Very deep, moderately well drained, sandy soils with moderately shallow water table on very gently sloping subdued sand dunes, with slight erosion:associated with very deep, moderately well drained, sandy soils.

K 02 Very deep, somewhat excessively drained sandy soils with moderately deep water table on very gently sloping beaches, with slight erosion;associated with very deep, moderately well drained, sandy soils with moderately shallow water table.

K 05 Very deep, imperfectly drained, clayey soils with shallow water table on level lands with valleys, with slight erosion.

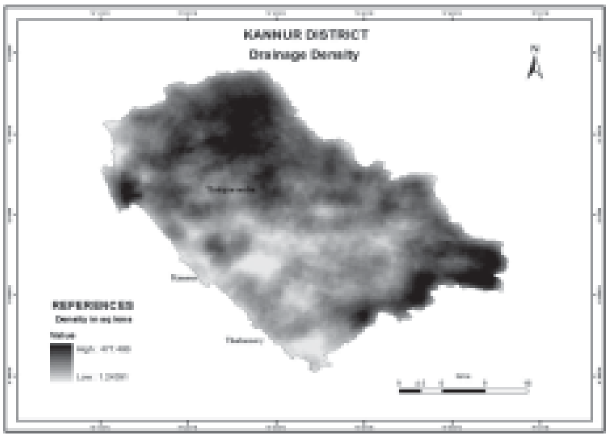
K 07 Very deep. Well drained, gravelly clay soils on gently sloping coastal laterites, with moderate erosion;associated with very deep, well drained, gravelly clay soils with moderate surface gravelliness.

K 08 Very deep, moderately well drained, clayey soils with moderately shallow water table in nearly level narrow valleys, with slight erosion:Associated with very deep, imperfectly drained clayey soils with moderately shallow water table on nearly level land.

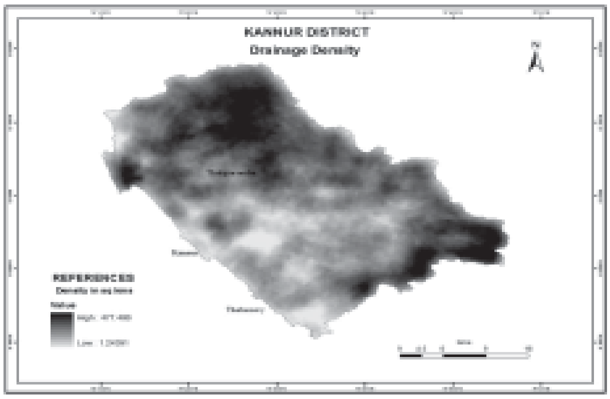
K 09 Very deep, well drained gravelly clay soils with moderate surface gravelliness on moderate steeply sloping satellite mounds with moderate erosion;associated with deep, well drained, gravelly clay soils on gently slopes.

K 10 Very deep, well drained, gravelly clay soils on gently sloping midlands laterites with valley of northern Kerala, with moderate erosion;associated with deep, well drained, gravelly clay soils with moderates surface gravelliness and ironstone layer at 100 to 150cm on nearly level lands, slightly eroded.

K 13 Deep welldrained, gravelly clay soils with moderate surface gravelliness and ironstone layer at 100 to 150cm on gently sloping midland laterites, with moderate erosion;associated with Laterite outcrops.



Map 5: Drainage



Map 6: Drainage Density

ANALYSIS

Physiographically the entire district is divided into Lowland, Midland and High land. Relief map was prepared from topographical maps and it is found that the height is varies from mean sea level to more than 1800 meters, General slope of the district is varies from less than 3 degrees to more than 30 degrees. The district is endowed with six major rivers such as Valapattanam, Ancharakandy, Kuppam, Peruvamba, Mahe and Thalassery river. Valapattanam is the longest river. Major part of the district is having lateritic soil except the coastal strip. From the drainage density analysis it is found that most of the areas having moderate to high density. The Percentage wise drainage density of the study area are Very low

(6.27%), low (27.20%), moderate (33.36%), high (24.86%) and very high (6.40%).

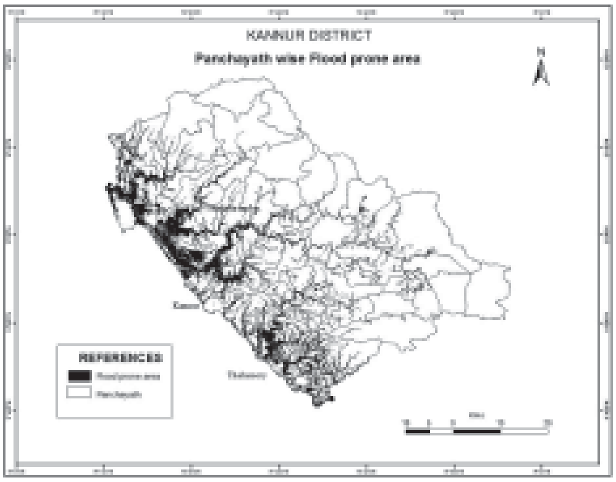
RESULTS AND DISCUSSION

The total flood prone area of the district is 437.55 sq.km. More than 60% of the total area is flood prone in Cherukunnu (78.31%), Mattool (73.72%), Pappinissery (64.31%), Kalliassery (63.10%), Dharmadom (61.61%),. Payyannur (25, 66%), Thalassery (12.55%), Cherukunnu (12.05%) Ezhome (10.96%), Thaliparamba (10.63%) have less prone area (Table 1).

Table 1
Flood Prone Panchayaths in Kannur District

Name of Panchayath	*Total area*	*Flood prone area*	*%of flood prone area*
Cherukunnu	15.39	12.05	78.31
Mattool	13.38	9.87	73.72
Pappinisseri	15.49	9.96	64.31
Kalliassery	15.96	10.07	63.10
Dhamadom	11.25	6.93	61.61
Ezhome	18.40	10.96	59.57
Narath	16.58	9.41	56.73
Kariyad	10.57	5.85	55.30
Azhikode	14.59	7.68	52.61
Madayi	17.55	9.21	52.51
Eranholi	10.11	5.25	51.97
Kunhimangalam	15.79	8.16	51.69
Pinarayi	19.45	9.71	49.93
Panniyanur	9.60	4.77	49.73
Thalasseri	25.57	12.55	49.09

The total agricultural drought prone area of the district is 443.58 sq. km. From the analysis it is found that Kangole Alapadamba (48.32%), Peringome-Vayakara (42.41%), Pariyaram (39.56%), Eramam Kuttor (38.18%), Kadannapally Panapuzha (34.08) are

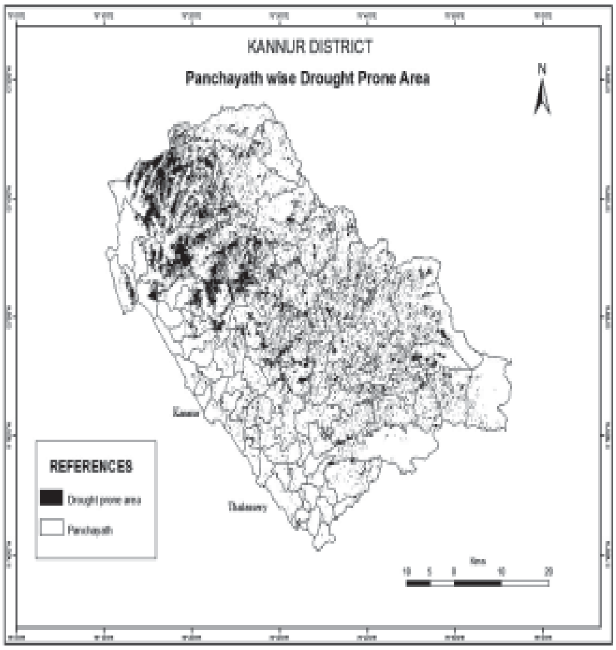


Map 7: Panchayath Wise Flood Prone Area

Table 2
Drought prone Panchayaths in Kannur District

Name of Panchayath	*Total area*	*Drought prone area*	*%of flood prone area*
Kankole-Alapadamba	41.70	20.15	48.32
Peringaome-Vayakara	78.91	33.47	42.41
Pariyaram	55.94	22.13	39.56
EramamKuttur	74.24	28.34	38.18
Kadanapalli-Panapuzha	52.12	17.76	34.08
Changalayi	68.58	21.65	31.57
Kurumathur	51.43	16.05	31.20
Taliparamba	43.24	13.14	30.39
Cheruthazham	32.51	8.76	26.95
Chapparapadavu	38.23	9.39	24.57
Malapattam	17.60	4.31	24.50
Keezhalur	27.51	6.56	23.86
Irikkur	12.62	2.97	23.49
Koodali	41.15	9.55	23.21
Padiyoor-Kalliad	53.65	11.46	21.36

the panchayats facing more agricultural drought in summer season (Table 2). Drinking water scarcity is a major problem in these panchayat during summer season.



Map 8: Panchayath Wise Drought Prone Area

RECOMMENDATIONS AND CONCLUTION

- District Development works such as construction of roads, buildings should be consider the geographical settings of the district.

- Regular and timely cleaning and maintenance of urban drainage is recommended
- Avoid the reclamation of paddy fields since these are the places through which the rain water is percolated and ground water resources are maintained.
- Rainwater harvesting methods should promoted by the government
- Future growth and development should consider flood and drought in the planning process.

It is always better to take precautionary steps rather than organizing post disaster management plans, rehabilitation and rescue operations after the occurrence of natural disaster. GIS is an authentic tool to identify the disaster prone areas. The different tools in GIS help the authorities to provide accurate and timely management and mitigation plans at a faster and an easier manner.

REFERENCES

1. Ajin. R. S., R. R. Krishnamurthy, M. Jayaprakash 2 and Vinod. P. G. (2013) Flood Hazard Assessment of Vamanapuram River Basin, Kerala, India: An Approach Using Remote Sensing & GIS Techniques, Advances in Applied Science Research,Vol. 4(3) pp. 263-274.
2. District Level Natural Hazard Zonation Maps of Kerala, 2009: Centre for Earth Science Studies Trivandrum, India
3. Jyothirmayi P., Diji V., P. Deepthi, U.M. Divya, Savitha Vijayan, M. Sulfikkar, Ahalya Sukumar and B. Sukumar (2009) Mitigation and management for Agricultural Drought Prone Areas in Kannur district, Kerala using GIS, Proc. National Workshop on Natural Hazards, Disaster Mitigation and Management held at Thiruvananthapuram 25-26 August 2009, Centre for Earth Science Studies, pp. 38-39
4. Jyothirmayi. P. and Sukumar. B. (2009) Mitigation and Management of Hazard Prone areas-Valapattanam River Basin, Kannur District kerala Using Geospatial Tools, Proceedings of the International Conference on Disaster Management and Mitigation ICDMM-2009, PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, pp. 599-610
5. Resource Atlas of Kerala, 1984: Centre for Earth Science Studies Trivandrum, India
6. Savitha Vijayan, Sulfikkar. M., Sukumar.B and Ahalya Sukumar (2009) Mitigation and Management of Landslide Prone Areas in Iritty and Irikkur Blocks of Kannur Districts, Kerala using GIS and Remote Sensing Proceedings of the International Conference on Disaster management and Mitigation ICDMM-2009, PSNA College of Engineering and Technology, Dindigul, Tamil Nadu, pp. 611-627.
7. Sukumar B. & Ahalya Sukumar(2009) Mapping the Disaster-prone Areas for Mitigation: A GIS Solution for Kannur District Kerala, , Natural Hazards and Disasters Essays and Impact and Management, Dept of Geography, Sri. Krishnadevaraya University, Anantapur,Andhra Pradesh,India pp 100-110.
8. Sukumar B. (2009) Need for Mapping Agricultural Drought Prone Areas in Kerala, Proc. National Workshop on Natural Hazards, Disaster mitigation and Management held at Thiruvananthapuram 25-26 August 2009, Centre for Earth Science Studies, pp. 56-57.
9. Thivya P. and Ramalingam M. (2009) Evaluation of Dryland Agriculture and its Drought Vulnerability study using R S and GIS Proceedings, National Conference on Innovations and Recent Advances in Geospatial Technology, PSNA College of Engineering &Technology, Dindigul. pp. 158-167.

ASSESSING NATURE, CAUSES AND OCCURRENCES OF FLOOD: A CASE OF DARAKESWAR-MUNDESWARI INTERFLUVE IN HUGLI DISTRICT, WEST BENGAL

Soumen MANDAL[1] & N. C.JANA[2]

ABSTRACT

Flood is one of the significant disasters in the humid tropics especially in India. From the Puranas and the Government reports, it is evident that the Mundeswari (the main distributary of River Damodar) and Lower Darakeswar are the endemic flood-prone tropical rivers. The maximum flood in Darakeswar-Mundeswari interfluve recorded in the pre-dam period was in 1913 with a peak flow of 18,406 cumec (before the implementation of Damodar Valley Scheme). The all-time high combined inflow to the dam system observed in the valley occurred in September 1978 with peak flow of 21,900 cumec, needless to say that without these dams, which comprise the above scheme, the whole area would have been devastated.

Both natural and anthropogenic causes are responsible for flood of the rivers. The causes of floods of the rivers become highly complex and their relative importance varies from place to place. Anthropogenic activities such as building activity and eventual urbanization, channel manipulation through diversion of river's course, construction of bridges, barrages and reservoirs, agricultural practices, deforestation, land use changes etc. induce floods in the study area.

The objectives of the paper are to: (i) study the nature of flood, (ii) find out the causes responsible for flood and its occurrences, and (iii) suggest possible measures towards reducing the devastating nature of flood in Darakeswar-Mundeswari Interfluve in Hugli District of West Bengal.

The methodologies used in the present paper include different cartographic techniques like Bar graph, Line graph, Hydrograph, Unit Hydrograph. GIS technique has also been used for demarcation of flood-affected areas.

According to field investigation and analysis of official records, the nature and intensity of flood decreased in the post-dam period up to 1970, but after this period it has gradually increased due to the siltation in Dams and River beds. It has been revealed in the personal interview of local senior citizens that the removal of flood water takes much more time than the previous. Hence the effect of present flood is more devastating and long lasting. Such massacre is caused by the siltation in river bed and anthropogenic encroachment of river valley in the lower reaches.

Keywords**:** *Flood-affected, Interfluve, Flood Intensity, Hydrograph, GIS Technique*

INTRODUCTION

Flood is one of the significant disasters in the humid tropics especially in India. From the Puranas and the Government reports, it is evident that the Mundeswari (the main distributary of River Damodar) and Lower Darakeswar are the endemic flood-prone tropical rivers. The maximum flood in Darakeswar-Mundeswari interfluve recorded in the pre-dam period was in 1913 with a peak flow of 18,406 cumec (before the implementation of Damodar Valley Scheme). The all-time high combined inflow to the dam system observed in the valley occurred in September 1978 with peak flow of 21,900 cumec, needless to say that without these dams, which comprise the above scheme, the whole area would have been devastated.

Both natural and anthropogenic causes are responsible for flood of the rivers. The causes of floods of the rivers become highly complex and their relative importance varies from place to place. Anthropogenic activities such as building construction and eventual urbanization, channel manipulation through diversion of river's course, construction of bridges, barrages and reservoirs, agricultural practices, deforestation, land use changes etc. induce floods in the study area. Hence the effect of floods is more devastating and long lasting.

The study area i.e. Darakeswar-Mundeswari Interfluve is situated in the south- western part of Hugli District in West Bengal. The study area lies between the latitudes 22°362 153 N to 22° 572 353 N and longitudes 87°452 003 E to 87° 582 103 E (Fig-1). The study area covers four blocks viz. (i) Arambagh,

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(ii) Pursurah, (iii) Khanakul-I, and (iv) Khanakul-II. Arambagh Block-15 GPs & 1 Municipality with 19 wards, Khanakul-I Block-13 GPs, Khanakul-II Block-11 GPs, Pursurah Block- 8 GPs.

Geomorphologically, the study area is a part of deltaic plain in the lower Gangetic Delta. The natural landforms consist of present day active channels, Palaeo channels, natural leeves, back swamps and point / channel bars (Roy Chowdhury, 1973).

OBJECTIVES

The objectives of the paper are to: (i) study the nature of flood, (ii) find out the causes responsible for flood and its occurrences, and (iii) suggest possible measures towards reducing the devastating nature of flood in Darakeswar-Mundeswari Interfluve.

DATABASE AND METHODOLOGY

Both primary and secondary data are used in the present study. Secondary data are collected from Sub-divisional Disaster Management Department, Arambagh, Hugli and School Education Department, topographical map (73N/13 & 73N/14) from Survey of India.

The methodologies used in the present paper include different cartographic techniques like Bar graph, Line graph, Hydrograph, Unit Hydrograph. GIS technique has also been used for demarcation of flood-affected areas.

DISCUSSION AND ANALYSIS

Nature of Flood in Darakeswar-Mundeswari Interfluve

The catchment area of Darakeswar and Mundeswari (i.e. Damodar) Rivers experiences seasonal rains due to South-West Monsoon season. It may be mentioned in this context that the cross section area of the lower Damodar (i.e. Mundeswari) and Darakeswar in the delta area has become considerably shallower, thus reducing its drainage capacity.

The maximum flood in Darakeswar-Mundeswari interfluve recorded in the pre-dam period was in 1913 with a peak flow of 18,406 cumec (before the implementation of Damodar Valley Scheme). The all-time high combined inflow to the dam system observed in the valley occurred in September 1978 with peak flow of 21,900 cumec, needless to say that without these dams which comprise the above scheme the whole area would have been devastated.

According to field investigation and official records, the nature and intensity of flood decreased in post-dam period up to 1970, but after this period it has gradually increased due to the siltation in Dams and River beds. It has been revealed in the personal interview of local senior citizens that the removal of flood water takes much more time than the previous. Hence the effect of present flood is more devastating and long lasting. The cause of such massacre is caused by the siltation in river bed and anthropogenic encroachment of river valley in the lower reaches.

Causes of Flood in the Study Area

Both natural and anthropogenic factors are responsible for flood of the rivers. The causes of floods of the rivers become highly complex and their relative importance varies from place to place. Anthropogenic activities such as building activity and eventual urbanization, channel manipulation through diversion of river's course, construction of bridges, barrages and reservoirs, agricultural practices, deforestation, land use changes etc by man invite flood. The main causes of flood in this study are:

- High discharge of water from DVC is one of the most important factors of flood in this area
- Heavy rainfall at the Darakeswar-Mundeswari basin area (Fig. 3).

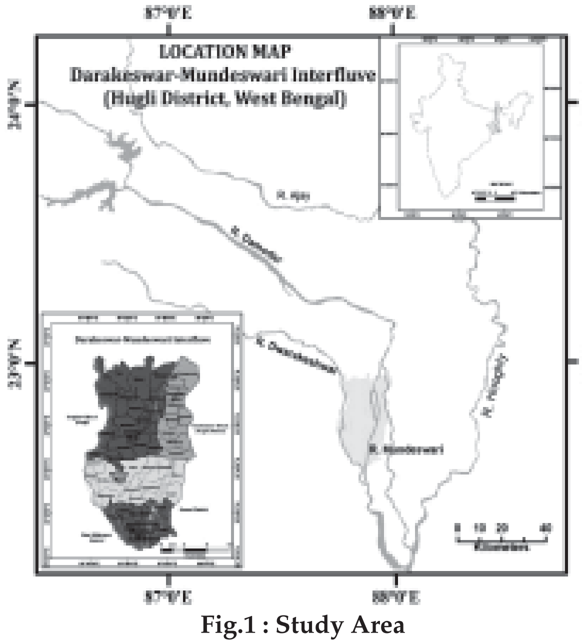
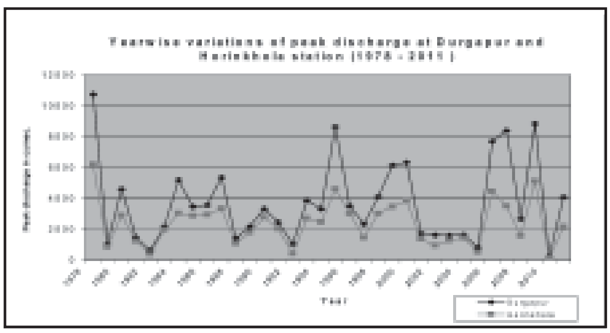


Fig.1 : Study Area



Source: Irrigation & Waterways Directorate, Harinkhola, 2012

Fig. 2 : Discharge of Water

- Due to overflow of water from the Rivers Mundeswari, Darakeswar, Kana-Darakeswar, Ruponarayana is a major cause of flood in this area.
- Deforestation in the upper catchment area, which results in sedimentation on channel bed.
- Due to sedimentation in river bed, the carrying capacity of the rivers decreases, thereby induces flood in the study area.
- Very gentle slope of the River Darakeswar and Mundeswari. The average slope of the River Darakeswar is approximately 0.369 metres/km.
- Unwise construction of flood embankment on spill zone of rivers resulting in deposition of solids in the river bed.
- Worst condition of embankment and natural leeves in both side of the Rivers Mundeswari, Darakeswar, Kana-Darakeswar and associated channels (Hurhurh Khal, Arora Khal, Karakdha-Panjhula Khal, Kata Khal, Deb Khal etc.) (Sub-divisional Disaster Management Department, Arambagh, 2010).
- Narrowing of channel width due to agricultural encroachment in some parts of the lower basin.
- Construction of road, rice mill, brick industry and embankment on the floodplain across the natural drainage line (Plate-1).

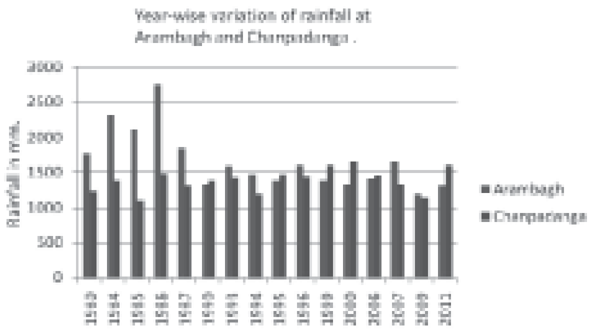


Fig. 3 : Variation in rainfall

- Back-pressure of water from Rupnarayan River due to tidal waves and high-velocity flow of Darakeswar River are responsible for flood along the Mundeswari basin (Plate-2).
- Lack of alertness of the concerned administrative machineries about flood situation.
- The Government is not in a position to allocate fund for repairing the Dams during pre-monsoon period.

Plate.1: Establishment of brick industry in the channel bed of Darakeswar River near Arambagh, which obstructs the natural flow and increases the chances of flood during the period of heavy rainfall

Plate.2: Confluence point of Darakeswar, Mundeswari and Rupnarayan Rivers. It is also a tri-junction of Hooghly, Howrah and West Medinipur Districts. River Mundeswari frequently used to spill over for the Back-pressure of water from Rupnarayan River due to tidal waves and high-velocity flow of Darakeswar

Occurrences of Flood

Temporal variation in frequency of occurrences of flood (1978-2011)

Ten major floods have been selected for temporal variation in frequency of occurrence of flood. Among these 10 major flood periods; flood occurred twice in 373 mouzas (100 %) in 1978 and 2000. The number of mouzas faced flood for three, four, five and six times are 338, 332, 330, and 305 respectively. Similarly, the number of mouzas, confronted the same for seven, eight and nine times are 295, 294, and 211 respectively. There are 184 mouzas, which have been flooded ten times out of ten flood-years (Table-1).

Decadal Changes in flood occurrences (1900- 2009): The total number of floods was 43 in 11 decades (1900-2009). Among these 8 floods had occurred in the decade of 1900-1909. Floods took place 5 times in two

Table-1

Temporal variations of flood in frequency of occurrences of flood (1978 – 2011)

Frequency	No of flood mouza	Name of flood years	% of total flood affected mouzas
1 time	----	------	----
2 times	373	1978 , 2000	100
3 times	338	1978 , 2000 , 2007	90.6
4 times	332	1978, 2000, 2007, 1987	89.0
5 times	330	1978, 2000, 2007, 1987, 1995	88.4
6 times	305	1978, 2000, 2007, 1987,1995,1999	81.8
7 times	295	1978,2000,2007,1987,1995,1999,1980,	79.1
8 times	294	1978,2000,2007,1987,1995,1999,1980,2006	78.8
9 times	211	1978,2000,2007,1987,1995,1999,1980,2006,2009	56.7
10 times	184	1978,2000,2007,1987,1995,1999,1980,2006,2009,2011	49.3

Source: Disaster Management Department, Arambag Sub-Division, 2012

decades such as 1980-89, and 1990-99. In the decades of 1910-1919, 1970-1979 and 2000-2009, flood unveiled itself for four times. Floods occurred two times in the rest two decades: 1920- 1929 and 1960-1969 (Table-2).

Table-2

Decadal changes in flood occurrences (1900- 2009)

Decade	*Frequency*	*Year of occurrence*
1900 – 1909	8	1901, 1902, 1903, 1904, 1905, 1906, 1907, 1909
1910 – 1919	4	1910, 1911, 1913, 1916
1920- 1929	2	1926, 1928
1930 -1939	3	1933, 1935, 1939
1940 – 1949	3	1941, 1943, 1949
1950- 1959	3	1956, 1958, 1959
1960 – 1969	2	1961, 1963
1970 – 1979	4	1970, 1971, 1973, 1978
1980 – 1989	5	1980, 1984, 1985, 1986, 1987
1990 – 1999	5	1990, 1993, 1995, 1998, 1999
2000 – 2009	4	2000, 2006, 2007, 2009

Source: Disaster Management Department, Arambag Sub-Division, 2012; District Gazetteer, Hugli, 1965

Prepared by the authors

Flood-prone Area

The demarcation of flood-prone area is a very difficult job for any floodplain because the nature, intensity and extension vary from year to year and month to month and even weekly. Darakeswar-Mundeswari Interfluve (inter-riverine plain) is not exception in this context. There are 4 Blocks, 47 Gram Panchyats and 373 Mouzas usually affected by flood in the lower Darakeswar-Mundeswari basin. The flood prone area of this part has been displayed in the map (Fig-4).

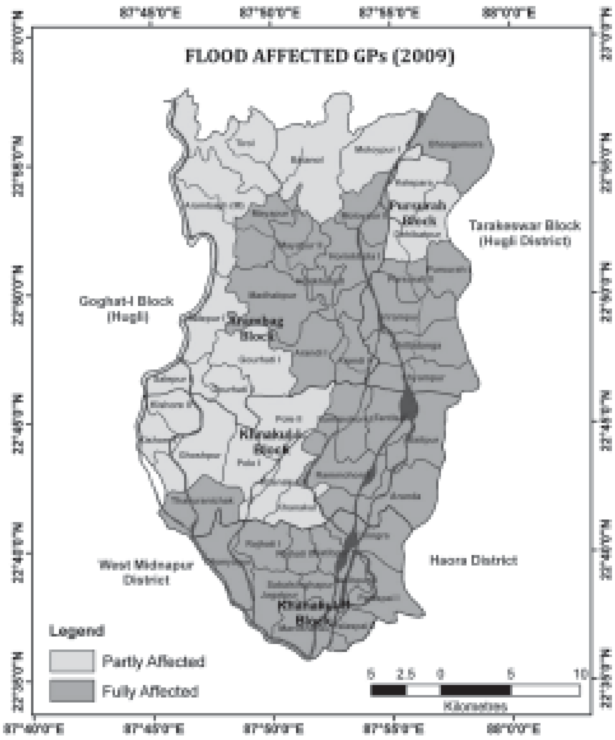


Fig. 4

River Regime and Geo-Hydrological Characteristics of Flood

River regime can describe one of the two characteristics of a reach of an alluvial river: (i) the variability in its discharge throughout the course of a year in response to precipitation, temperature, evapo-transpiration, and drainage basin characteristics (Beckinsale, 1969); (ii) a series of characteristic power-law relationships between discharge and width, depth, and slope (Leopold and Miller, 1995)

The variability in discharge over the course of a year is commonly represented by a hydrograph. River hydrographs show how a river responds to precipitation events within its drainage basin. The hydrograph shows changes in discharge over time (Raghunath, 1985) (Fig-5 & 6).

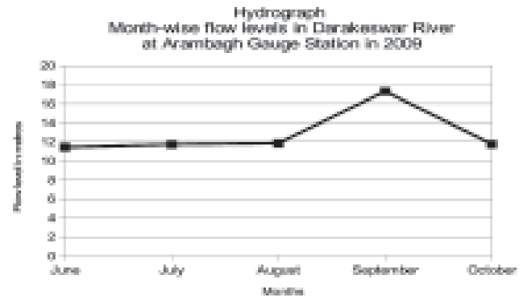


Fig. 5

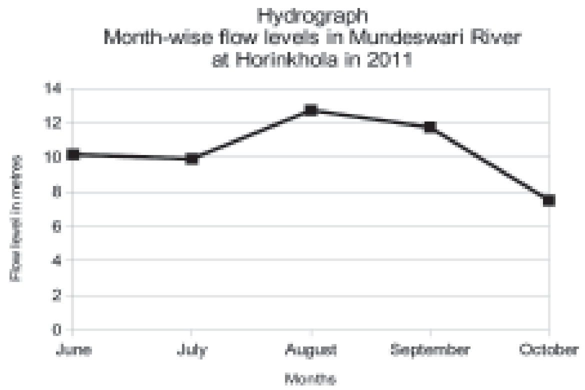


Fig. 6

A **Unit Hydrograph** (UH) is specific to particular watershed and specific to a particular length of time corresponding to the duration of the effective rainfall. The UH technique provides a practical and relatively easy-to-apply tool for quantifying the effect of a unit of rainfall on the corresponding runoff from a particular drainage basin. Nevertheless, application of UH methods typically yields a reasonable approximation of the flood response of natural watersheds (Raghunath, 1985) (Fig-7 & 8).

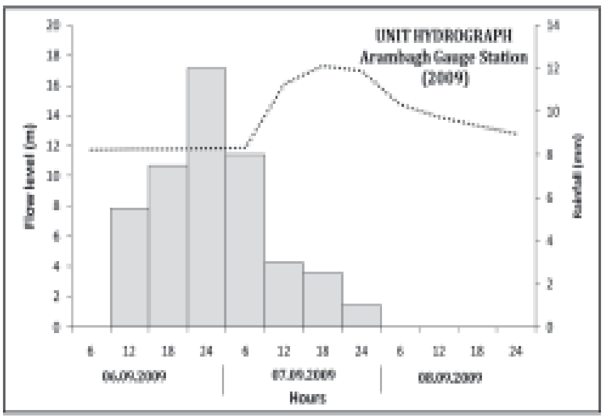


Fig. 7

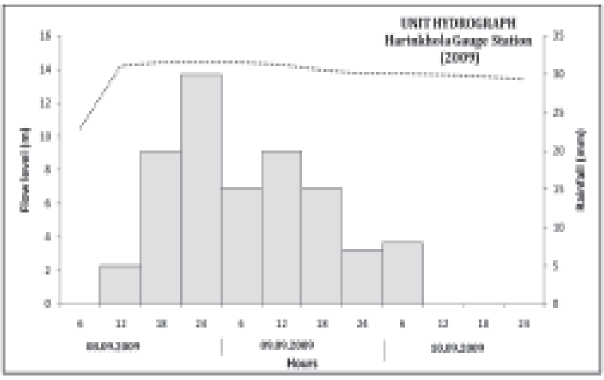


Fig. 8

CONCLUSION AND FINDINGS

- The first recorded flood was 1730 in Darakeswar-Mundeswari Interfluve (Voorduin, 1947).
- A peak discharge about 18,678 cumec, i.e. absolutely abnormal has been recorded thrice in August 1913, August 1935 and October 1941.
- In the time span of 155 years (1857–2011), 25 severe inundations took place, out of 22 occurred in first 100 years (pre-dam stage) and 3 in the last 54 years in post-dam situation. In pre-dam period the magnitude as well as frequency of flood was greater but in post-dam situation the magnitude decreases but the frequency has not been hopefully decreased.
- In pre-dam period return period of flood for bankful stage of 7080 cumec had a recurrence interval of 1.8 years. But in the post-dam period return period for the bankful stage has been increased to 14.81years (Bhattacharyya, 1998).
- In the post-dam situation i.e. after 1958 only three high floods have been occurred, one in October 1959 and the other two in September-October 1978 and 2000 respectively.
- According to field investigation and official records, the nature and intensity of flood decreased in post-dam period up to 1970, but after this period it has gradually increased due to siltation in Dam and River bed.
- There is a widespread flooding with long period inundation in parts of Khanakul-I and Khanakul-II Blocks and some parts of Pursurah and Arambagh Blocks.
- In respect of known spatial extension, the largest area was inundated during the flood of 1978 and 2000 and small area in the 2011 flood.
- Some time sudden falling in recession limb of hydrograph one upstream station to another down- stream station which is mostly due to breaching of embankment.

SUGGESTED MANAGEMENT MEASURES

Measures to mitigate flood damage can be classified as either **Structural** or **Non-structural**. Flood in Darakeswar-Mundeswari Interfluve is a recurrent problem. So, it cannot be avoided, but the magnitude of its impact on life and property can be mitigated through proper management measures.

Structural Measures include (i) River channel improvement through destroying sand bars or dredging the river beds; (ii) Proper and scientific reservoir control: (a) controlling measures of DVC dams through reducing siltation from the dams, systematic release of water from the dams and increasing carrying capacity of the reservoirs by dredging, (b) controlling measures of Mukutmonipur Barrage through reduction of siltation and increase of reservoir capacity to store excess water; (iii) Reducing flood-peaks by volume reduction through the moderation of flood to the maximum extent possible (Chandra, 2003); (iv) Maintenance of embankment through heightening and repairing of embankments in pre-monsoon period as well as bouldering the embankments in vulnerable spots; (v) River bank protection through (a) construction of dyke to limit the occurrence of flooding and (b) concretization of river bank; (vi) Reducing flood levels through (a) stream channelization to increase the volume of the channel and velocity of water flow, (b) construction of bypass and diversion channels to carry the excess flood water away from the area.

Non-Structural Measures include (i) Effective flood forecasting and early warning can enable the community to prepare for a possible flood, thereby minimizing damage and averting death or injury (Seth, 1998); (ii) Preparation of Flood Vulnerability Zoning Map with zone-wise mitigation measures and land use recommenda-tions; (iii) Ensuring Flood Insurance; (iv) Introducing Disaster Risk Management (DRM) based curriculum in educational institutions; (v) Awareness programmes to make the residents of the flood-prone area aware and prepare themselves to minimize the adverse impacts of floods.

REFERENCES

1. Beckinsale (1969): Wikipedia, the free encyclopedia.
2. Bhattacharyya, K. (1998): *Applied Geomorphological Study in a Controlled Tropical River: The case of Damodar between Panchet Reservoir and Folta*, unpublished Ph.D. thesis, Department of Geography, The University of Burdwan.
3. Chandra, S. (2003): 'India: Flood Management-Damodar River Basin' in *WMO/GWP Associated Programme on Flood Management Symposium.*
4. Luna, B. Leopold, M. John P.Miller (1995): *Fluvial Process in Geomorphology*, New York: Dover publication.
5. Raghunath, H.M. (1985): *Hydrology*, Wiley Eastern Limited, New Delhi, Bangalore, Bombay, Calcutta, Madras, Hyderabad.
6. Roy Chowdhury, S. (1973): 'An Outline of the Hydrology of the Alluvial Plains Around Arambagh, Hooghly', *Journal of Indian Minerals*, Vol-27, No-4 (Octo-Dec.)
7. Seth, S.M. (1998): 'Flood Hydrology and Flood Management in India' *Journal of Memoir Geological Society of India*, No.41, 1998, pp.155-172.
8. Voorduin, W.L. (1947): *Preliminary Memorandum on the Unified Development of the Damodar River*, Central Technical Power Board, Cal.

Geo-spatial Technologies for Sustainable Tourism

HABITAT MONITORING OF SEASONAL MIGRATORY BIRDS IN KULIK BIRD SANCTUARY, WEST BENGAL, INDIA USING REMOTE SENSING AND GIS TECHNIQUES

A. K. ADHIKARI[1], R. KARMAKAR.[2], P. CHOUHAN.[3]

ABSTRACT

Remote Sensing and GIS techniques are very popular instrument for assessing the environmental sustainability and management of natural resources. Kulik Bird Sanctuary is a well-known tourist spot and eco-park in West Bengal, 3 km away from Raiganj town covered by mixed deciduous forest. This area is very famous for seasonal migratory birds like Asian Open Bill Stork, Night Heron, Egrets, Cormorant, and others. Naturally, these birds usually come to this place in July-November for breeding and rearing their chicks. This paper is an attempt to monitor the Habitat of seasonal migratory birds using remote sensing and GIS techniques. To understand that Land use & Land-Cover Mapping, NDVI, NDWI, Tasseled Cap Transformation upon Landsat Data NDVI temporal analysis has been adopted. The primary focus of the paper is on mapping and monitoring of nesting zone, detection of land use & land-cover changes, mapping wetland zone for birds food collection, mapping eco-park zone and determination of ban period to tourists. Overall, the incoming season of birds occurs during monsoon when vegetation health is high. Land use & land-cover changes especially of the built-up zone, are gradually increasing around the surroundings of the sanctuary causing habitat threats. To extend the migratory period, artificial measures such as covering more evergreen vegetation, zonation of the sanctuary, converting lowlands into wetlands, banning tourists during the breeding season, etc. can be taken for the betterment of the sanctuary habitat.

Keywords: *Habitat Monitoring, Land use & Land Cover Changes, Sustainable Development, Landsat, NDVI, NDWI, Tasseled Cap Transformation*

INTRODUCTION

Habitat and wildlife restoration are very relevant in current environmental changes and spatial dynamics. Moreover, monitoring of landscapes and habitat changes in protected areas has become an important issue for international nature conservation agencies, super-national, national and regional authorities and also for the local managers; which is crucial for the assessment of current conservation policies, ongoing processes, and management practices (Mairota et al. 2013). It also brings forth the present scenario and status of habitat into our focus. Raiganj Wildlife Sanctuary, popularly known as 'Kulik Bird Sanctuary'(Sharma 2007) is one of the few 'Heronry' in India which were particularly protected against the human greed (Sharma 2007; Roy & Sah 2013:19-20). It is a mixed breeding heronry of different water birds, came into notice in 1984 and now established as the largest Asian Openbill- Stork heronry in India (Sharma 2007).

In several recently conducted studies, remote sensing and GIS techniques have been widely used to assess the habitat quality and monitoring. Among them studies by Balzter, H. et al. (2014), Palmer, S.C. J. et al. (2014), Heilmeier, H. et al. (2014), Medcalf, K. et al. (2014) are important. These studies have been conducted to map and monitor the quality of different types of biodiversities in various parts of European countries. Heilmeier, H. et al. (2014), Zlinszky, A. et al. (2015) in their study had widely discussed the scope that how remote sensing & GIS techniques can be useful for habitat monitoring purposes.

Several studies have established that the relationship between wildlife and habitat must be placed in proper spatial and temporal context (Block & Brennan 1993, Morrison, M. L. 2002). Particularly Hutto, R. L. (1985) has emphasized on hierarchical spatial scaling, where geographic range and different sites determine the habitat and life of specific species. Wecker (1964) and Weins (1972), and Askins (2000) can be quoted under similar studies, where they advised to stay careful about specific species, geographic site, scales and other ecological factors related to that particular locale of the study (as quoted in Morrison, M.L. 2002). Morrison, M. L. (2002) has also emphasised on temporal components of habitat analysis where he suggested that any study on habitat must focus on the period to which any environmental agents (i.e. may be biological and physical like vegetation, water bodies, rainfall, temperature, other natural landscapes, etc.) have occurred and create an influenced on the certain species of that area. Thus,

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any habitat monitoring or restoration process must consider the specific species, period, and site. Thus, for this study, we only focus on the migratory and native bird's habitat and interrelated environmental factors, for which Raiganj Wildlife Sanctuary (Kulik Bird Sanctuary) is famous.

Several studies (Datta & Pal (1993), Pramanik, Santra, & Manna, (2010, 2014), Roy & Sah (2013)) have been conducted on Kulik Bird Sanctuary and they have given a detailed account of the flora, fauna, ecological and environmental diversity, existing threats to the sustainability of the sanctuary. It has been seen that species composition of birds is interrelated with the type of vegetation, physiography, availability and diversity of microhabitats and other factors. Specifically for bird habitats, molluscs and fishes are significant components that serve as food for in-situ bird population in the sanctuary. Pramanik, Santra, and Manna (2010) also suggested that sustainable use of the molluscs and fishes are important to serve the need of many inhabiting birds in this sanctuary area.

Morrison, M. L. (2002) emphasized on seasonal livelihood resources of the species and with an example of birds species, he explained that their main food in winter is the seeds but in summer, it depends on insects for their food. In this present study, we have analyzed the information for the last twenty-five years i.e. from the year 1989 to 2014. It is basically to see the long-term changes of various elements responsible for greenness, brightness and wetness related health of the habitat; in addition to these, we have studied seasonal variations for the same over the monsoon to the winter season of the recent year of 2014. In this case 'habitat availability,' (i.e. accessibility of physical and biological components needed by the birds) and 'habitat quality' (i.e. the ability of the environment to provide conditions appropriate for the species) are also important (Morrison, M. L. 2002).

Other important related factors in habitat restoration are resources, niche and the landscape. Habitat is the container of resources which impacts on abundance, livelihood and reproduction whereas niche controls the access and use of those resources, creating a spatial landscape or habitable unit. In this case distribution and abundance of resources, availability and use of such resources plays a crucial role in the particular habitat of any species (Wiens, J.A 1989 as in Morrison, M. L. 2002). So, we tried to map the wetlands that were bird's food collection zone. Further, we proposed the possible lowlands areas which can be converted into wetland to extend the current wetland zone (i.e. current food collection zone) by proper planning.

In Kulik, it has been seen that the overall population of birds is increasing over the years (Figure:1). Although, Roy & Sah, (2013) have found that the negative growth of birds were associated with flooding in the Kulik river and adjacent area. At the same time, they argued that the global climate changes had compelled birds from other harsh regions to come in the Kulik birds sanctuary.

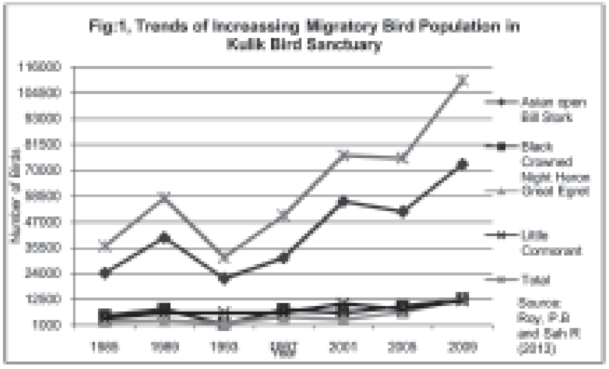

Fig:1. Trends of Increasing Migratory Bird Population in Kulik Bird Sanctuary

In Kulik, some of the birds namely Egrets, Herons, and Cormorants were more in abundance in the core region than the buffer, but Open-billed stork population were seen both in the core and buffer region as they can tolerate human interference (Pramanik et al. 2014). Due to this adaptability of Stork, Egrets, and Herons, the number of birds is increasing here over the years; which may also be possible for the suitability of the niche, availability of habitat and access and abundance of the needed resources for those particular birds species. Although, the area is nowadays predominantly exposed to different threats which must be encountered through proper planning and monitoring.

Different migratory birds, from the various South Asian countries and coastal regions, are the main attraction of Kulik bird sanctuary, although various native birds (like kites, flycatchers, owls, kingfishers, woodpeckers, drongoes, etc.) can be seen. The main migratory birds include open-bill storks, egrets, black-crowned night Herons, and Cormorants. The details of these birds have been given in the following table 1.

During the rainy season, unfavorable weather causes harm to birds' habitat especially on nesting and creates an easy way to predators and human interference (Pramanik et al. 2010; Roy & Sah 2013a, 2013b) also found that flood in the Kulik river is a significant cause of habitat destruction.

So it can be seen from the above discussion that there are various studies about Kulik river which mainly dealt with species diversity and related natural & anthropogenic factors. However, there are no studies of Kulik bird sanctuary on habitat monitoring over a long period through remote sensing techniques. Thus, this study tried to show the temporal changes in

Table:1, Range and Habitat of Migratory Birds

Sl. No.	Name of birds	Scientific Names	Range and Habitats	Major plant species used for building nest
1.	Open Bill Stork	*A.oscitans*	OR	F.bengalensis, A.indicus, A. Scholaris, B.acurangula,B tulda, T. Arjuna, S.asper, D.sisoo, T. Nudiflora,etc.
2.	Black Crowned Night Heron	*N.nycticorax*	Central NA to Southern NT, Southern WP, EP to AF	
3.	Great Egret	*C.albus*	NA, NT, AF, EP, OR, AU	
4.	Little Cormorant	*P.niger*	OR	

Note: WP-Western Palaearctic including northern Africa & Middle East; EP-Eastern Palaearctic including Japan & Northern China; AF-Aftropical region including Red sea; OR-Oriental region including Himalayas, Philippines & up to Wallace's line; AU-East of Wallace lines to Eastern New Guinea, Australia & New Zealand; NA- Near Arctic south of Rio Grande; NT-Neotropical, America & West Indies.

Source: Roy, P.B, and Sah, R. (2013)

habitat environment, using remote sensing & GIS techniques and also analyze the current habitat situation in Kulik Bird Sanctuary and will identify the possible threats and solutions for sustainable growth.

STUDY AREA

The Raiganj Wildlife Sanctuary, popularly known as Kulik Bird Sanctuary, situated in Uttar Dinajpur West Bengal (located at 25º 37´N to 25º 62´ N and 88º 07´ E to 88º 12´ E) (Fig:2). It is initially created as an artificial forest by the forest department in 1970 on the natural setting of Kulik river and later declared as wildlife sanctuary in 1985 (Sharma, 2007a, 2007b; Pramanik et al. 2010). The sanctuary is the home to 164 species of birds (Sharma, 2007a). The geographical area of the sanctuary is 1.3 Sq. Km, of which 0.14 Sq. Km area denoted as the core area. The sanctuary is a rich hotspot of different flora and fauna (Pramanik et al. 2010) situated beside the river Kulik and interconnected with artificial canals which get water all over the year from the river (Sharma 2007b). Moreover, the river Kulik flows in a circular fashion forming the eastern and southern boundary of the sanctuary. Here the main forest type is deciduous broad-leaved forest which provides the suitable nesting environment for the birds at different heights.

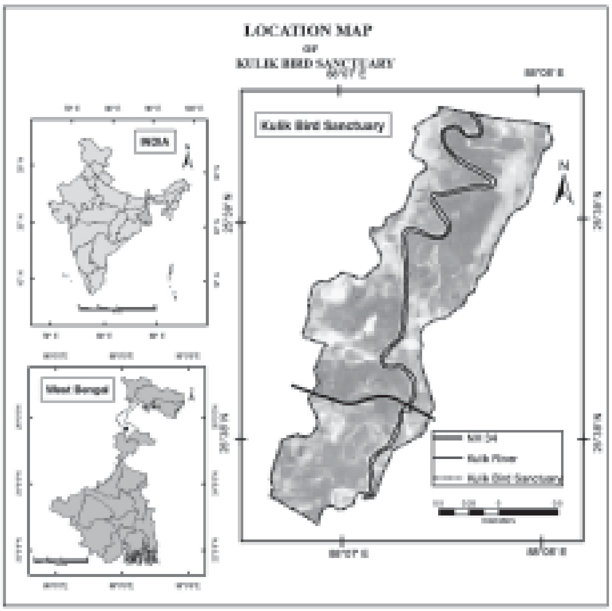

Fig: 2

OBJECTIVE

The main objective of this paper is to monitor the Habitat of seasonal migratory birds using remote sensing and GIS techniques. The primary focus of the paper is on mapping and monitoring of nesting zone, the detection of land use/land cover changes, mapping of wetland zone for birds food collection, mapping eco-park zone and determination of ban period to tourists for sustainability of the habitat.

METHODOLOGY AND DATABASE

The study conducted deals with a microhabitat, which specifically focused on migrant bird's habitat availability and habitat quality with a cautious indication of possible threats and solutions for habitat restoration. For making the conceptual framework, a vast literature has been reviewed and consulted. For monitoring purpose, a specific time scale has been selected based on the availability of high quality satellite imagery, collected from Landsat platform. Using the remote sensing and GIS techniques changes in Land use & Land-Cover Mapping, NDVI, NDWI, Tasseled Cap Transformation upon Landsat Data NDVI temporal analysis has been done.

The details of the satellite information are given in the table 2.

Image Subset

From the whole Landsat scene, an Area of Interest (AOI) has been created over the study area. Along with the AOI in ERDAS IMAGINE, the study area was subsetted from the main image. Final mapping was done by masking the shape file of the Sanctuary area.

Table 2
Details of Satellite Imageries from USGS

Satellite	*Sensor Type*	*Reference System*	*Path/Row*	*Date of Acquisition*
Landsat-5	TM	WRS-2	139/042	02/11/1989 15/04/2009 18/06/2009 24/10/2009
Landsat-7	ETM+	WRS-2	139/042	26/10/2001
Landsat-8	OLI/TIRS	WRS-2	139/042	16/06/2014 04/11/2014

Tasseled Cap Transformation

Tasseled cap transformation technique and Principle Component Analysis are widely used in remote sensing with GIS analysis. In 1976, Kauth & Thomas, from the Environmental Research Institute of Michigan first used the term "Tasseled Cap Transformation" in their article "The Tasseled Cap — A Graphic Description of the Spectral-Temporal Development of Agricultural Crops as Seen by Landsat." Here Landsat TM, Landsat ETM+, and Landsat OLI/TIRS data have been used, and the coefficient values of the different satellites are as follows:

Table: 3
TCT Coefficient for Landsat TM

Components	*B1*	*B2*	*B3*	*B4*	*B5*	*B7*
Brightness	0.3037	0.2793	0.4343	0.5585	0.5082	0.1863
Greenness	-0.2848	-0.2435	-0.5436	0.7243	0.0840	-0.1800
Wetness	0.1509	0.1793	0.3299	0.3406	-0.7112	-0.4572

Source : Crist & Cicone 1984.

Table: 4
TCT Coefficient for Landsat ETM+

Index	*Blue*	*Green*	*Red*	*NIR*	*MIR*	*MIR*
Brightness	0.3561	0.3972	0.3904	0.6966	0.2286	0.1596
Greenness	-0.3344	-0.3544	-0.4556	0.6966	-0.0242	-0.2630
Wetness	0.2626	0.2141	0.0926	0.0656	-0.7629	-0.5388

Source : Huang, Wylie, Yang, Homer, & Zylstra 2002.

Table: 5
TCT coefficient for Landsat-8

Index	*Blue*	*Green*	*Red*	*NIR*	*MIR*	*MIR*
Brightness	0.3029	0.2786	0.4733	0.5599	0.508	0.1872
Greenness	–0.2941	–0.243	–0.5424	0.7276	0.0713	–0.1608
Wetness	0.1511	0.1973	0.3283	0.3407	–0.7117	–0.4559

Source : Baig, Zhang, Shuai, & Tong, 2014.

Preparation of NDVI Map

Normalized Difference Vegetation Index (NDVI) map has been generated for the year 1989, 2001 and 2014 with the help of empirical formula for calculating NDVI. Higher the NDVI value more the vegetation. The formula used for the calculation of NDVI (Rouse et al., 1973; Weier and Herring 2000) is as follows:

NDVI= (NIR-RED) / (NIR+RED)……… (Eq. 1)

Preparation of NDWI Map

Similarly, Normalized Difference Water Index (NDWI) calculation has been done by Green and NIR band for the year of 1989, 2001 and 2014. The high value of NDWI indicates perfect water bodies or wetlands. The following formula proposed by McFeeters (1996) was used for NDWI calculation:

NDWI= (GREEN- NIR) / (GREEN+NIR)…(Eq. 2)

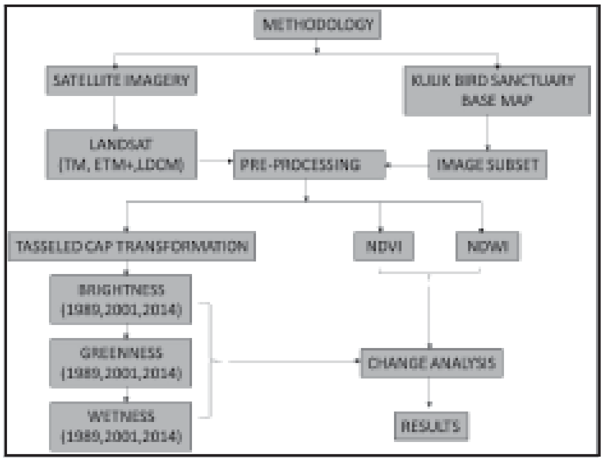

Fig : 3

DISCUSSION AND ANALYSIS

Tasseled Cap Transformation

Mainly three types of parameters have been selected such as Brightness, Greenness, and Wetness values. The threshold value has been taken as 5% increase or decrease of the total area. The obtained results are as follows:

Changes in TCT Brightness

From 1989 to 2001 Change Map (Fig. 4), it can be seen that in the 30.4% area of the total sanctuary, the brightness values has been increased. Only in the 1.33% of the total area of the sanctuary, brightness values decreased. So, during this period (1989-2001) the surface soil and build up area features has been increased in the sanctuary. Similarly, from 2001 to 2014 change map, in 67.37% of the total area of the sanctuary, TCT Brightness values has been increased. In 30.56% area of the sanctuary, brightness has been moderately decreased and in 2.07% area of the total sanctuary, brightness value has been decreased.

The obtained result indicates that there is a continuous increase of surface soil or built-up areas. It also indicates the climatic variability for seasonal dryness, bare soil for agricultural practice which gives the high value of TCT brightness. So, it can be said that the changing nature of climate and agricultural practices has been increased surface soil or built-up areas over this 25 years.

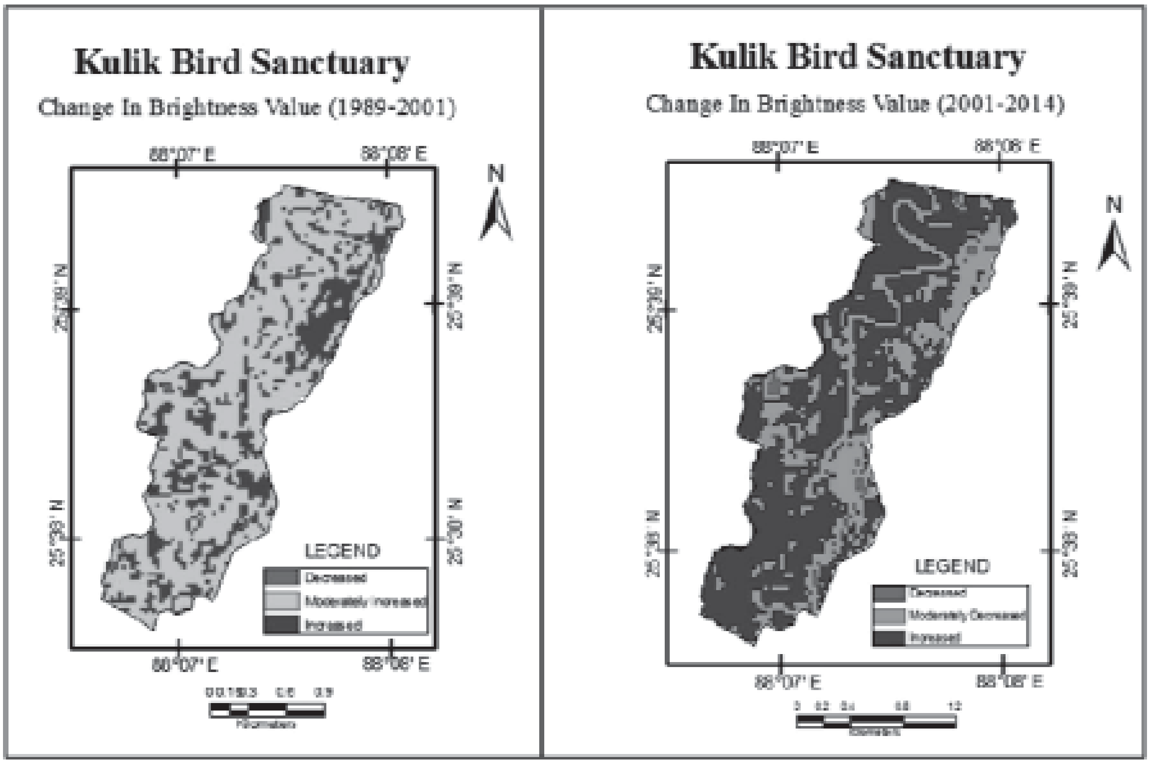

Fig: 4

Changes in TCT Greenness

Fig. 5, shows the changes in TCT greenness values. From 1989-2001, only in 0.08% of the total sanctuary area, greenness values increased and in 16.86% of the total area of the sanctuary greenness value has been decreased. In 98.48% of the total area of the sanctuary, the greenness value increased which indicates that during the last 13 years (2001-2014) the concerned authority has increased the forest coverage. Similarly, it denotes the late occurrence of the winter season. Because the forest species are mostly deciduous (Roy and Sah, 2013) in nature and high greenness value indicates the leaves not started falling yet. So, the grassland or vegetation cover over the Kulik Bird Sanctuary has been increased within the total study period (1989-2014).

Changes in TCT Wetness

Fig. 6, shows the result of TCT wetness changes. From 1989-2001, TCT Wetness value highly increased only in 1.79% of the area of the total sanctuary. Similarly, only in 2.77% area of sanctuary wetness index highly decreased. However, for the rest of 49.29% area of sanctuary wetness value moderately increased and for other 46.15% area, it has moderately decreased. In the case of 2001 to 2014, only 13.7% of the area of the sanctuary, wetness value highly increased and in 2.23% of the total area wetness value decreased. During this 13 years, 97.77% of the total sanctuary area has been experienced an increased in wetness index. That is also another indication of climatic variability or conversion of agricultural lower fallow lands into wetlands.

Another notable thing is that the areas where TCT brightness value increased and TCT greenness also increased those areas are suffering in Biomass loss. These areas can be found in the surrounding region/ peripheral region of the Kulik Bird Sanctuary. Moreover, the places where TCT brightness decreased and TCT greenness increased those areas has been re-forestation performed. Only northwestern part of the area shows these type of result.

Monitoring through Landsat NDVI

NDVI value more than 0.45 has been considered in our study as it shows the areas with healthy vegetation. For migratory birds vegetation or trees are essential factors for nesting or breeding. In our study, two types of NDVI study has been adopted, and these are as follows:

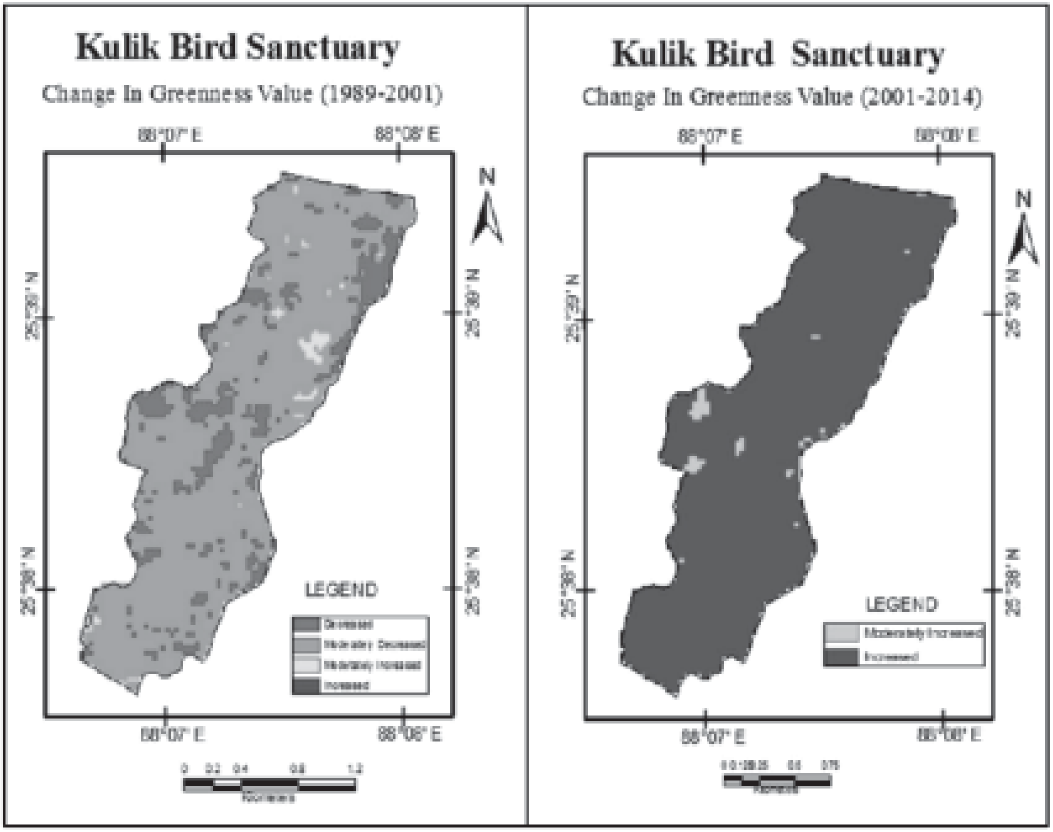
Kulik Bird Sanctuary
Change In Greenness Value (1989-2001)
88°07' E
88°08' E
25°39' N
25°38' N
N
LEGEND
Kulik Bird Sanctuary
Change In Greenness Value (2001-2014)
88°07' E
88°08' E
25°39' N
25°38' N
N
LEGEND

Fig: 5

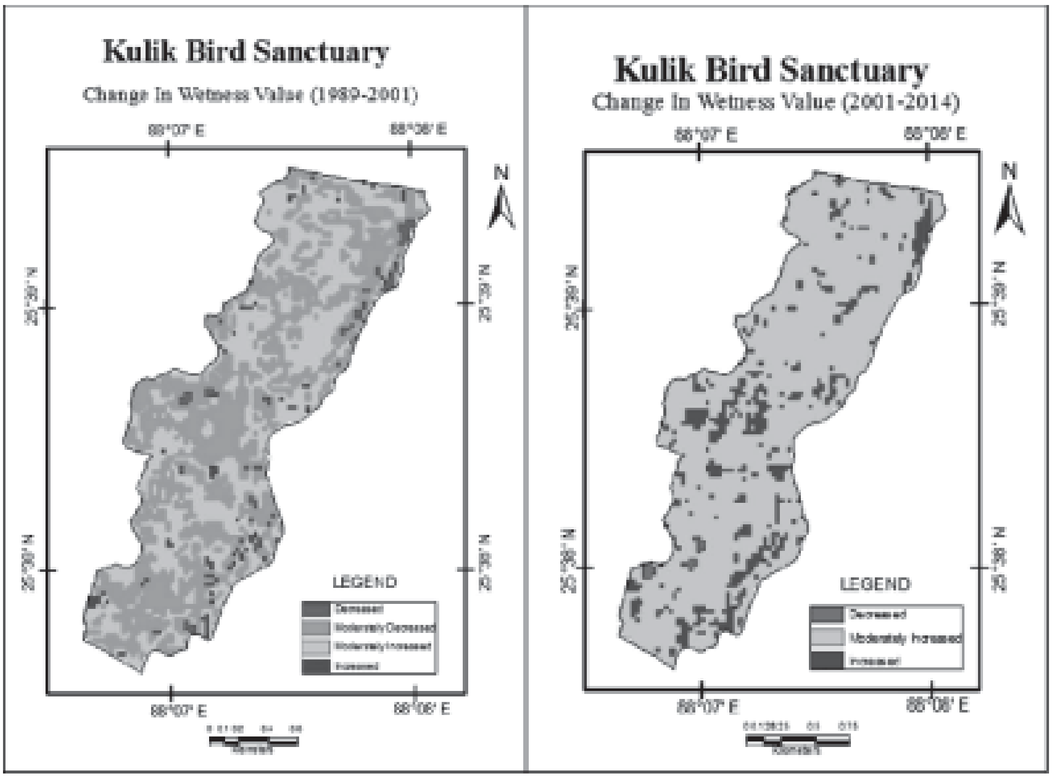
Kulik Bird Sanctuary
Change In Wetness Value (1989-2001)
88°07' E
88°08' E
25°39' N
25°38' N
N
LEGEND
Kulik Bird Sanctuary
Change In Wetness Value (2001-2014)
88°07' E
88°08' E
25°39' N
25°38' N
N
LEGEND

Fig: 6

Long Term NDVI Change

From 1989 to 2014 the NDVI changes has been studied. From 1989-2001 only a small portion of the area shows the net gain in NDVI and the major portion of the area suffering in NDVI net loss. Similarly, from 2001-2014 major portion of the area remain unchanged and nearly 30% of the area has net NDVI gain. As it was stated earlier that late coming of winter season causing the late falling of deciduous leaves, so the obtained result shows the higher NDVI value. These has been shown in fig. 7.

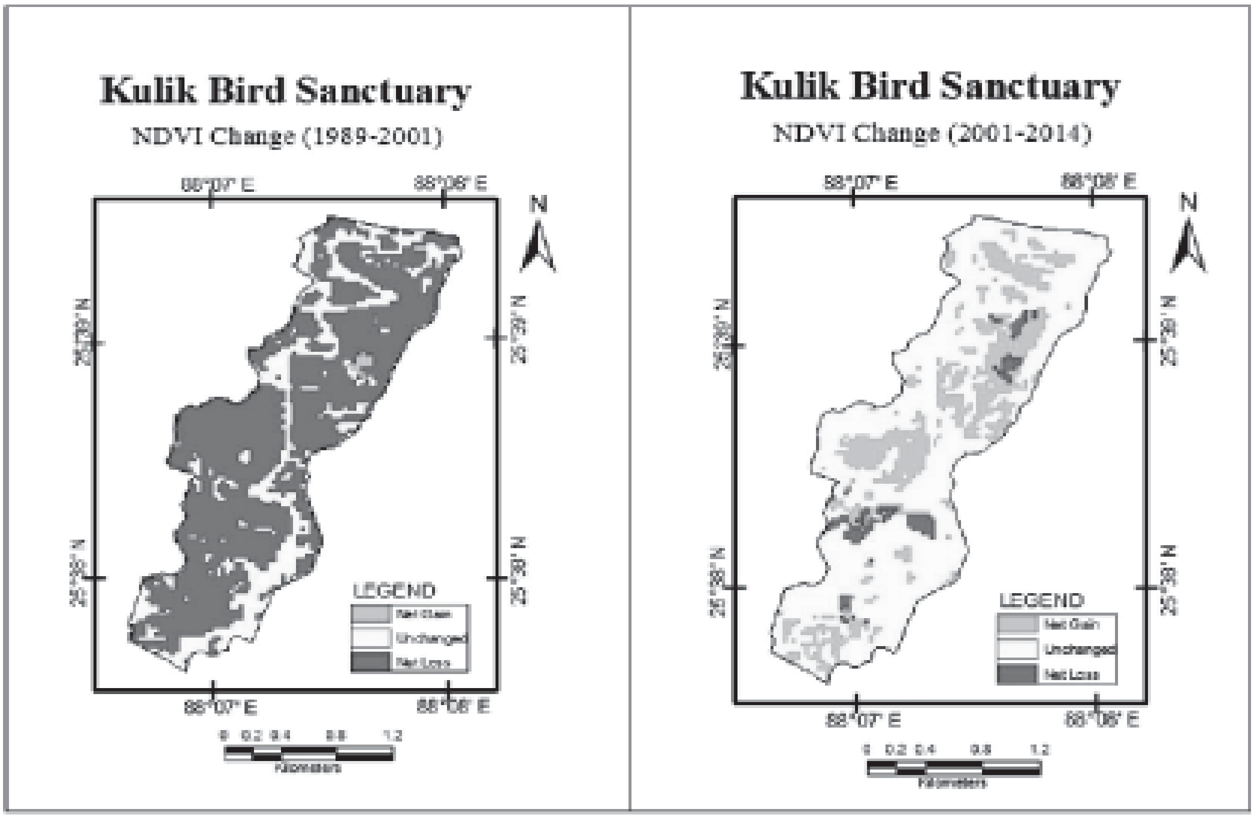

Fig: 7

Seasonal NDVI Change

For seasonal NDVI analysis, Landsat TM 2009 data of April, June, and October has been adopted as summer, rainy season and autumn month respectively. According to IMD annual report (2009), that year was very crucial because there was a deficient in rainfall over this area up to -59% during June to September month. So, in NDVI changes from Summer to rainy season month >50% of the area experienced net loss (Fig:8 and Fig:9). Oppositely, during the autumn season the whole Kulik area experienced high gain of NDVI.

Monitoring through Landsat NDWI:

A Higher value of NDWI shows more surface water or moisture content. These are very suitable for the growing of molluscs, fishes, and amphibians because these are the main food sources of the migratory birds especially Asian Open Bill Stork (Roy & Sah, 2013a, 2013b). Surrounding Kulik river area shows the high value of NDWI. Besides the lowlands, abandoned river channel and agricultural fields in the rainy season shows high NDWI values. From 2001-2014, NDWI values increased than the 1989-2001. But, if we concentrate on seasonal change of NDWI, the value is decreasing from June month to November. The possible reasons are decreasing surface water content, changes in agricultural practice, use of water for irrigation, etc. So, there must be a proper plan to restore food availability for migratory birds.

In our present study, Landsat-8 data of June 2014 has been used for mapping wetlands and agricultural fields which are mainly the food collection zone of birds (Fig.10 a). So, those features have been mapped using rainy season data which gives the best result for wetlands and associated agricultural fields like paddy or jute. The possible lowlands areas abandoned river channel, or low-lying agricultural fields were mapped (Fig: 10 b) which can be converted into the wetland to extend the current wetland zone (i.e. current food collection zone) by proper planning.

Mapping Nesting Zone

In Kulik Bird Sanctuary, most of the birds are

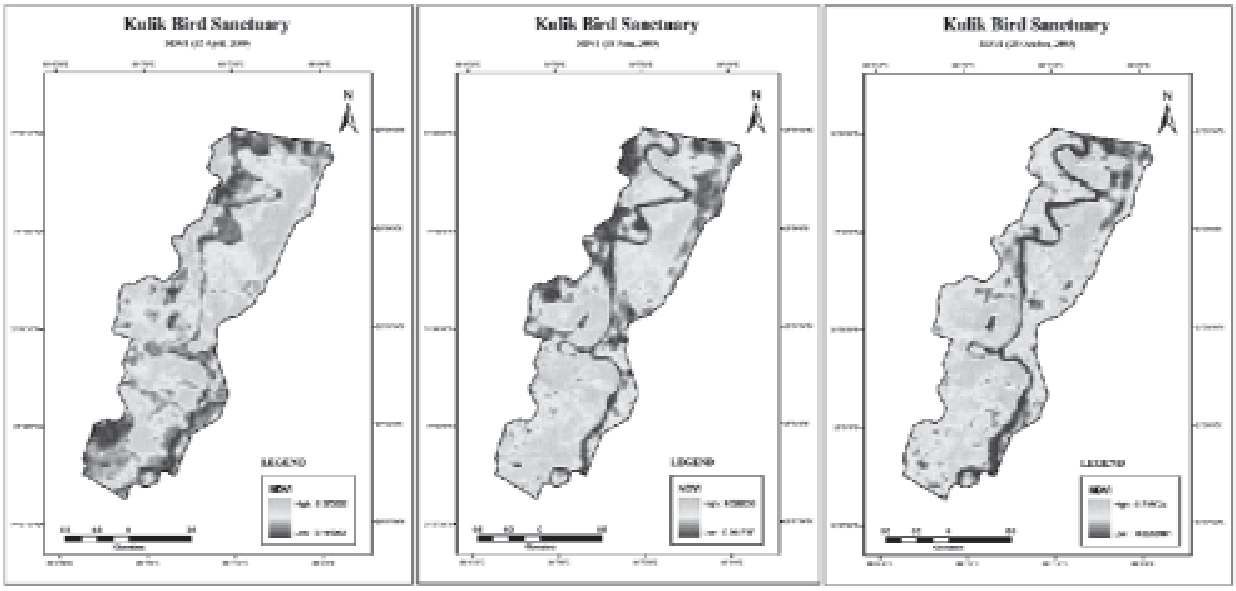

Fig: 8

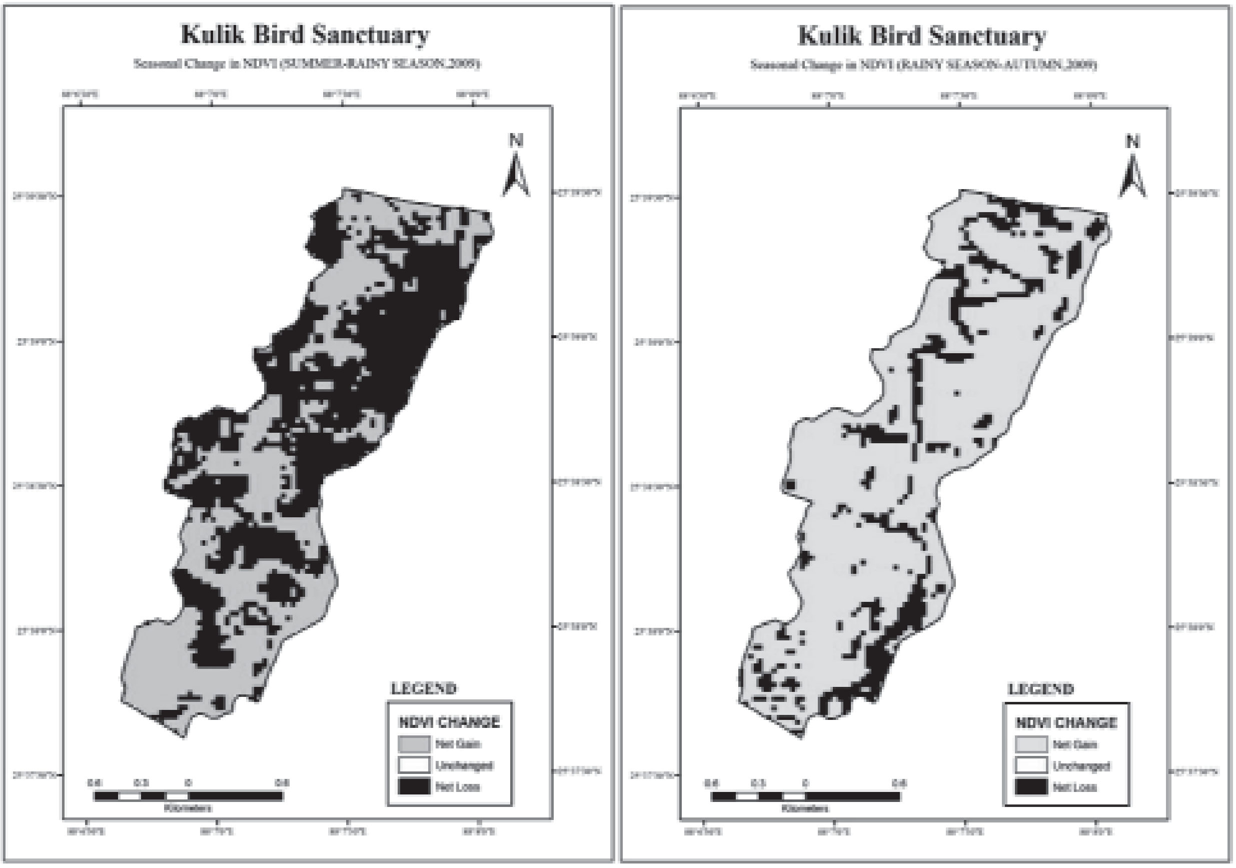

Fig: 9

migratory in nature (Das & Ghosh, 2014; Datta & Pal, 1993; Roy & Sah, 2013b). They come these place for nesting, breeding and rearing their chicks. Materials used for the nesting are dry plants, thin stalk, and dry grass or hay. They choose healthy vegetation for nesting. So, an attempt has been made to map the nesting zone of these migratory birds to proper fencing of the nesting zone for breeding success and healthy rearing of the chicks of the birds. These can be found only in the middle portion of the sanctuary area. After covering this area, the birds spread over the other parts of the sanctuary. Depending on the

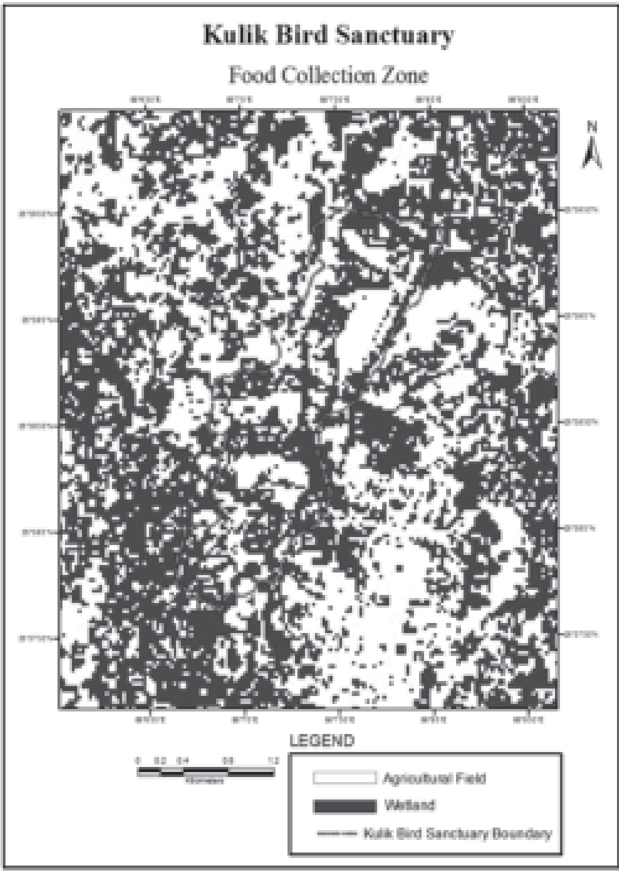

Fig: 10 a

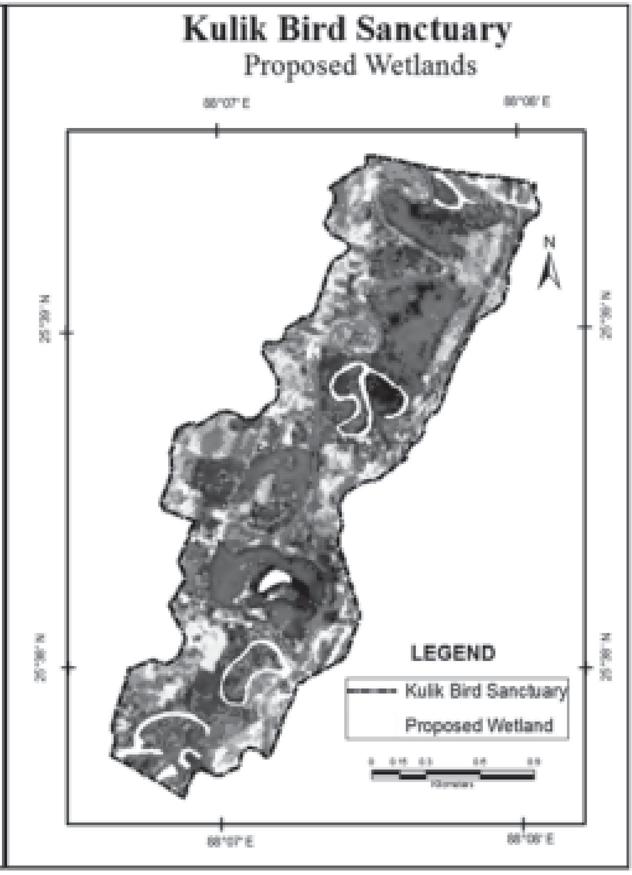

Fig: 10 b

information received from the forest department and other secondary sources, nesting zone has been mapped as fig. 11a.

Mapping Eco-Park and Picnic Spot

Kulik Bird Sanctuary is famous for its natural beauty and also as a picnic spot in vacations during the winter season. The forest department of Govt. of West Bengal has established an Eco-Park cum amusement park here. Regarding the increasing percentage tourist flow from 2002 to 2007, Kulik Bird Sanctuary stands second in North Bengal (Karmakar 2011) which may lead to its degradation in a much rapid speed. Moreover, the wastes generated by tourists/ picnickers during the peak visiting months in winter causes pollution that is harmful to birds habitat. Landsat-8 30m multispectral data with 15m panchromatic data marked and by visual interpretation these area has been mapped over False Colour Composite map. As the picnic spot is very close to nesting zone so it has been felt that there must be a "TOURIST BAN PERIOD" during the breeding and rearing period of the migratory birds. Fig. 11b shows the location of Eco-Park and picnic spot.

Mapping Vulnerability

Habitat destruction can accelerate to habitat and food loss in breeding, staging or wintering areas (Askins R. A. 2000 as quoted in Morrison M. L. 2002). In the context of the present study, Kulik Bird Sanctuary is also facing the same problem. Farmers using pesticides in their agricultural field causing disturbance for the insects, snails, and fishes which reducing the foods for birds and also polluting the water of Kulik river which may cause harm to their successful reproduction and decreasing their survival chances. Moreover increasing waste materials is also polluting Kulik river.

Thus, while monitoring a habitat, possible vulnerability mapping is also an important aspect. Here attempts have been taken to map the potential future threats for sanctuary.

From land use/land cover mapping of 2014 Landsat data, it has been seen that the Raiganj city is rapidly growing towards its periphery and also chasing towards sanctuary (Fig. 12a). Another notable thing is that there is a brickfield to the north of the sanctuary (Fig. 12b) which may cause the future problem to the habitat by increasing its area or increasing air pollution. Similarly, NH 34 is the important roadway from Kolkata to Siliguri (Fig. 12b). This National Highway (NH-34) has divided the sanctuary into two parts, and the high level of traffic noise, visual

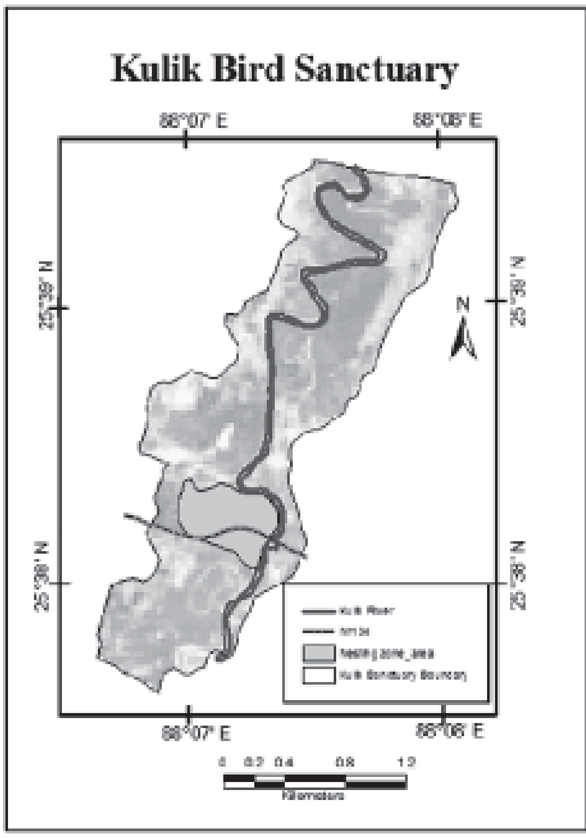

Fig: 11a

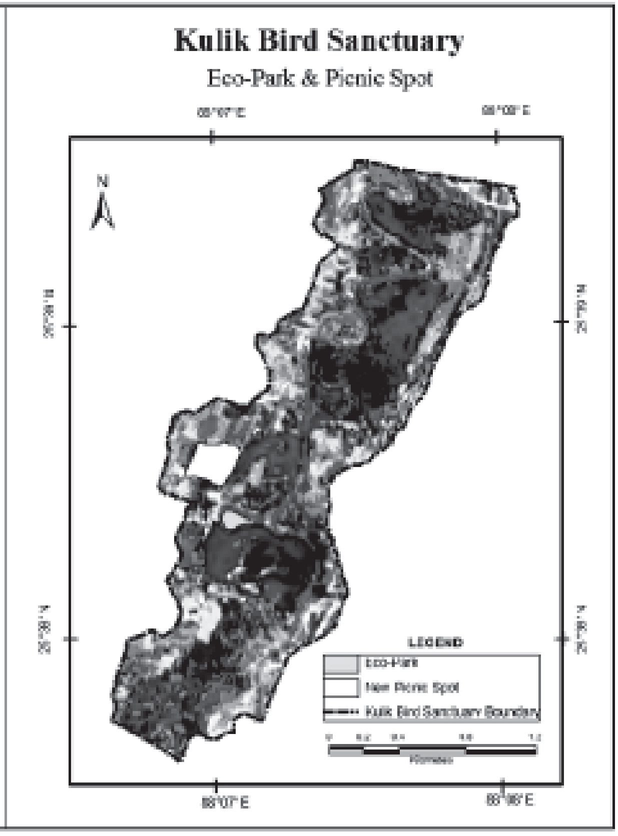

Fig: 11b

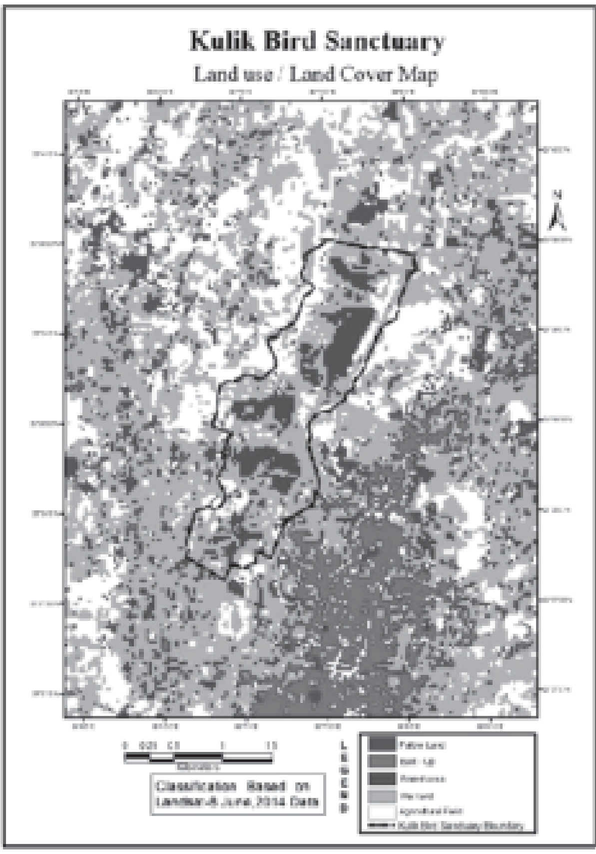

Fig: 12a

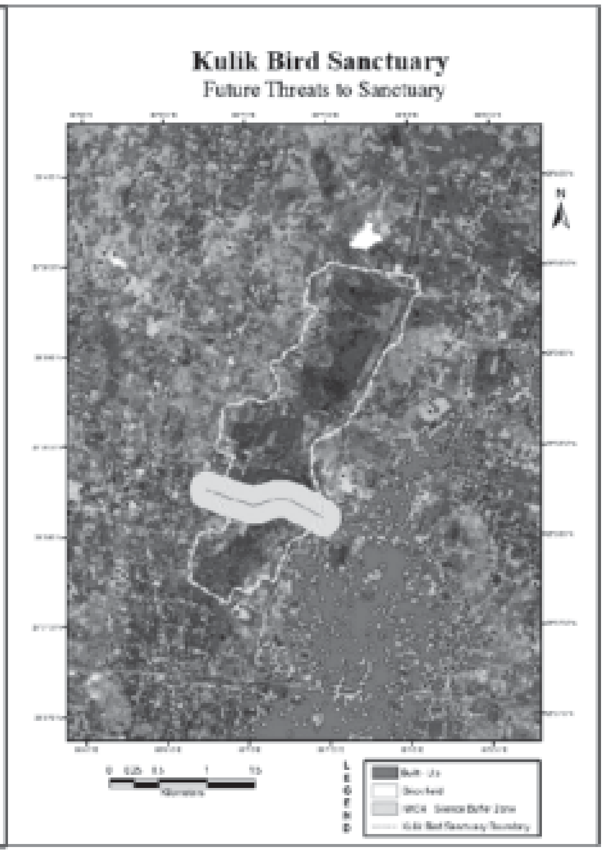

Fig: 12b

disturbance from passing vehicles and the risks of collision with cars, buses and trucks could hamper the habitat sustainability if it is not checked properly. With increasing population and urbanization, if the road width increase in future, the traffic flow with noise and air pollution will also be increased. So, for the betterment of sanctuary, any noise pollution must be avoided and an alternative bypass route for traffic flow must be made. Figure 12b shows the proposed silence buffer zone otherwise which will be a future threat to the sanctuary.

CONCLUSION

Monitoring Kulik Bird Sanctuary through remote sensing data it has been seen that vegetation health is very high during June, July month of the season and the NDVI value is >0.45 and more. This season is the rainy season here, so the vegetation health is good and also for the same reason, the migratory birds come here for nesting and breeding for next few month. There is less NDVI value during September-November month because of commencement of winter here and as most of the trees are deciduous, so the NDVI value reduces. Tasseled Cap Transformation over the area from 1989-2014 shows that there is a biomass loss around the peripheral region of the sanctuary, and only northwestern part of the sanctuary is an area which gone under reforestation. Seasonal NDWI based studies show us that grazing land of the Asian Open Stork Bill is gradually decreasing because these birds use wetlands for the collection of small fish or snail-like food. So, our study recommends increasing wetlands by converting the river abandoned channels by water and converting fallow lands into the evergreen forest so that the habitation period will be longer in this place.

It can be said that habitat monitoring depends on the various features that are all interrelated. As NH-34 passes through it and our map shows that the nesting zone coincides with the National Highway, so existing "SILENCE ZONE" must be strictly followed at least during the breeding period of the migratory birds. Another initiative which can be taken i.e. June to September months can be declared as "TOURIST BAN PERIOD" so that reproduction and rearing of the birds will no longer be hampered.

REFERENCES

1. Annual Report (2009): Indian Meteorological Department, Ministry of Earth Sciences, Government of India.
2. Block, W.M., and Brennan L.A. (1993): "The Habitat Concept in Ornithology: Theory and Applications," *Power, D.M. (Eds.) (1993): Current Ornithology, Vol. 11, Chapter 2, pp 35-81*, New York: Plenum Press.
3. Balzter,H., Rodrigues-Veiga, P., Wheeler, J., Ningthoujam, R., Nicolas-Perea,V., Tansey,K., Smith,G., Palmer, S.C.J., Stratoulias,D., Toth,V.R. (2014): Beyond Copernicus: New remote sensing approaches to habitat quality mapping and monitoring *In Pfeifer, N. and Zlinszky, A. (Ed.)(2014): Proceedings of the International Workshop on Remote Sensing and GIS for Monitoring of Habitat Quality, pp. 13,* Dept. of Geodesy and Geoinformation, Vienna University of Technology, Vienna.
4. Baig, M. H. A., Zhang, L., Shuai, T., & Tong, Q. (2014): Derivation of a Tasselled Cap Transformation based on Landsat 8 at-satellite reflectance. *Remote Sensing Letters*, Vol. *5,* No. 5, pp. 423–431. doi:10.1080/2150704X.2014.915434
5. Crist, E. P., & Cicone, R. C. (1984): A Physically-Based Transformation of Thematic Mapper Data—The TM Tasseled Cap. *IEEE Transactions on Geoscience and Remote Sensing*, Vol *GE-22,* No. 3, pp. 256–263. doi:10.1109/TGRS.1984.350619
6. Das, D., & Ghosh, P. (2014): Phytodiversity of Raiganj Wildlife Sanctuary (Kulik Bird Sanctuary) of Uttar Dinajpur District in West Bengal, India, IOSR *Journal of Environmental Science, Toxicology and Technology (IOSR-JESTFT)*Vol. 8, No. 10, pp. 79–99.
7. Datta, T., & Pal, B. C. (1993): The Effect of Human Interference on the Nesting of the Openbill Stork Anastomus oscitans at the Raiganj Wildlife Sanctuary, India, *Biological Conservation,* Vol. 64, pp. 149–154.
8. Higuchi, H. (2012): Bird Migration and the Conservation of the Global Environment, *J Ornithol, 153*. doi:10.1007/s10336-011-0768-0.
9. Huang, C., Wylie, B., Yang, L., Homer, C., & Zylstra, G. (2002): Derivation of a Tasselled Cap Transformation Based on Landsat 7 at-Satellite Reflectance. *International Journal of Remote Sensing*, Vol. *23,* No. 8, pp. 1741–1748. doi:10.1080/01431160110106113
10. Heilmeier, H., Alexander, C., Deak, B., Kania, A., Mucke, W., Schroiff, A., Szekely,B., Vari,A., Zlinszky, A., Pfeifer,N. (2014): What Remote Sensing Can Do and What Not for Habitat Mapping and Quality Assesment- Lessons from the "Changehabitats2" Project *In Pfeifer, N. and Zlinszky, A. (Ed.)(2014): Proceedings of the International Workshop on Remote Sensing and GIS for Monitoring of Habitat Quality, pp. 134,* Dept. of Geodesy and Geoinformation, Vienna University of Technology, Vienna.
11. Karmakar, M. (2011): Ecotourism And Its Impact On The Regional Economy – A Study Of North Bengal (India), *Tourismos:An International Multidisciplinary Journal of Tourism,* Vol 6, No 1, Spring, pp. 251–270.
12. Kauth, R. J., & Thomas, G. S. (1976): *The Tasselled*

Cap - A Graphic Description of the Spectral-Temporal Development of Agricultural Crops as Seen by LANDSAT. *Proceedings of the Symposium on Machine Processing of Remotely Sensed Data, West Lafayette, Indiana, U.S.A, 29 June-1 July 1976*. West Lafayette. Retrieved from http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1160&context=lars_symp on 15 oct, 2015.

13. Medcalf, K., Breyer,J., Bell, G., Robinson,P., Neal,S., Horlock,M. (2014): Monitoring and Mapping for Biodiversity Using Remote Sensing: A Case Study from Norfolk *In Pfeifer, N. and Zlinszky, A. (Ed.)(2014): Proceedings of the International Workshop on Remote Sensing and GIS for Monitoring of Habitat Quality, pp. 175,* Dept. of Geodesy and Geoinformation, Vienna University of Technology, Vienna.

14. Mairota, P., Cafarelli, B., Boccaccio, L., Leronni, V., Labadessa, R., Kosmidou, V., & Nagendra, H. (2013): Using Landscape Structure to Develop Quantitative Baselines for Protected Area Monitoring. *Ecological Indicators*, Vol. *33*, pp. 82–95. doi:10.1016/j.ecolind.2012.08.017

15. McFeeters, S.K., (1996): The use of the Normalized Difference Water Index (NDWI) in the Delineation of Open Water Features. International Journal of Remote Sens. 1996, Vol. 17, No 7, pp. 1425–1432.

16. Morrison, M. L. (2002): Wildlife Restoration Techniques for Habitat Analysis and Animal Monitoring, Society for Ecological Restoration, Washington DC: Island Press.

17. Markham, B. L. and Barker, J. L., (1986): Landsat MSS and TM Post-Calibration Dynamic Ranges, Exoatmospheric Reflectances and At-satellite Temperatures, EOSAT Landsat Technical Notes, 1: 3-8.

18. Palmer, S.C.J., Zlinszky, A., Balzter,H., Toth, V.R. (2014): Remote Sensing for Aquatic Habitat Quality Mapping and EU Water Framework Directive (EU-WFD) reporting *In Pfeifer, N. and Zlinszky, A. (Ed.)(2014): Proceedings of the International Workshop on Remote Sensing and GIS for Monitoring of Habitat Quality, pp. 35,* Dept. of Geodesy and Geoinformation, Vienna University of Technology, Vienna.

19. Parris, K. M., & Schneider, A. (2008): Impacts of Traffic Noise and Traffic Volume on Birds of Roadside Habitats. *Ecology and Society*, Vol 14, No 1, 23. Retrieved from http://www.ecologyandsociety.org/vol14/iss1/art29/ Research on 20th Oct, 2015.

20. Pramanik, A. K., Santra, K. B., & Manna, C. K. (2010): Abundance and Diversity of Plants and Animals in the Kulik Bird Sanctuary, Raiganj, West Bengal, India. *J Biodiversity*, Vol 1, No 1, pp 13–17.

21. ____(2014): Seasonal abundance and factors influencing the population of Asian Open-Billed Stork (Anastomus oscitans) in the Raiganj Wildlife Sanctuary, West Bengal, India. *Asian Journal of Conservation Biology*, Vol 3, No 1, pp 28–37.

22. Palmer, S.C.J. et al.

23. Rouse, J.W., Hass, R. H., Schell, J. A.and Deering,D. W. (1973): Monitoring Vegetation Systems in the Great Plains with ERTS, Third ERTS Symposium, NASA SP-351 I, pp 309-317.

24. Roy, P. B., & Sah, R. (2013a): Bird Watching as an Eco-Health Indicator/ : A Case Study of Kulik Wild life Sanctuary, Uttar Dinajpur District, West Bengal, India, IOSR *Journal of Environmental Science, Toxicology and Technology (IOSR-JESTFT)*Vol 4, Issue 2, pp18-23.

25. ____ (2013b): Causes of Temporal Variation in the Arrival of Asian Open Bill Stork Population/ : A Case Study of Kulik Wildlife Sanctuary, West Bengal, India, *International Research Journal of Environmental Science,* Vol 2, No 4, pp 39–43.

26. Sharma, A. (2007a): Asian Openbill-Storks Anastomus oscitans of Raiganj Bird Sanctuary, Uttar Dinajpur. *Indian Birds*, Vol *3*, No 3, pp 94-96.

27. ____ (2007b): The Asian Open-billed Stork thrives in the Kulik Bird Sanctuary. *The Statesmen*. Retrieved from http://archive.is/m1ErF on 5th Oct, 2015.

28. Weier, J. and Herring, D. (2000): Measuring Vegetation (NDVI & EVI), Features Article, NASA Earth Observatory, retrieved from URL: http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_1.php on 15th Oct, 2015.

29. Zhou, Y., Buesching, C. D., Newman, C., Kaneko, Y., Xie, Z., & Macdonald, D. W. (2013): Balancing the Benefits of Ecotourism and Development/ : The Effects of Visitor Trail-use on Mammals in a Protected Area in rapidly developing China. *Biological Conservation*, *165*, pp 18–24. doi:10.1016/j.biocon.2013.05.007

30. Zlinszky,A., Heilmeier,H., Balzter, H., Czucz,B., Pfeifer,N. (2015): Remote Sensing and GIS for Habitat Monitoring : New Approaches and Future Research, *Editorial, Remote Sensing, Vol.7, pp. 7987-7994. doi: 10.3390/rs70607987.*

AN ASSESSMENT OF POTENTIAL ECOTOURISM AREAS IN NAINITAL DISTRICT, UTTARAKHAND THROUGH GIS APPLICATION

Kalpana BHAKUNI[1]

ABSTRACT

In India, there is a proliferation of mass tourism over last few decades. This relentless effort of tourism growth has been founded on quick but short term development goals. The consequences of such unmindful strategies have unleashed long term repercussions in the resource system, particularly in the dynamic mountain systems. Ecotourism emerges as the viable alternative to promote the economic and social well being of local populace while safeguarding the natural integrity of the region.

Nainital district of Uttarakhand is endowed with high degree of natural scenic resources with a significant potential of tourism development. It is desirable that ecotourism as a nature-based form of tourism should be adopted in this hill district to attain the goals of sustainable development. In order to identify the potential ecotourism areas in the district, the GIS technique has been applied meaningfully. GIS as an information system is capable of providing the location and extents of various factors to be taken into account to identify the potential ecotourism areas. When such information are integrated through multi media tools, it provides intelligent mapping and analytical capabilities.

The potentiality of ecotourism depend on a number of natural as well as cultural factors such as, relief, altitude, slope, aspect, drainage, forests, accessibility and population. All the selected variables that are considered significant to indicate the potentiality of ecotourism, are assigned values on the basis of certain assumptions. The geospatial data base is organised in layers to facilitate the analysis of a combination of variables. Compiling all the variables and analysing them in order to generate a composite map of potential ecotourism areas is rather difficult manually. Geographic Information System has enabled it to handle several kind of information on selected variables and relate to the purpose of the study. Through the application of GIS the selected variables are evaluated and the potential areas of ecotourism are identified.

***Keywords**: Ecotourism, Natural Integrity, Mountain Systems, Geographic Information System, Analytical Capability.*

INTRODUCTION

Eco-tourism is "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (TIES, 1990). It may be further elaborated as, 'that form of tourism that involves traveling to relatively undisturbed natural areas with the specific objectives of studying, admiring and enjoying nature and its wild plants and animals as well as any existing cultural aspects, past or present, found in these areas' (Ceballos and Lascuraine, 1987). In principle, ecotourism is a nature based activity and envisaged to help in conservation of natural and cultural resources alike.

Eco-tourism in most acceptable terms referred as 'travel to undisturbed natural areas' and in this spirit it is emerging as an alternative to Mass tourism. Eco-tourism conforms to the principles of a well preserved and maintained ecosystem through low-impact visitor behaviour by those who are attracted by nature and motivated by learning and education, lowest possible consumption of non-renewable resources and active involvement of the local people (Fennell, D.A. 2001). Some people regard ecotourism as inclusive tourism which focuses upon social values, community development, social responsibility and conservation of nature (Weaver, D.B. and Lawton L.J.,2007).

Ecotourism as an alternative tourism has been evoked by the planners and developers but on the ground reality its conceptualisation and implementation remain quite vague. Many times it seems that ecotourism shares a content with adventure tourism or nature tourism because of their common ground of natural settings, but the fact remains that it is certainly different from mass tourism and emerging as an alternative to it in certain way (Fennell, D. 2003).

It was suggested in 2004 that ecotourism or nature tourism was growing three times faster globally than the tourism industry as a whole (WTO 2004, cited in TIES 2006). The reasons of such a trend could be attributed to the adverse effects of mass scale tourism, rise of special interest tourism, aversion to typically overcrowded destinations or simply a yearning to be close to nature. Mass tourism has inflicted unprecedented and irreparable damage to the Himalayan region in last two decades. The deforestation at alarming rate, indiscriminate construction of roads and buildings, heavy vehicular

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movements and huge inorganic wastes, all these have put a degenerative pressure on the sensitive mountain system (Madhava Ashish, 1979).

Eco-tourism segment of tourism may emerge as the most viable option in such ecologically sensitive areas that can thrive best if the nature – culture synergy is maintained within their system. In other words, it is the ecological base, consisting of the ingredients of nature and human, which provides the ground to tourism development in any natural area. This equation becomes much more significant when the nature/people assume a special value by virtue of uniqueness of their natural environment. For instance, in a mountain system like the Himalayas where the natural scenery reigns supreme, instead of mass tourism, nature-based tourism is the most viable development option for stimulating eco-friendly development that contribute to local welfare. However, ecotourism is not all about randomly carrying out activities like camping, biking, nature walks etc. It needs to be planned systematically first of all by identifying the areas with potentiality of ecotourism and prepare an inventory of such potential areas. The areas with highest potential need to be worked upon first in the order of priority. Such areas should be evolved strategically, where there should be synergy of ecotourism resources as well as visitation of tourists.

This paper attempts to identify the potential eco-tourism areas in the hill district of Nainital using GIS techniques. This work undertakes to identify the potential eco-tourism areas in each Block of the district through the application of a suitable GIS module. Such application would require the multi layering of topography, aspect, slope, land use, forest resources, water resources, roads etc. In a generic sense, GIS applications are tools that allow users to create interactive queries, analyze spatial information, edit data, maps, and present the results of all these operations.

In the present study GIS is used as a technique to identify the potential eco-tourism areas in Nainital District. The use of GIS is far more effective in terms of time, location and resources than any manual procedure or field survey. Though the earlier topographical surveys are of much significance that are used in digitisation of this work.

The area under consideration of this study is Nainital district in Uttarakhand, which has two distinct administrative divisions- Kumaon and Garhwal. Nainital is one of the thirteen districts of Uttarakhand lying in Kumaon division. To its north is Almora distict and to its south lies Udham Singh Nagar district. Champawat distict flanks it in the east and district of Pauri Garhwal is in the west.It is located approximately between 80o.14'and 78o 80' East longitudes and 29o 00' and 29o 05' North latitudes. It lies mainly in the Outer Himalayan zone. Geographically, Nainital district lies in two zones-Hilly part and Bhabhar. The area under Nainital district is 6794 sq km. which is third highest after Chamoli and Pithoragarh.

Nainital is popularly known as the 'lake district' of Uttarakhand, which has a number of natural lakes of big and small dimensions, such as Nainital, Bhimtal, Saat tal, Naukuchiatal, Khurpatal, Harishtal, Malwatal etc. Some of them have become obscured with time. Kosi is the main river flowing through this district besides Ramganga featuring in its lower margins. Administratively, there are eight tehsils/ blocks, namely, Ramnagar, Kotabagh, Bhimtal, Haldwani, Okhalkanda, Dhari, Ramgarh and Betalghat.

The identification of the potential ecotourism through GIS based approach worked with the natural elements such as relief, altitude, aspect, panorama, water bodies, forest, vegetation etc. and cultural elements like the historical monuments, old temples, folk traditions, fairs and festivals etc. Apart from presence of these features, accessibility and population are regarded other important criteria.

It is to be noted that in the present study to identify the potential ecotourism areas, two well established tourism areas are not included, namely, Nainital town around the focal point of Naini lake and Jim Corbett National Park area in Ramnagar Block. Haldwani block/ tehsil also plays a restricted role in the potential ecotourism due to its commercial and industrial character primarily.

RELEVANCE OF SELECTED INDICATORS IN IDENTIFICATION OF ECOTOURISM AREAS

The identification of potential ecotourism areas in a hill region like Nainital is based on a set of indicators such as-

1. Relief poses as an expression of landscape that exhilarates the aesthetic sense of the travellers.
2. Altitude is yet another factor that excites the tourists to scale the heights of the folds of mountains. The high points of the region are much sought after for their panoramic scenic values.
3. Slope is important in hilly terrain where the gradient controls the land use as well as the accessibility.
4. Aspect bears the factors of duration of sunshine hours and density of vegetation.
5. The water elements in the hills are great attraction for eco-tourists. The mountain rivers, waterfalls, natural springs, lakes are most

effective in drawing the tourists by their natural charms.

6. Apart from the natural features, that are the prime attractions for tourist, cultural and historical features also hold significance. These include pilgrim centres, archaeological sites, museums, forts and others. It also includes fair and festivals where the cultural heritage of folk, music, cuisine, dress and lifestyles.
7. Other than the natural and cultural richness of the region, accessibility emerges as a major factor for the development of ecotourism at any site. Though the region has to be unique and exclusive but it should also be approachable from the nearby town or state. Inaccessibility is taken as a hindrance to the development of a potential site for ecotourism.
8. The density of population is an indicator of human resource available in the region. It is an important pre-requisite of the development of ecotourism, as the local population provide necessary services to the visitors.

ASSUMPTIONS FOR ASSESSMENT OF ECOTOURISM POTENTIAL

The selective variables, which are considered significant to indicate the potentiality of ecotourism, carry assigned values on the basis of certain assumptions (Bhakuni, Kalpana, 1988, 1999). These assumptions are mostly based on a perception study carried out in this hill region of the Himalayas. The study related to the aesthetics of various features in the natural scenery of Kumaon Himalayas. Besides the aesthetic matter the deep understanding of mountains as a first-hand experience of the researchers, has also contributed significantly to form such assumptions.

The values are allocated on the ordinal scale of 1-5, in ascending order for each variable, which are positively related to the degree of potential.

Relief

Relief in the mountain landscape is of much interest for the viewers. The exciting heights and serene lows hold great appeal to the travellers. In fact, if one has to experience mountains he has to be there at such a level from where the vista offers an interplay of folds in the visual field.

S. No.	*Height in meters*	*Category of relief*	*Assigned value*
I	1640-2120	High relief	5
II	1160-1640	Medium relief	4
III	680-1160	Low relief	3
IV	2120-2600	Very high relief	2
V	200- 680	Very low relief	1

When it comes to the value assignment, the highest value is given to category of High relief (1640-2120 mts), as the eco-tourists would prefer to visit High relief areas when it comes to experience the mountain region. This category is mostly accessible by metalled roads and many tourist sites fall in this category in Nainital district. Subsequently, the categories of Medium relief (1160-1640 mts) and Low relief (680-1160 mts) are assigned the 4 and 3 values respectively. The category of Very High relief gets value 2, by virtue of its inaccessibility and difficult terrain. Though a small number of adventure tourists choose this category for adventure such as mountaineering and trekking. The Very Low relief category has been assigned the lowest value on the scale because it is the downstream areas of rivers devoid of much natural charms.

Aspect

Aspect is a very important factor in the mountains. Various aspects are projected due to pronounced three dimensions of the mountain landscape. Some aspects are generally more preferable than others by all, whether locals or visitors because of certain considerations of micro climatic bearings. This is evident by the pattern of settlements by the local populace. There are invariably very scanty settlements found on the northern aspects of the hills.

S.no	*Category of aspect*	*Assigned value*
I	South facing	5
II	East facing	4
III	West facing	3
IV	North facing	2
V	Flat terrain	1

The highest value of 5 is accorded to the South facing aspect. The South facing aspect is valued most because of the longest sunshine hours. Sunshine is a very important factor so far aspect of a place is concerned in the hills. The subsequent category of 4 for East facing aspect is also preferable with the factor of sunrise and morning sunshine hours, followed by West facing aspect with the advantage of 'sunset points' and sunshine warmth in the latter half of the day. The North facing aspect is generally steep and cold in the hill region. They are characterized by the shadow areas in the hills, therefore it has been assigned a low value of 2. The flat terrain has been given the lowest value of 1, in regard to the aspect.

Slope

The slope is a vital physical factor of hill terrain. Slopes are important to indicate the suitability from point of view of land use and accessibility. Steep gradient of slope may be desirable in a very restricted sense of adventure, but generally the risk factor undermines its value for tourism. Steep gradient of slope is also not feasible for transportation in tourism system.

S.no.	*Degree of slope*	*Type of slope*	*Assigned value*
I	25-35	Moderate	5
II	15-25	Low	4
III	35-45	High	3
IV	> 45	Very low	2
V	< 15	Very high	1

So far the feasibility of tourism is concerned the Moderate slopes are preferable with the highest assigned value of 5, followed by Low slopes with gentle topographic expressions with value 4. Though High slopes are also preferred but only in a lesser extent and selective purposes. The areas with Very low slopes are given less value such as near flat terrain of downstream 'terai' areas, whereas the Very high slopes are given the lowest value in the scale of assigned values due to its unsuitability for human use.

Water Element

Water element naturally draws the viewers toward its visual dynamism, fluidity and reflections. It holds some emotional appeal to those who philosophically equate it with flow of life. In one such perception study related to this region, it was found that water element carried the maximum aesthetic value among the scenic resources (Bhakuni, Kalpana, 1999). Water element is sought after by the eco-tourist for various water related activities. There is a significantly high incidence of natural lakes in the selected area of this study.

S.no.	*Type of water element*	*Assigned value*
I	lakes	5
II	waterfalls	4
III	rivers	3
IV	springs	2
V	reservoir	1

The highest value of 5 is assigned to the lakes, which are most sought after in the natural landscape, followed by waterfalls with the value of 4 as they hold fairly high aesthetic charm in natural scenery. Nainital district is well known for its natural lakes. Even Britishers, who had a refined sense of landscape aesthetics, sought after the locales in the close vicinity of such lakes in erstwhile days. The incidence of waterfall not significantly high in the Nainital district. The rivers are also not more frequent in their occurrence here, with the value of 3. The natural springs do not bear much visual character here, therefore they score less value of 2. The reservoir as a manmade water feature bears the lowest value for the purpose of ecotourism.

Land Use

Land use prevailing at a given place has strong relation with the potential of ecotourism. Since ecotourism is conducive to natural or cultural elements, it may thrive well with a natural or a cultural landuse. Paul and Sudhakar, in one such work with GIS approach in Midnapur district, West Bengal, regarded land use such as dense forests, highly important for ecotourism, which could be developed as wilderness areas. Open forests or degraded forest also hold significance in the terms of ecotourism development and plantation areas as floral regions etc.

Forest land use is much desired by eco-tourists or nature lovers for long walks, hiking, bird watching, camping etc. Though high density and low density forests have different implications presumably. Other land use as farming or cultivation are also suitable for ecotourism as it offers a glimpse of the way of living of the local people. Though barren land may not be of much aesthetic value but it may be useful for other infrastructural purposes of ecotourism.

S.no.	*Type of land use*	*Assigned value*
I	High density forest	5
II	Low density forest	4
III	Cultivation/ Farming	3
IV	Barren/ fallow	2
V	Industrial land	1

The character of the high density forest is most suitable for eco-tourism, therefore the value of 5 is assigned to it, followed by low density forest with value 4. Though the agriculture land is not directly related to ecotourism but as a part of the indigenous culture and lifestyle of the locals it has some value therefore value 3 is given to it. The barren/ fallow land is given a low value of 2. The industrial land use has the lowest value so far ecotourism is concerned.

The values which are assigned and processed through the application of GIS technique with above mentioned factors, should be supplemented with the other values for cultural landmarks, prominent fairs and festivals etc. to understand the ecotourism potential comprehensively.

Now, the factors of accessibility and population are brought in, with the view to prioritise those eco-tourism potential areas which can be accessed by the eco-tourists, and also hosted by the locals to fulfil the objectives of enjoyment of natural areas and socio-economic benefits to the local communities.

A. Accessibility

B. Population

A. Accessibility

Those potential ecotourism areas which are easily accessible by metalled roads at present should be taken up first for the development and management of ecotourism in the hill district of Nainital. The roads in the selected district are mainly PWD roads, forest roads and panchayat roads. The network of roads in this hill district is reasonably high.

The query of buffer zone of the metalled road is applied on the map of the selected area. There are three categories of buffer zones; 1000-1500 metres, 500-1000 metres and less than 500 metres. Considering the highly uneven topography of this district the buffer zone with villages in less than 500 metres on both sides of the roads are taken into account on priority for the purpose of development of ecotourism.

B. Population

The density of population is an indicator of human resource available at a given place to play the role of the host community within the framework of ecotourism. Any natural area endowed with natural beauty but devoid of human inhabitants can not be a part of tourism industry. Tourism as a driver of economic development of any region has to encompass the local population factor, as stakeholder as well as beneficiary, otherwise it would remain as an individual endeavour. More so, there is need to have some inhabitants to provide services to the visitors or eco-tourists.

THE POTENTIAL AREAS FOR ECOTOURISM

On the basis of the assigned values of the selected five variables, namely, relief, aspect, slope, water element and land use, a composite map is generated showing the potential eco tourism areas in Nainital district. As a net result of applying the GIS technique through multi-layering of the selective variables the final picture emerges which presents the potential ecotourism areas in Nainital district. These areas are identified into five categories on ordinal scale such as, 1. least potential, 2. low potential, 3. moderately potential, 4. highly potential and 5. very highly potential.

Thus, in the present study the layering, classification, querying and buffering – all the important functions of GIS are meaningfully applied to identify the potential ecotourism areas in Nainital district.

The conservative outlook may have serious apprehensions in opening such natural areas to modern development but protection of such regions by resisting the development forces may not be the answer; rather a development process with appropriate measures should be adopted, which stimulates the growth and diversification, and at the same time maintain its natural integrity.

REFERENCES

1. Atlas-Uttaranchal (2001) Census of India, Directorate of Census Operations, Uttar Pradesh and Uttaranchal.
2. Bhakuni, Kalpana (1988), "Identification and Development of Potential Scenic Sites in Pithoragarh District, Kumaon Himalayas", Unpublished M. Phil dissertation, University of Delhi.
3. Bhakuni, Kalpana (1999), "Identification of Potential Scenic Resources in Kumaon Himalayas", Unpublished Ph.D dissertation, University of Delhi.
4. Bisht, D.S 1982, Guide to Garhwal and Kumaun Hills (Uttarakhand hill region of Uttar Pradesh), Trishul Publication, Dehradun.
5. Blamey, R.K. (1997). Ecotourism: The Search for An Operational Definition. Journal of Sustainable Tourism 5(2): 109–130.
6. Boo, E. (1990). Ecotourism: The Potentials and Pitfalls, Vol. 1. World Wildlife Fund, Washington, DC.
7. Boyd, S.W., Butler, R.W., Haider, W. and Perera, A. (1995). Identifying Areas for Ecotourism in Northern Ontario: Application of a Geographical Information Systems Methodology. Journal of Applied Recreation Research 19 (1): 41–66.
8. Ceballos-Lascurain, H. (1987). The Future of 'Ecotourism'. Mexico Journal, p- 13.
9. David McAdam (1999) The Value and Scope of Geographical Information Systems in Tourism Management, Journal of Sustainable Tourism Vol. 7, No. 1, 1999.
10. Daniel Longmatey, Samuel Amoako-Atta, and Benjamin K. Prah, Management and Promotion of Tourism in Ghana: A GIS Approach, Retrieved from http://proceedings.esri.com/library/userconf/proc04/docs/pap1912.pdf.
11. Diamantis, D. (1999) The Concept of Ecotourism: Evolution and Trends, Current Issues in Tourism Vol. 2, No. 2&3.
12. Fennell, D.A. (2001). A Content Analysis of Ecotourism Definitions. Current Issues in Tourism 4(5): 403–421.

13. Fennell, D. 2003, Ecotourism: An introduction, 2nd Edition, Routlege, London.
14. Hall, C.M. and Boyd, S. (2003). Ecotourism in Peripheral Areas. Channel View Publications, Clevedon, UK.
15. Hinch, T. (1998). Ecotourists and Indigenous Hosts: Diverging Views on their Relationship with Nature. Current Issues in Tourism 1(1): 120–124.
16. Joshi, S.C, Joshi, D.R and D.D Dani 1983, Kumaun Himalaya: A Geographical Perspective on Resource Development, Gyanodaya Publication, Nainital.
17. Kushwaha Avantika, Debanjana Chatterjee and Prerna Mandal, "Potentials of GIS in Tourism and Heritage", Retrieved from www.geospatialworldforum.org/2011.
18. Lück, M. (2002) Large-scale Ecotourism – A Contradiction in Itself ?, Current Issues in Tourism Vol. 5, Nos 3&4, 2002, pp. 361-370.
19. Madhav Ashish, 1979 "Agricultural Economy of Kumaon Hills: Threat of Ecological Disaster", Economic and Political Weekly, 14 (25), p. 1058.
20. Negi, S.S 1993, Kumaun: The Land and People, Indus Publishing Company, New Delhi.
21. Pathania, K.S and Arun Kumar (2008) Ecotourism, Regal Publications, New Delhi.
22. Paul, S.K. and Sudhakar, R.C. 'Remote Sensing and GIS based Ecotourism Planning: A Case Study for Western Midnapur, West Bengal, India', Retrieved from http://www.gisdevelopment.net/application/miscellaneous/misc028.html.
23. Pearce, D.G. (1994). Alternative Tourism: Concepts, Classifications and Questions. In Smith, V. and Eadington, W. (eds) Tourism Alternatives. Potential and Problems in the Development of Tourism. John Wiley & Sons, Chichester, UK, pp. 15–30.
24. Ryan, C., Hughes, K. and Chirgwin, S. (2000). The Gaze, Spectacle and Ecotourism. Annals of Tourism Research 27(1): 148–163.
25. Siddiqui,S. (2000) Eco-friendly Tourism in U.P Himalayas, B.R Publishing Corporation, Delhi.
26. The Atlas of Uttaranchal (2003) NATMO, Kolkata.
27. The International Ecotourism Society TIES, 2006, Fact Sheet: Global Ecotourism. Retrieved from http://www.box.net/shared/static.
28. Weaver, D. (2002) Asian Ecotourism: Patterns and Themes, Tourism Geographies, Tourism Geographies 4 (2), 2002, 153–172, pp 153-172, Retrieved from http://www.tandf.co.uk/journals.
29. *Weaver D.B.*, L.J. *Lawton* / Tourism Management 28 (*2007*) 1168–1179. 1169. Page 3.

ROLE OF CARTOGRAPHIC TECHNIQUES AND INDUSTRIAL DEVELOPMENT : A CASE STUDY OF RAJASTHAN TOURISM

Pinku SUTHAR[1]

ABSTRACT

Cartography is the Science, Technique and art of making and using Maps. graphic methods used on maps to show the spatial arrangement of phenomena and their combinations, relationships, and development. The Industrial Developments in Rajasthan is growing at fast pace as Under:- Handicraft, Textile, Stone, Stainless Steel Sheets, Stainless Steel Utensils, Guar Gum, Mineral – based, Cement, Solar Plants & Wind Energy, Offshore crude Oil, Foundry, Bearing component, Engineering, Plastic, Packaging, Paint, Electronics and Telecommunications, Software, Automobiles and components, Footwear and leather goods, Cement, glass and ceramics, Agro Industries and general Industries which serve to all the major Industries and markets all over the country and abroad are situated all over the state of Rajasthan, But Rajasthan is famous for Tourism and Hotel Industry.

This article particularly focuses on tourist maps. Their defining is a relatively difficult task, because a definition can adopt various criteria. The most important criterion, namely content of the map, suggests that a tourist map is a cartographic product with thematic content including information necessary for the tourist to plan and execute travel. The division of tourist map is also disputable, considering various criteria. The development of various forms of tourism is accompanied by specialised maps useful for their practice. Considering their content, tourist maps can be divided into three groups: General tourist maps, Specialised tourist maps and Thematic tourist maps.

Keywords: *Cartographic techniques, Industrial development, Tourist, Travels, Hotels, Places of interest.*

INTRODUCTION

Cartographic methods used on maps to show the spatial arrangement of phenomena and their combinations, relationships, and development. A special system of characters—the cartographic symbols, which are summarized and systematized in a relatively small number of cartographic methods of presentation—is used in cartography for this purpose. The primary methods include those of signs, line symbols, isoclines, and the qualitative background; angle diagrams; the point method; area patterns; signs of motion; and collation and choropleth maps. Before the dawn of Independence, there were only seven cotton mills, two cement factories and two sugar mills in the Rajasthan. In 1951, there were 103 registered factories with capital worth Rs. nine corer and 18,000 people employed in these factories. According to the data available for the year 1992-93 the number of factories has increased to 3,958 with 2.61 lakh people employed in them. However, subsequent governments in the State have framed such industrial policies so as to encourage industrial activities. The thrust areas identified in view of the inherent strength, their growth potential and long term sustainability are - Garments and Knitwear, Gems & Jewellery, Textiles, Electronics and Telecommunications, Software Automobiles and components, Footwear and leather goods, Cement, glass and ceramics, and Agro processing. But Rajasthan is famous for Tourism & Hotel Industry. The integration of maps plays an important role in tourism. Travel companies and customers are equally interested in reliable and detailed maps, whether on water, land or air tour operators must be able to offer their customers an accurate representation of resorts or hotels. Detailed maps for travel guides, city maps or wall maps must be drawn manually in precision work. Tourist maps are essential resources for tourists to an unfamiliar city because they visually highlight landmarks and other points of interest such as museums, restaurants, parks, and shopping districts. The most effective tourist maps are carefully designed to present this information so that they can easily navigate to the places they are most interested.

OBJECTIVES

The aim of the authoress is to provide practical suggestions for the development of cartographic techniques and analyse the tourism industry and their impacts, which would optimally predict the integrated development of tourism in the study area.

METHODOLOGY

In this research paper secondary data used to prepare graph and maps is collected from government and non-government departments and organisations, magazines, journals, newspapers and statistical analysis is used as per requirement wherever necessary.

STUDY AREA

Rajasthan, due to its rich historical, cultural and

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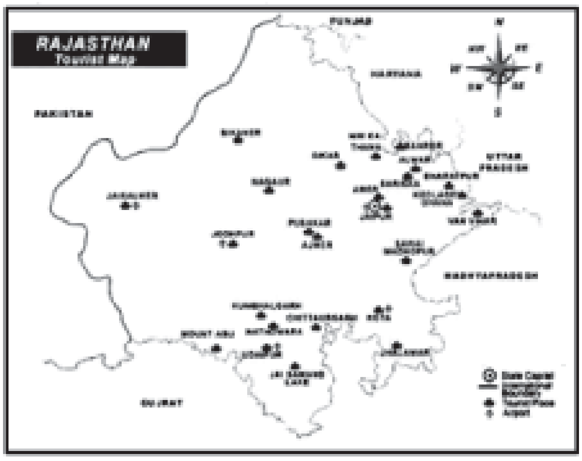
environmental heritage, coupled with various fairs and festivals has become a favourite destination for tourists from all over the world. The scarcity of water, lack of industries and an underdeveloped backward economy are the characteristic features of this area. But since past two decades tourist arrival and the development of tourist industry in these regions has become a major source of income for the native people.

Keeping this in view, Government of Rajasthan granted status of the industry to tourism sector in 1989, therefore, all the facilities and concessions available to industries in the State also available to tourism units. First 'Tourism Policy of Rajasthan' was announced by State Government in 2001, which was designed to ensure optimum utilisation of rich tourism resources of the State to generate employment specially in rural areas, to develop already market for the rich and varied handicrafts, to preserve and to accelerate contribution of tourism industry in socio-economic development of the State by making tourism a truly People's Industry in Rajasthan. It is situated at the north-western part of India is the biggest state in the country of India and lies between 23°3´ to 30°12´ North latitude and 69°30´ to 78°17´ East longitude occupying 10.45 percent of land in the north western part of India covering 1070 kilometre of international and 4850 kilometre of interstate boundary. (Fig. 1.)



Source :www.rajasthantourism.in

Fig. 1. Study Area

ROLE OF CARTOGRAPHIC TECHNIQUES IN RAJASTHAN TOURISM

Geographers study the spatial expression of tourism as a human activity, focusing on tourist generating and tourist receiving areas. The study can incorporate a variety of scales, climate, tourist recourses to local landscape, resorts etc. From the geographical point of view, tourism has three main components-

1. The tourist from one country to another country is known as generating areas.
2. The destination area of tourist receiving countries or region or local areas.
3. The route travelled between respective destinations
4. Modern tourism cartography has deep roots. Its sources and development are connected with the necessity of supporting travels and geographical research (discoveries). It was ancient travellers (navigators, merchants, pilgrims collecting data on new lands and peoples) who made the first descriptions and maps, a basis for new travels and scientific studies of territories in terms of geology, ethnography, biology, etc. Therefore postal service (road) maps, travel route maps, maps of regional geographic character; city, palace, monastery complex plans, et cetera are considered to be tourist map prototypes. Refer Fig. 2.

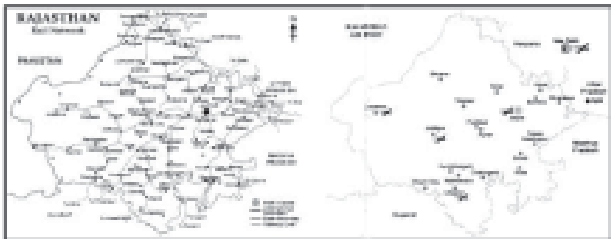


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Fig. 2 Communication lines

Tourist information presented by various producers on modern maps and in atlases of different countries and regions is uniform enough. It focuses, as a rule, on the groups of objects representing:

a. Communication lines (airports, roads, transport infrastructure);

b. Tourist service (hotels, motels, restaurants, post offices, banks, etc.);

c. Official buildings, international organizations;

d. Notable places, cultural and education centres (monuments, museums, theatres, parks, exhibitions, etc.), without any systematization or strict approaches to their depicting.

Distinctions in map contents are seen only due to the level of the development of the general territory infrastructure, that of the knowledge and popularity of objects of cultural and historical heritage, other places of interest, special features of particular tourism kinds connected with natural and national regional peculiarities. Rajasthan is presented with tourist load on numerous atlases of motorways.

Historically developed tendencies and national features can be traced in road displaying. Peculiarities are expressed through developed road classifications, ways of their depicting. It is sometimes difficult to make a differentiation between maps close in their themes like road maps with some information for tourists and tourism maps with information on roads. Topographic maps have been often used as a geographic basis for tourist maps, especially in recent years, which promotes, on the one hand, their high accuracy and partial unification, but levels down contents specialization and graphic means. Tourist maps are too approximated to their basis. In a considerable number of the tourist maps and atlases analyzed, we could not encounter any logical and consecutive display of natural and cultural heritage objects. Maps of the recreational potential of landscapes, maps of the degree of usefulness (comfort) of territories for tourism by various conditions – climatic, medical-and-geographic, sanitary-and-hygienic ones; maps of the risk of dangerous natural phenomena, maps of tourist resources as a whole – all these maps can be labelled as tourism maps of rather new contents.

Examples of such maps are available in regional atlases, in thematic GIS-projects Devoted to recreation and tourist activities, in regional publications. Showing natural, indicators, combination with economic ones, tourist-and-recreation maps and ecological maps are of great importance for planning the trade and complex development of regions. On the list of cartographic products, atlases in line with the principles of consistency and interrelationship in depicting natural, social, and cultural-and-educational objects possess a clear advantage. A map analysis made has given a good basis for further studies and corroborated the necessity for working out and developing scientific bases for tourism maps.

Classification of Maps

A classification of tourism maps can become a methodological basis for their design, GIS creation, and the system formation of corresponding spatial data. While working out our classification we assumed the tourist map to be a geographic map intended for the purposes of tourism. In turn, tourism is considered as an organized or independent travel across the native country (internal tourism) or in foreign countries (international tourism), made on holidays with information purposes and also of sports character. The first step of the classification offered shows the levels of mapping, i.e. maps of various scales (or ranges of scales), representing territories of different spatial coverage; these maps have a uniformity of approaches to designing, a common directivity and measure of information selection. The levels of mapping are interconnected, but each has its own peculiarities, which show up in their mathematical, general geographic bases and the classification of objects displayed on maps as well as in map design, etc.

In maps for tourism, we should point out world maps, continent maps, maps of countries, administrative or geographical regions, cities, separate kinds of tourist objects (like natural and architectural ensembles, national parks, etc.). The administrative or geographic approach to establishing the levels results from the degree of dependence of tourism development on the economic and political conditions or on the specific geographic character of tourist zones and areas. As the basic information "is tied" to political and administrative borders, a majority of map-makers prefer the simplest way – to operate by administrative units.

The scales are closely connected with the territorial coverage and they are the function of the map purpose. They determine the information volume, in other words, the detail of maps.

Tourism, on the one hand, is the most effective means of satisfying recreational and informative requirements of the population, and on the other hand, is a branch of non-productive sphere of economy, whose enterprises and organizations fulfil tourists' requirements of material and non-material services, like those of transport, hotel industry, trade, excursions, culture-and-entertainment, and sport, health-improving. It has caused the division of maps into two big blocks:

1. Tourism proper maps (for organized and independent tourists);
2. Maps of tourism organization and planning.

Topographic maps (they are also basic ones) and transport maps can be classified as auxiliary maps.

Organized tourism is understood as a travel under a program planned by tourist establishments, with a complex of services provided. Independent tourism (backpacking) is a travel under the plan drawn up by the tourist, with a considerable share of self-service. Maps for independent forms of tourism should have more information on transportation services, tourism infrastructure, and tourism safety.

Cartographic support is needed by various tourism kinds and forms, such as informative, recreational, natural, historical-and-cultural, event-trigger, ethnographic, collecting, adventure health-improving, sports, extreme, religious, ecological ones as well as walking, horse riding, bicycle travels, and so on and so forth.

Therefore, in our classification of maps (and it also means: in their subsequent production), we have tried to reflect very diverse (wide and single-purpose oriented) requirements that should meet themes and kinds of tourist maps.

1. Tourism Proper Maps can be general ones, they have territorial (areal) coverage, the objects of tourists' interest being shown across the whole territory; or route ones– they are designed along a certain route (and objects are shown along this route strip). Among route maps, we can see walking, bicycle, horse-riding, automobile, railway, ski, water, mountain, combined route maps. This map list by kinds of excursion routes can be continued.

Further, tourism proper maps are divided according to their contents into:

a. Informative maps;

b. Maps for health-improving and recreational tourism;

c. Maps for sport, non-professional tourism;

d. Special maps.

(a) *In informative maps*, we have general ones; nature; history and culture ones. General maps depict the basic locality panorama (general geographic elements) and general tourist information, such as service facilities (accommodation, public catering, communication, health service, resting establishments, etc.); tourist information centres; vocation and amusement places, places for various sports entertainment; information on the location of sights, objects of cultural heritage. As a rule, these are tourist plans of cities and popular maps sometimes with expanded country-specific or regional geographic contents for region-study specialists, tourists, schoolchildren, and all those who are interested in studying their native land. They are useful for getting acquainted with a particular area, for choosing a travel route, obtaining general information.

Nature maps show full complexes of scenic landscapes, specially preserved natural territories, natural sights of a certain character (volcanic, hydrological, biological and cave formations). In recent years, territories (water areas) possessing a lot of exotic features, like a landscape nature variety, has become extremely popular. Travels connected with transition from one season into another one (for example, from winter to summer, or vice versa), caused by a sharp change of climatic conditions, belong there too.

Informative maps of history and culture either deal with a wide range of themes or are single theme-oriented, they are devoted to historical, military-historical events and monuments, remarkable men's lives, archaeological, ethnographic topics, town-planning and architecture monuments, national trade and craft places, their profile and characteristics.

Maps of ecological tourism can enter both the class of natural maps and that of historical and cultural maps, they facilitating ecological education of people, protection of the natural and cultural-and-historical environment, ecosystem integrity preservation, observance of ecological regulations and wildlife management modes.

(b) *Maps for health-improving and recreational tourism* are intended to show resources of health-improving tourism, such as resorts of different profiles, therapeutic recreation zones.

(c) *Maps for sports tourism and non-professional* one are aimed at displaying, accordingly: sports routes of different kinds and categories of complexity, sports orientation routes and venues, venues for holding sports competitions of different kinds; their results; attractive hunting and fishery places, etc.

(d) *Special maps* are cult, mystical, esoteric guidebooks for pilgrims and tourists visiting 'energetically strong' places, 'bottomless wells of life-giving space energy', maps of power anomalies', they including local legends and customs too.

2. Maps for Tourism Organization and Planning are not less important than tourism proper maps as tourism industry occupies one of the leading places in the economy of many countries. In some areas, tourism is the only industry influencing significantly their development. We have the following kinds of maps in this group.

(a) *Maps for tourism advertising and propagation*. They are designed for popularizing vacation spots, various sites as well as for attracting domestic and foreign tourists.

(b) *Maps of the historical development and dynamics of tourism* reflect historically different aspects of tourism movement development, its material resources, organizations, service volumes, recreational resources. Changes in the number of tourists, in the social structure of tourist streams, cost indicators, tourist concentration degree in different places, tourism dynamics and its geographic distribution can be the themes of these maps. The maps are important for solving some technical, scientific, organizational problems, for revealing promising areas and directions of tourism development.

(c) *Tourism infrastructure* maps are used for representing the whole set of constructions, buildings, systems and services providing organization and services for tourism.

The tourism material-and-technical basis includes enterprises with different functions, tourist bases, and boarding houses, other accommodation types, transport, special post offices serving only tourists. There are special tourist centres and establishments making their service programs in view of the peculiarities of specific tourism kinds, travel ways, the age, professional and other features of their clients.

Tourism infrastructure maps should be distinguished from maps of the industrial and social infrastructure of a region, showing the services the local population is provided with, although these enterprises participate in performing tourist services too (city and international transport, trading enterprises, public health services, cultural entertainment establishments, sports facilities, etc.). As a whole, infrastructure maps reflect the development level of territories for tourism.

(d) *Zoning districts and zone maps* have the basic purpose to display the complex information and specificity of tourist zones for territorial tourism organization and optimal use of recreational resources. The region specificity may be caused by geographical, biological characteristics, economic ties, local traditions, system of mutual relations between human cultures and conditions of the environment. The below factors can act as criteria for the division into districts (and for map themes):

i. Tourism kinds;
ii. The intensity of its development;
iii. The stability of natural complexes to tourist loads;
iv. The preservation level of natural and historical-and-cultural objects;
v. The representatives and status of tourism objects, natural, anthropogenic conditions and hazards, other signs (grounds for the division).

Zoning districts and zone maps can show the results of various estimations and functional zoning of territories. For example, there might be displayed zones of short-term mass tourism, transit, all-the-year-round, seasonal, trade-connected tourism (like hunting, fishery), zones of therapeutic recreation, zones of various comfort (usefulness) levels of natural and man-trigged conditions of tourism (climatic, medico-geographical, sanitary-and-hygienic ones, pollution indicators, etc.).

As a whole, tourist district zoning is a kind of territorial differentiation, the basis for it reflecting the peculiarities of the environment, those of its development and the formation of socio-cultural systems. Maps of these themes can serve long enough provided that certain parts of their contents are periodically updated.

(e) *Maps for planning and economic appraisal*. International, state, regional tourism planning is directly connected with the general territorial planning of lands, with an appraisal of the recreational potential of landscapes, tourist resources and tourist district zoning.

Besides, tourism is characterized by a system of indicators through which we can appraise it economically and make maps of corresponding themes. Let us give a few examples of the most common indicators. They characterize: the development of the material basis; quantity of accommodation (including the division according to the comfort level); tourist density factors (quantity of per capita accommodation); service volume (the quantity of tourists who visited the district, city, country); stay duration in a certain district; the volume of tourist services, which means the total monetary receipts from tourists; the data showing the place of tourism in the system of economy industries (the quantity of the population directly and indirectly occupied with tourist services, the share of tourists in the sum of all receipts from the population (the sum of sales); the share of receipts from foreign tourists in the country's balance of payments (currency receipts).

In addition to dividing the maps considered by their contents they can be differentiated by their representation form: paper, digital, electronic, multimedia maps, navigating GPS-cards, Internet-maps. The map design is of great value for their perception. They employ bright art design, panoramic images, various indexes, photos, and descriptions.

Natural and Cultural Heritage: In all kinds of maps, especially tourism proper ones, it has been offered to display objects of natural and cultural heritage. But unlike a majority of domestic and foreign tourist maps where sights are represented as a set of monuments of different kinds available in some territory without estimation of their statuses and rankings, the authors have worked out a strict system of heritage data, regulated by legislative and standard documents. In the system offered, the basis for natural heritage is formed by specially preserved territories, making their complete list, and separate monuments and phenomena of nature, which are to be established in the course of mapping each particular region. (Fig. 3).

The cultural heritage includes monuments of history, archaeology, town-planning, architecture; ensembles (palace, landscape, gardening ones, etc.); places of

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Fig. 3. Natural and Cultural Heritage

concentration of non-territorial forms of heritage (in museums, archives, exhibition halls, etc.); nature-history-culture territories; historical cities and other settlements.

ach heritage object is shown according to the decision setting up the protection regime, with the object profile and the protection establishing date given. Each object is shown with its value - of world (under the UNESCO registers), federal, regional, local value (under documents of the corresponding level). From the ranks (statuses) listed, objects of world value are the most important ones, especially at global, federal levels.

The increasing mass character of tourism and high level of interest to places and Monuments of outstanding universal value (included on the world heritage list) involve the problem of competent organization and directing of tourist streams. It is no coincidence that the UNESCO has adopted a program whose strategy is directed at perfecting tourism management and finding ways to preserve monuments at high levels of safety. One of the methods for deepening public understanding of the world heritage importance is to support natural and cultural tourism with the corresponding cartographic products having considerable priorities over other information types.

Electronic Maps have been compiled and made in compliance with these goals. Lists of objects/sites of the world heritage (both natural and cultural one) with their characteristics have been generated. A reference search website containing prompts, map images, lists of objects with a search system, pages of textual and graphic reference information has been developed.

The Legends of the world natural and cultural heritage maps (correspondingly, on the maps and lists) show:

- The state ownership of sites (owned by one country, by several countries);
- Their preservation state (good, satisfactory, non-uniform, great maintenance resources are required, under the threat of disappearance);
- Sites possessing a unique characteristic peculiarity;
- The cultural importance of sites
- creation masterpiece, unique for some cultural tradition (civilization), an example of the culture of some significant period of history and the interaction of man and the environment;)
- Origin time (7 gradations).Natural monuments are represented, besides the state ownership, with the characteristics of the nature protection profile (pale geographical, hydrological, botanical ones, etc.); the protection regime (5 gradations); the value (a nature phenomenon, an outstanding example of wildlife, its evolution, inanimate nature, the Earth's history, and geographical names).

CONCLUSION

A generalization of tourist cartography issues around the world at present is not only of independent interest, it has allowed the authors to reveal both immediate directions for further development of tourism cartography theoretically as well as methodologically and approaches to scientific organization of map manufacturing. The classification of tourism maps offered for the first time; raised and never expanded before, the problem of systems display of natural and cultural heritage, taking into account the tendencies of international tourism; and a complex of experiments on designing and drawing up map originals – all these serve the above purposes. The research has been based on the systems cartographic approach, the theoretical and methodological fundamentals of thematic, complex, topographic mapping, atlas cartography. It has taken into consideration the legislative base in the field of geodesy, cartography, ecology; the international standard documents and (UNESCO) programs in the field of science, culture, communications and information.

REFERENCES

1. Anson, R. W. and Ormeling, F., J., 2002: Basic Cartography for Students and Technicians (Volume 2). Butterworth & Heinemann, Oxford, England. ISBN 978-0750649964.
2. Bertin, J., 2011: Semiology of Graphics, Esri Press, Redlands, USA. ISBN 978-1-58948-261-6.
3. Brewer, C. A., 2005: *Designing Better Maps: A Guide for GIS Users.* Esri Press, Redlands, USA. ISBN 978-1-58948-089-6.
4. Cartography - to Tourism. - Materials of Scientific and Practical Conference. St.-Petersburg, September 21-24, 2008. – Maps Publishing House, St.-Petersburg, 2008, 184 pp.
5. KEATES,J.S.(1978).Cartographic Design and Production. 2. ed. London, Longman. 240 p.
6. Leiper, N. (1979), The Framework of Tourism: Towards a Definition of Tourism, Tourist and Tourist Industry, Annals of Tourism Research, 6(4), pp. 390-407
7. Niemelä O (1982). Thematic Maps – Important Cartographic Products. Maankäyttö 4, 169–172.
8. RAISZ, E.: General Cartography. N. York, McGraw-Hill Book Co., 1948. 354 p.
9. ROBINSON, A, H., SALE, R., MORRISON, J. L. (1978). Elements of Cartography. 4. ed., N. York, J. Wiley and Sons. 448 p.
10. Vereshchaka T.V. Topographic Map: Scientific Bases for its Contents. - Ì: ÌÀÌÊNauka / Interperirdika, 2002. – 319 pp.

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Natural Resource Monitoring and Management

AN ANALYSIS OF LAND USE/ LAND COVER PATTERN OF THE PERUVAMBA RIVER BASIN, KERALA

Abhilash T. K.[1], S. Jane MITHRA[2], & Jayapal G[3]

ABSTRACT

It is well established that the water resource planning depends on the physical and cultural characteristics of a river basin. Hence, the optimal utilisation of water resources is being planned and managed in an integrated and holistic way. Sustainable management of water resources requires systematic and integrated decision-making that recognises the interdependence in the existing land use/cover, water and environment, economic and social conditions and the policy decisions at the administrative level. In this paper, an attempt is made to delineate and analyse the land use/ land cover pattern of the Peruvamba River Basin using remote sensing data in GIS platform. The Peruvamba river basin extends from 12o0' to 12 o 15' north latitudes and 75 o 10' to 75o 20' east longitudes. River originates from the Western Ghats near Pekunnu at an altitude of 356 m above MSL and has a length of 51Km.The basin has a total area of 298.15 sq.km covering 19 villages spread over 12 panchayats, 3 blocks in Kannur and Kasargod districts of Kerala State. The main objective of this study is to prepare the existing pattern of land use/cover in the Peruvamba river basin from satellite remote sensing data and to analyse the physical and cultural factors controlling and affecting the pattern. IRS LISS IV data is used for interpreting the land use pattern and the work is carried out in Arc GIS. From the analysis, it is observed that the depletion of mangroves in the lower reaches, land mismanagement, induced land use changes especially the conversion of paddy fields, under-utilization of potential croplands, increasing population etc. are the major driving forces of land use/cover pattern in the Peruvamba river Basin.

Keywords*: Water Resources, Changes in LULC, Peruvamba River Basin, Kerala.*

INTRODUCTION

River basin is a natural geographical unit with a certain extent of homogeneity and uniformity. The planning of natural resource management programmes is mainly based on administrative boundary basis. The concept of river basin as a basic unit does not mean that the implementation needs to be on basin basis, but being a natural geographical unit it is better to do so, as otherwise, the interlinked nature of land and water resources and the dynamic hydrologic processes may create another set of new problems.

The land is the generous provider of a variety of resources, agricultural, forest, settlement and others. Land use is referred to various human activities, which are carried on land, and land cover is referred to "Natural vegetation, water bodies, rock or soil, artificial cover and other land transformations noticed on the land". Land use of an area is a cumulative outcome of historical events, the interpretation of economic forces with the natural environment, and the values of society. Since the land use/land cover information is the basic pre-requisite for land, water and vegetation resources utilisation, it becomes necessary to use latest technologies and tools like Remote Sensing Satellites for effective planning and management of these resources in modern times. Remote sensing techniques complemented by GIS are of great use in various river basin applications. Change detection of river and stream courses, inundation mapping and erosion affected area assessment have been carried out using multi-date and multi-sensor satellite data in several parts of India. IRS data with temporal and required spatial resolutions have proved to be invaluable for basin characteristic studies especially land use /land cover analysis. This paper deals with the land use / land cover patterns in the Peruvamba river basin with the following objectives in view.

OBJECTIVES

The main objective of this study is to report the existing pattern of land use/land cover in the Peruvamba river basin from satellite remote sensing data and to analyse the physical and cultural factors controlling and affecting the land use pattern in the basin.

METHODOLOGY

The secondary data collected from concerned Panchayath, Krishibhavan, Kerala State remote Sensing & Environment Centre and Survey of India topographic map have been studied and analysed for a physical and cultural aspect of the region. Collected data have analysed with the help of proper statistical techniques. Geographic Information System has been

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used for preparing and analysing maps for the study using Arc GIS software.

STUDY AREA

The Peruvamba river basin extends from 12o 0′ to 12o15′ north latitudes and 75o10′ to 75o20′ east longitudes. The river originates from the Western Ghats near Pekunnu at an altitude of 356 m above MSL and has a length of 51 Km. It is bounded by Taliparamba taluk of Kannur district and Hosdurg taluk of Kasargod district in the north, Kannur and Taliparamba taluk of Kannur district in the south, Taliparamba taluk of Kannur district in the east and Arabian sea in the west (Fig. -1). The basin has a total area of 296.08 sq km covering 19 villages spread over 12 panchayats, 3 blocks in Kannur and Kasaragod districts of Kerala state.

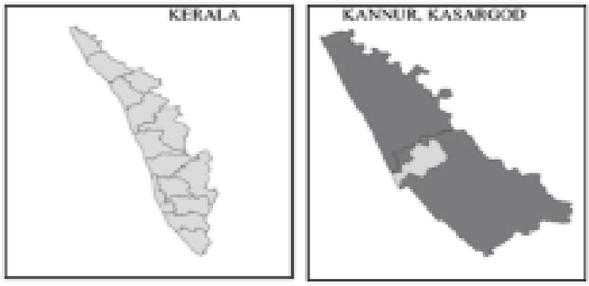

Fig. Location Map

CLASSIFICATION OF LAND USE/ LAND COVER CATEGORIES

In the Peruvamba basin, five land use/ land cover categories have been delineated at the first level and 18 categories in the second level on 1:12,500 scale. Fig. 2 shows the GIS map of land use/cover pattern in the peruvamba river basin. The classification followed for the mapping of the land use/land cover is given in Table .1. The first level categories of land use delineated in the Peruvamba basin are as follows.

1. Settlements and transport network
2. Agricultural crops and Plantation crops
3. Waste lands and
4. Water bodies.

Table 1
Lad use/Cover Pattern Areal Distribution

LAND USE/ COVER- L1	LAND USE/ COVER-L2	AREA IN SQ KM 2010	AREA IN SQ KM TOTAL	% OF AREA
Settlements	Built- up land	0.08		0.02
	Residential	4.01		1.3
	Mixed built- up	4.72	8.81	1.59
Agriculture	Double crop	3.38		1.13
	Mixed crop	45.97		15.52
	Coconut dominant mixed crop	45.08		15.22
	Banana	0.13		0.04
	Current Fallow	1.85	96.41	0.62
Plantation	Coconut	11.68		3.94
	Mixed trees	53.28		17.99
	Pepper	19.81		6.69
	Rubber	21.41		7.2
	Cashew	0.36	106.54	0.11
wastelands	Land with Scrub	73.97		24.98
	Land without Scrub	1.29		0.43
	Mining	0.12		0.04
	Barren Rocky/Stony waste/Sheet rock	1.33	76.71	0.44
Water bodies	Water bodies	7.61	7.61	2.56
	Total	296.08	296.08	

Settlements and Transport Network

The settlements or built–up land is described as an area of human habitation developed due to nonagricultural use and that has a cover of buildings, transport network, communication utilities in association with water, vegetation and vacant lands.

Fig. 2 Transport Network

Built – up land in the study area is scattered all over the basin with well developed transport network as shown in Fig. 2. The areal extents of the settlements in the basin vary from 0.25 to 2 Km2 with maximum concentration in the Payyannur town. The total built –up land is 8.81 Km2. The low land is comparatively densely populated and the settlements are developed along the tracts where transportation is available.

The major settlements in the basin from south to north are Ramantali, Kandankal, Elimala, Payyannur, Cheruthazham, Perumba, Pilathra, Vilayamkode, Mathamangalam, Kuttur, Ramapuram, Kuruveli, Aravachal, Olayampadi, karippal, Eriyam, Peringom in the north east, etc. The criss-crossing transport network, as shown in Fig. 2, of the basin plays an important role in the development and the regional planning of the area.

Agricultural Crops and Plantation

The Peruvamba basin is predominantly agricultural with high intensity of cropping. (Fig. 3 shows the land use/ cover pattern of the basin). The agricultural practices are of two types, agricultural crops and agricultural plantations. Agricultural crops classified in the basin includes the area covered by crops and fallow land The main agricultural crops are Mixed crops, coconut dominant mixed crops, double crop and fallow lands. The total area under agricultural crops is estimated at 96.41 Km2 including the present fallow land. The principal crops grown are coconut, paddy, rubber, tapioca and banana. It is noticed that most of the paddy fields are now being converted for other plantation crops like Banana, Tapioca, Coconut and Rubber. Plantation is described as an area under which agricultural tree crops and other horticulture nurseries are grown. Plantation crops are very extensive with about 106.54 Km2 of which mixed trees predominates with 53.28 Km2 followed by rubber (7.2%), and pepper 21.41 (6.69%), and 19.81 Km2 respectively. Coconut occupies 11.68 Km2 area (3.94%).

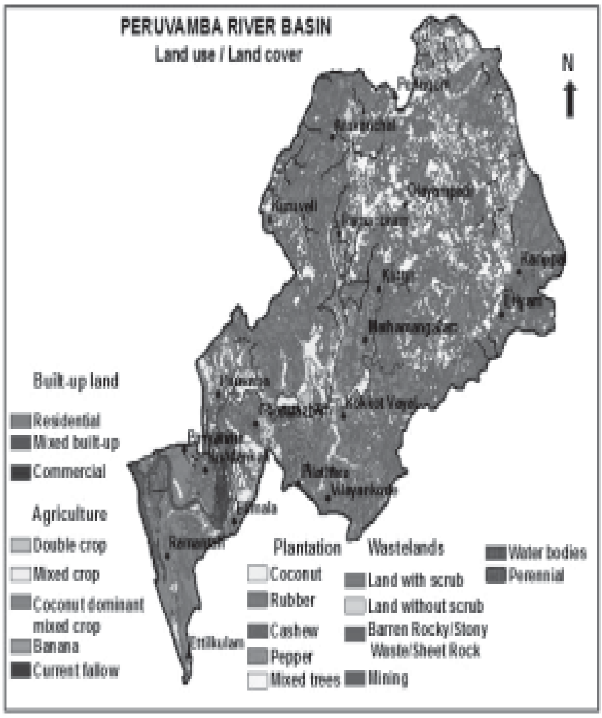

Fig. 3

Waste Lands

Waste lands are described as degraded lands which are currently under-utilized and deteriorating either due to lack of an appropriate management or due to natural causes. These lands can be brought under vegetative cover with reasonable effort. Land with or without scrub, marshy or swampy land, sandy, mining and industrial waste and barren rocky areas come under the wasteland category in the basin. The total aerial extent of the wasteland in the peruvamba basin is recorded as 76.71 Km2 , 25.21% of the total area. The land with scrub occupies 73.97 Km2 , land without scrub 1.29 Km2. The barren rocky terrain or sheet rock is found atop some hills in the form of flat-topped terrain and in rocky hill slopes without any vegetation which occupies 1.33 Km2 area. .Land with or without scrub occupies a relatively higher terrain like uplands or high grounds prone to degradation or erosion. In the lower reaches, the lands under mangroves were facing the depletion by conversion of these eco-sensitive lands into other practices.

Water Bodies

The water body is a natural or artificial body of impounded water often with a regulated flow of water. Water bodies include both man-made reservoirs, tanks or canals and natural rivers and streams, etc. The total areal extent of water bodies in the basin is 7.61 Km2. (2.56 % of the total area of the basin.)

SUMMARY AND CONCLUSION

Remote sensing techniques complemented by Geographical Information System are of great use in various river basin applications. Through this paper, an attempt is made to analyse the land use/ land cover pattern of the Peruvamba River Basin using remote sensing data in GIS platform. In the Peruvamba basin, five land use/ land cover categories have been demarcated at the first level and 18 categories in the second level on 1:12,500 scale.

The low land areas are comparatively densely populated and the settlements are developed along the road tracts where transportation is available. There is a tremendous growth in the built-up land area in the basin. The small settlements are scattered over the basin in the upland regions. The northeastern part of the basin is sparsely inhabited with forest cover.

There are two types of agricultural practices exists in the peruvamba basin, agricultural crops and agricultural plantations. The main agricultural crops are Mixed crops, coconut dominant mixed crops, double crop and fallow lands. The main crops grown are coconut, paddy, rubber, tapioca and banana with a total area of 96.41 Km2 . It is noticed that the paddy fields are now being converted for other plantation crops like Banana, Tapioca, Coconut and Rubber. Plantation crops are very extensive with about 106.54 Km2 of which mixed trees predominates followed by rubber, pepper. Coconut occupies 11.68 sq.km area.

There is extensive land under waste land category which is degraded lands currently under-utilized, deteriorating due to lack of an appropriate management or natural causes. Land with or without scrub, marshy or swampy land, sandy, mining and industrial waste and barren rocky. These lands can be brought under vegetative cover with reasonable effort. Land with or without scrub, marshy or swampy land, sandy, mining and industrial waste and barren rocky areas come under the wasteland category in the basin. The land with scrub occupies about 73.97Km2 area offers an extensive area for developmental activities in the basin.

From the analysis, it is observed that the depletion of mangroves in the lower reaches, land mismanagement, induced land use changes especially the conversion of paddy fields, under-utilization of potential croplands, increasing population etc. are the major driving forces of land use/cover pattern in the Peruvamba river Basin. As of many earlier case studies on land use /cover, based on the Indian remote sensing satellite data this attempt could provide the required information on land use/ land cover pattern of the peruvamba river basin.

REFERENCES

1. Anil Kumar. R. 1994, “Landscape Ecology and Land Use Pattern”, A study in Karamana Drianage Basin, Unpublised Ph.D thesis, University of Kerala, Kerala

2. Chattopadhyay. S., Salim M. B. and Sankar. G. 1986, “Integrated Environmental Assessment for Eco-development – A Case Study of Aralampuzha-Bavalipuzha Drainage Basins in Kerala”, Proc. of the Seminar on Eco-development of Western Ghats- Peechi, Kerala pp. 266-275.

3. Jayapal, G. (2001), “Desirable Land Use Planning for Sustainable Development A Biophysical Case Study of Kallada River Basin, Kerala”, Unpublised, PhD thesis, University of Kerala.

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NATURAL RESOURCE MONITORING USING REMOTE SENSING TECHNIQUES

Asit Kumar SARKAR[1]

ABSTRACT

Remote sensing techniques are considered as essential tools for monitoring different aspects of natural resources available on the surface of the earth. But the indiscriminate use of the technology has been restricted by the United Nations' resolution on principles relating to remote sensing, where the term remote sensing means the sensing of earth's surface from space by making the use of properties of electronic waves emitted, reflected or diffracted by the sensed object, for purpose of improving natural resource management, land use and protection of the environment. It is possible to monitor status of different types of natural resources like land, water, forest, soil, agriculture, etc. by using remote sensing techniques. The technology may be used for natural resource assessment, monitoring and also for cartographic purposes because of their advantages in terms of synoptic view, repetitive coverage and also uniform data set. To combat the situation related to degradation of natural resources, scientists need to observe the scenario precisely at regular interval. Here lies the importance of remote sensing techniques, which are considered as essential tools for monitoring different parameters of natural resource degradation with ultimate aim for drawing up planning strategies.

***Keywords**: Glacier, Lagoon, Natural Resources, Oil Spill, Ravine, Remote Sensing, Saline Soil, Shifting Cultivation, UN Resolution.*

INTRODUCTION

Natural Resources are all that exists without the human interference. A natural resource is anything that people can use which comes from nature. People do not make natural resources, but gather them from the earth (https://simple.wikipedia.org/wiki/Natural_resource). Natural resources may be grouped into two classes, renewable and non-renewable resources.

A *renewable resource* is an organic natural resource which can replenish to overcome usage and consumption, either through biological reproduction or other naturally reoccurring processes. Common sources of renewable energy include solar, geothermal and wind power, which are all categorised as renewable resources.

A *non-renewable resource* (also called a *finite resource*) is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically-derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas. Earth minerals and metal ores, fossil fuels (coal, petroleum, natural gas) and groundwater in certain aquifers are all non-renewable resources.

At the dawn of civilization, there was no dearth of natural resources on the earth. But rapid growth of population and human interference resulted depletion of natural resources. Renewable resources are a part of Earth's natural environment and the largest components of its ecosphere. Harnessing of renewable resources, for example, solar energy, wind energy, water resources may not cause problem, but depletion of non- renewable resources, like fossil fuel, forest resources, mineral resources, etc. causes much concern, particularly regarding availability of such resources for future generation. Human interference on nature also causes deterioration of quality of natural resources, in terms of pollution.

It has been observed that human intervention causes depletion of natural resources. Unscientific query in mining areas, depletion of forest resources for purposes like indiscriminate collection of forest products, urbanization, industrialization, extension of agricultural areas, etc., extraction of ground water for irrigation and also to meet industrial as well as domestic needs, use of pesticide to combat pests and insects in agricultural fields, etc. cause environmental degradation resulting threats in natural resource condition.

At this juncture it may be mentioned here that remote sensing techniques are considered as essential tools for monitoring different aspects of natural resources available on the surface of the earth. To combat the situation related to degradation of natural resources, scientists need to observe the scenario precisely at regular interval. Here lies the importance of remote sensing techniques, which are considered as essential

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tools for monitoring different parameters of environmental degradation with ultimate aim for drawing up planning strategies. Actually satellite borne remote sensing data have been very effectively utilized during the past couple of years for the study and monitoring of different aspects of natural resources. With this background, in the present paper an attempt has been made to observe the case wise scenario related to depletion of forest resources, accumulation of incrustation of salt in agricultural field, degradation in ravine and lagoon environment, pollution in sea water, etc. so that ultimately sustainable planning strategies may be drawn up from systematic assessment.

OBJECTIVES, DATABASE AND METHODOLOGY

The main objective of the present study is to assess the role of remote sensing technology for monitoring different types of natural resources available on the earth. The situation varies at periodic intervals, sometimes they deteriorate at alarming levels. All these scenarios would be critically analysed in the present study.

To achieve above mentioned objectives, remote sensing data belonging to various sensors of different satellite systems have been collected mostly from archives. Available published literatures have also been consulted and critically analysed to assess the situation. So far as methodology is concerned, primarily False Colour Composites have been prepared with specific band combinations for appropriately depicting the prevailing situation. Extraction of specific scenario depends upon appropriate choice of sensor belonging to satellite system. Depending upon the specific case study temporal data at periodic intervals have been analysed to represent the changing scenario. The area coverage of the concerned resource determines the choice of specific sensor because the spatial resolution varies considerably from one sensor to the other.

United Nations' Principles Relating to Remote Sensing of the Earth from the Space

The indiscriminate use of remote sensing technology has been restricted by United Nations General Assembly by its resolution adopted at 95th plenary meeting held on 3 December 1986, vide Annex Principle I, where *the term "remote sensing" means the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment.* As per Principle II, *remote sensing activities shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic, social or scientific and technological development, and taking into particular consideration the needs of the developing countries.* Further in Principle X, it is suggested that *remote sensing shall promote the protection of the Earth's natural environment. To this end, States participating in remote sensing activities that have identified information in their possession that can be used to avert any phenomenon harmful to the Earth's natural environment shall disclose such information to States concerned* (www.un.org/documents/ga/res/41/a41r065.htm).

Evolution of Satellite and Sensor System

Continuous research and development related to satellite remote sensing resulted availability of high resolution images from various sensor systems (Sarkar, 2012). Depending upon the application requirements, sensors have been developed with greater spatial, spectral, radiometric and temporal resolutions. Landsat-1 satellite which was launched in the orbit in 1972, was the first one to target systematic coverage of earth surface from space, the spatial resolution being 80 metres in MSS mode. The drastic change was made by the French satellite SPOT-1, launched in the year 1986 with 10 and 20 metres resolutions in Panchromatic and MSS mode respectively. IRS family of satellites which started with IRS-1A in 1988 with a spatial resolution of 72 metres and 36 metres in LISS I and LISS II respectively, improved the resolution to 5.8 metres with IRS-1C PAN sensor in 1995. It may be mentioned here that between 1995 and 1999, i.e. till the launch of IKONOS, this was the highest spatial resolution available in civilian domain (Sarkar, 2008). Technology Experiments Satellite (TES), an IRS group of satellite, launched in the year 2001 further improved the resolution to 1 metre. This was followed up with first dedicated high resolution stereo mission in Cartosat-1 with 2.5 metre resolution. Subsequently Cartosat-2, with a spatial resolution of better than one metre was launched into orbit in January, 2007. The latest addition to this, Cartosat-2A, has been launched on 28 April, 2008. The IKONOS, is a high resolution satellite with 1 metre spatial resolution. Launched in 2001, the Quick Bird collects image data at 0.61metre pixel resolution (Lillesand, et al. 2004). GeoEye1 has been launched successfully on September 6, 2008, provides 0.41 metre panchromatic and 1.65 metre multispectral imagery in 15.2 km swaths.

Dedicated satellite systems were also developed to serve specific purpose. Thematic Mapper attached to Landsat system were used for specific applications. Oceansat sensors were developed to study Ocean Colour Monitor (OCM). ERS of European Space Agency carried payloads like active and passive micro wave and thermal infrared radio meter. RESAT is India's radar satellite launched in the year 2009.

CASE STUDIES

The following case studies related to different aspects of natural resources monitored through remote sensing techniques are presented herein below:

Salt Affected Soil of Indo-Gangetic Plains

It has been estimated that about seven million hectares of land area in India suffer from problems associated with saline soils. It has also been observed that nearly 40 per cent pf such areas are located in the Indo-Gangetic Plains of Punjab, Haryana, Rajasthan, Uttar Pradesh and Bihar. This vast territory needs to be brought under cultivation or associated activities to increase the quantum of cultivated land. For the purpose of reclamation of such land, the prerequisite is to know their aerial extent, which is possible by analyzing the remote sensing data. IRS 1A LISS II (6th February, 1989) seems to be very helpful for this purpose (NRSA Appraisal Card No. 13). Detailed analysis of the image shows that the croplands appear in different shades of red, whereas salt affected areas can be recognized as dull white to bright white patches depending upon the encrustation of salt. The strongly salt affected soils are visible as smooth textured bright white whereas moderately salt affected soils appear as dull white colour with medium to coarse texture. Thus, remote sensing data have been found to be very useful for monitoring and mapping the salt affected soils.

Ravines of Chambal Valley

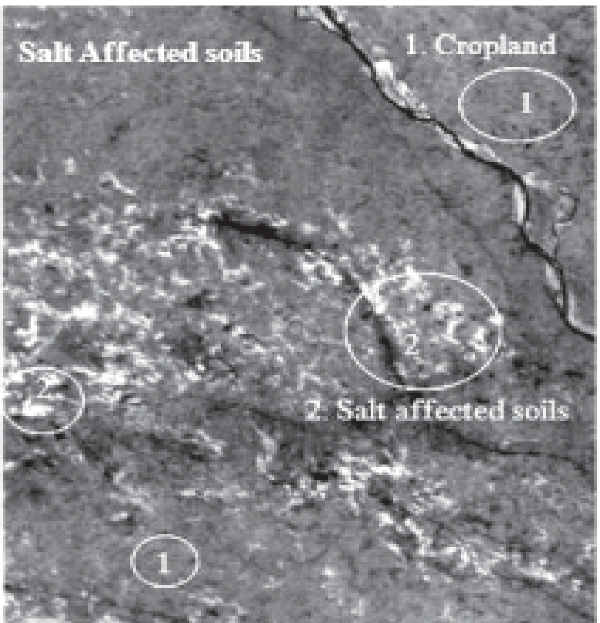
In the alluvial plains, large ravines exist due to differences in the local base level of erosion and adjoining uplands. These often occur along the streams and form a part of the drainage system. In each drainage system, ravines occur with definite side slope, bed width and depth. In the upper reaches, these are wide and shallow, whereas in the lower part of the drainage system, the ravines are generally very narrow and deep.

Ravines can be reclaimed to give room to different uses like extension of arable land, introduction of afforestation scheme, etc. The increasing demand for food, fodder and fuel has attracted the attention of planners towards the reclamation of these ravenous lands.

It is possible to introduce optimal land use planning in ravine land in accordance with depth classification. IRS LISS II data of 10th March, 2090 is a good example in this regard (NRSA Appraisal Card No. 014).

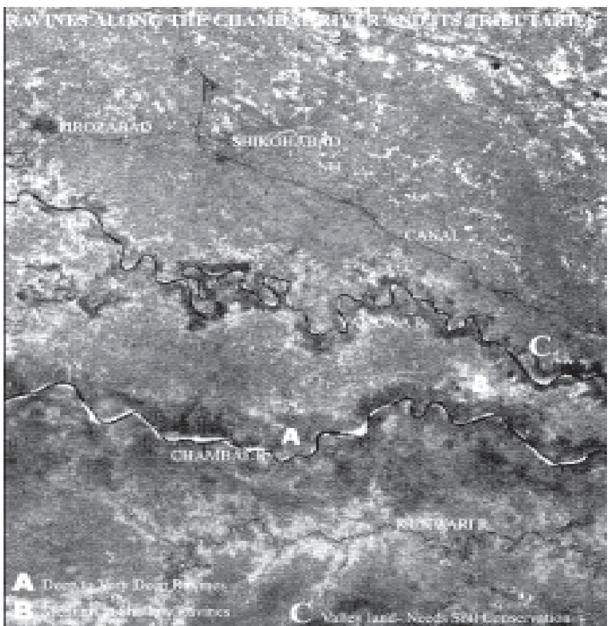
The satellite imagery obtained through IRS1A (LISS II) on 10th March, 1990 has been used for identification of different categories of ravine land. The careful observation of the imagery reveals that grey to dark grey smooth textured patches seen along the Chambal River indicate deep to very deep ravines (A), while light grey to yellow toned patches depict medium to shallow ravines (B). Table lands and valley lands (C) are manifested as smooth textured red tones on the imagery because of crops and other vegetation.

Deeper ravines can be identified in moisture laden



Source: National Remote Sensing Agency (1989), IRS Application appraisal card : 002

Fig. 1: Salt affected soils of Indo-Gangetic Plains



Source: National Remote Sensing Agency (1989), IRS Application appraisal card : 002

Fig. 2: Ravines along the Chambal River and its tributaries

areas which is caused either due to seepage flow or due to back flooding by the main river. The impact of higher moisture distribution in soils and also scattered vegetation cover result darker tone.

Reclamation Measure

The entire ravine land may be grouped into three categories:

Reclaimable ravine group: Broad, shallow and medium ravines form the reclaimable ravine group, where agricultural activities can be extended after appropriate treatment of the land (A in Fig. 1b).

Non-reclaimable ravine group: Deep ravines are suitable for introduction of afforestation schemes (B in Fig. 1b).

Valley land: This type of terrain requires soil conservation measures like contour terracing and bunding (C in Fig. 1b).

IRS data thus appear to be helpful in selecting priority areas for reclamation, i.e. for selecting areas which have the highest proportion of land suitable for reclamation for agriculture and associated activities. It may be mentioned here that the present exercise is based on visual interpretation of IRS data. For better output, identical exercise may be conducted with the help of digital data along with appropriate digital image processing software. In such a case extensive ground truth collection will help to prepare supervised classification of the entire land for faithful assessment of the ravine area under investigation (Sarkar, 2002).

Retreat of Glacier

Advanced remote sensing and GIS techniques offer abundant potential for mapping and monitoring the glaciers in extensive high and remote mountain areas (Thapliyal, et al. 2013). It has been estimated that the Himalayan glaciers cover about three million hectares or 17% of the mountain area as compared to 2.2% in the Swiss Alps. They form the largest body of ice outside the polar caps and are the source of water for the innumerable rivers that flow across the Indo-Gangetic plains. Himalayan glacial snowfields store about 12,000 km^3 of freshwater. About 15,000 Himalayan glaciers form a unique reservoir which supports perennial rivers such as the Indus, Ganga and Brahmaputra which, in turn, are the lifeline of millions of people in South Asian countries (viz. Pakistan, Nepal, Bhutan, India and Bangladesh). The Gangetic basin alone is home to 500 million people, about 10% of the total human population in the region.

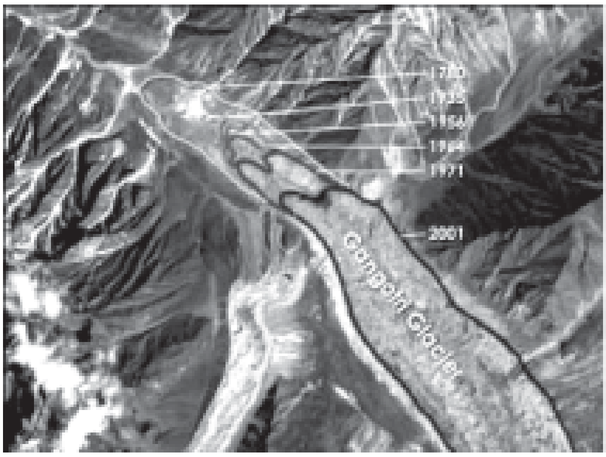
Glaciers in the Himalaya are receding faster than in any other part of the world (Table 1) and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner, if the Earth keeps warming at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km^2 by the year 2035 (WWF, 2005).

Table 1
Retreat of Some Glaciers in the Himalayas

Glacier	*Period*	*Retreat of Snout (Metre) (metre/year)*	*Average retreat of glacier*
Triloknath Glacier (Himachal Pradesh)	1969 to 1995	400	15.4
Pindari Glacier (Uttaranchal)	1845 to 1966	2,840	23.5
Milam Glacier (Uttaranchal)	1909 to 1984	990	13.2
Ponting Glacier (Uttaranchal)	1906 to 1957	262	5.1
Chota Shigri Glacier (Himachal Pradesh)	1986 to 1995	60	6.7
Bara Shigri Glacier (Himachal Pradesh)	1977 to 1995	650	36.1
Gangotri Glacier (Uttaranchal)	1977 to 1990	364	28.0
Gangotri Glacier (Uttaranchal)	1985 to 2001	368	23.0
Zemu Glacier (Sikkim)	1977 to 1984	194	27.7

Source : IPCC: Fourth Assessment Report: Climate Change 2007.

The receding and thinning of Himalayan glaciers can be attributed primarily to the global warming due to increase in anthropogenic emission of greenhouse gases. The relatively high population density near these glaciers and consequent deforestation and land-use changes have also adversely affected these glaciers. Currently 30.2 kilometers long and between 0.5 and 2.5 kilometers wide, Gangotri Glacier, situated in the Uttarkashi District of Garhwal Himalaya is one of the largest in the Himalaya. The glacier has been receding since 1780. Between 1842 and 1935, the glacier was receding at an average of 7.3, every year, but it has been receding alarmingly in recent years as depicted in the False Colour Composite satellite image (Fig. 3). It appears that the retreat quickened after 1971 (http://nsidc.org/cryosphere/glaciers/quentions/climate.html). The average rate of recession between 1985 and 2001 is about 23 m per year (Hasnain, 2002). It may be noted here that the blue contour lines drawn here to show the recession of the glacier's terminus over time are approximate.



S*ource*: Jeff Kargel, USGS

Fig. 3: Retreat of Gangotri Glacier

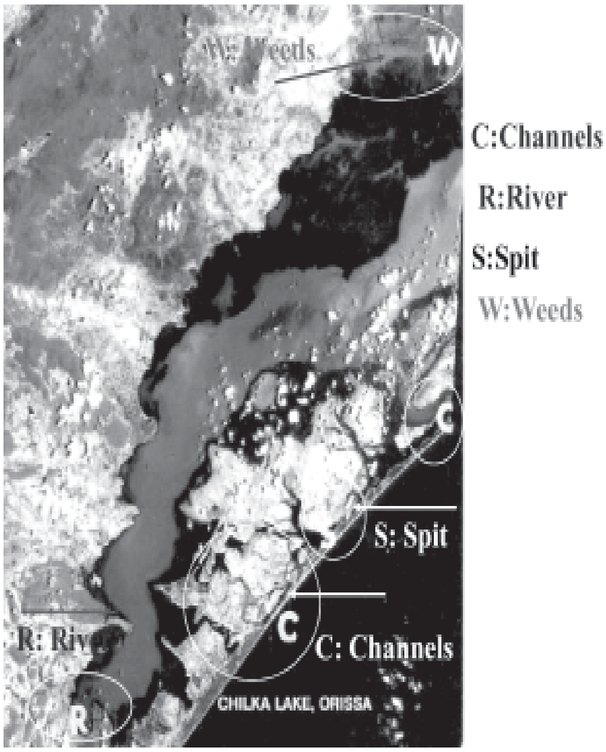
Indus, Brahmaputra and other rivers that criss-cross the northern Indian plain could likely become seasonal rivers in the near future as a consequence of climate change and could likely affect the economies in the region. Some other glaciers in Asia – such as glaciers shorter than 4 km length in the Tibetan Plateau – are projected to disappear and the glaciated areas located in the headwaters of the Changjiang River will likely decrease in area by more than 60% (Shen et al., 2002).

Environmental Hazards in Chilika Lake Area

Chilika is the largest brackish water body in the eastern coast of India which covers an area of about 1280 sq. km. Narrow channels cutting across linear spit connect the lake to the Bay of Bengal and create an estuarine environment. Several small rivers like Daya, Bhargavi, Makra, etc. supply fresh water to the lake particularly from southern end. Lake Chilika, a typical lagoon, is ecologically a very sensitive zone and is considered a significant ground for aquaculture and the home for migratory birds coming from distant areas as far as Siberia and Kazakhstan.

It has been observed that the False Colour Composite created through IRS LISS II data is very useful in studying the environmental situation of Chilika Lake area (NRSA Appraisal card 006). Remote Sensing data can easily detect the growth of water weeds, which cause fluctuations in dissolved oxygen content consequently affecting the fishing ground along with the fish population. The red tone on the image indicates the development of weeds in the shallow fringes which causes a threat to the fish population because of biological oxygen demand (Fig. 6). The turbidity level of the Lake water can also be monitored during different seasons thus estimating the influx of sediment carried by different rivers.

Over the last 25 years, Gangotri Glacier has retreated more than 850 meters, with a recession of 76 meters from 1996 to 1999 alone. It has further been observed that an overall reduction in glacier area from 169.186 sq. km in 1972 to 156.587 sq. km at present, an overall deglaciation of more that 7% (Haq et al. 2011). The current trends of glacial melts suggest that the Ganga,



Source: National Remote Sensing Agency (1989), IRS Application appraisal card : 002.

Fig. 4: Chilika Lake and its Environment

Shifting Cultivation in North East India:

Although 75 million hectares are classified in India as forest land, less than half of it is under tree cover, and as much as 20 million hectares of forest land is estimated to be affected by erosion problems. Only 12 percent of the land is under true forest cover. Excessive shifting cultivation is one of the major factors for the rapid degradation of forest. According to FAO, shifting cultivation is practiced on approximately 36 million sq. km. land in Africa, Oceania, South Africa and South East Asia. It provides temporary sustenance for 250 million people. In Asia alone, about 8 million hectares of forest area are taken over by shifting cultivators each

Source: National Remote Sensing Agency (1989), IRS Application appraisal card : 002.

Fig. 5: Shifting cultivation in North East India

Source: Satellite Atlas of India (2007), Plate No. 18, NATMO.

Fig. 6: Reclamation of Desert land.

year. In India, this method of cultivation is practiced extensively in tribal belts of Orissa, Madhya Pradesh, Andhra Pradesh, North Eastern states, etc. It has been estimated that this practice covers about one million hectares of land. Here lies the importance of remote sensing technology through which such information may be collected even from remote and inaccessible areas.

Actually shifting cultivation is considered as a dangerous agricultural practice causing environmental degradation. This slash and burn agriculture is known as *Jhum* cultivation in North-East India. During the dry winter season the selected forest patch is cleared and kept to dry. Before the onset of the monsoon, the dry debris are burnt so that during the rainy season the ash settles down and cleared forest patch becomes ready for sowing. In such a plot of land crops can be raised for twice or thrice and afterwards shifting is required due to loss of soil fertility. It needs years together to replace the soil fertility of the abandoned plot.

IRS 1A LISS II imagery dated 10 March, 1989 clearly depicts different stages of Jhum cultivation (NRSA Appraisal Card No, 2) as follows:

(a) The light tone on the image indicates the forest cut, dry and ready for burning.

(b) Actual burning is apparent with profuse smoke

(c) Dark patches denote freshly burnt areas

(d) Areas that have been abandoned after cultivation appear in medium light tone.

It may be noted here that the above mentioned scenario enables a temporal analysis to understand the location and stages of shifting cultivation along with the rate and patter of deforestation.

Reclamation of Desert Land

The Thar Desert, also known as the Great Indian Desert, is a large, arid region in the northwestern part of the Indian subcontinent that forms a natural boundary between India and Pakistan. It is the world's 17th largest desert, and the world's 9th largest subtropical desert. About 85% of the Thar Desert is in India, and the remaining part in Pakistan. In India, it covers about 320,000 sq. km, of which 60% is in Rajasthan and extends into Gujarat, Punjab, and Haryana. This desert comprises a very dry part, the Marusthali region in the west, and a semi-desert region in the east with fewer sand dunes and slightly more precipitation. Rainfall is limited to 100–500 mm per year, mostly falling from July to September.

For reclaiming the Thar Desert and checking the desertification of fertile areas, the Indira Gandhi Canal project was initiated. There is a planting programme for greening the desert in areas near the Indira Gandhi Canal which was started in 1965. It is one of the largest canal projects in India. It starts from the Harike Barrage at Firozpur, a few kilometers below the confluence of the Satluj and Beas rivers in the Indian state of Punjab and terminates in irrigation facilities in the Thar Desert in the north west of Rajasthan state. Previously known as the Rajasthan Canal, it was renamed the Indira Gandhi Canal in 1985 following the assassination of Prime Minister Indira Gandhi. The canal consists of the Rajasthan feeder canal with the first 167 kilometres in Punjab and Haryana state and a further 37 kilometres in Rajasthan followed by the 445 kilometres of the Rajasthan main canal, which is entirely within Rajasthan. The 649 km long Indira Gandhi Canal brings fresh water to the Thar Desert. It was conceived to halt spreading of the desert to fertile areas. A part of Thar desert (Bikaner area) has been extracted from Satellite Atlas of India (2007) prepared by National Atlas and Thematic Mapping Organisation using IRS 1C WiFS data. It may be noted that the spatial resolution of WiFS is 188 m and has only two bands, viz. Band 3 (6.2 mm – 6.8 mm : Red) and Band 4 (7.7 mm – 8.6 mm: near Infrared), hence one of the bands needs to be repeated to prepare a False Colour Composite from the above data set. In the image it is apparent that the desert scenario has been changed drastically due to availability of irrigation water from Indira Gandhi Canal system and part of desert land has been turned into slashing green. The result may be visualized in Fig. 6, where the vegetative cover appears in red colour. Because of different types of treatment, the scenario in India and Pakistan is quite distinctive and the international boundary appears as if a natural one.

The ocean water is a store house of huge amount of marine resources. It has been observed that due to occasional accidents, different types of disasters cause immense loss to these resources. In the following paragraphs, two examples are cited regarding loss of sea water resources in Panay Gulf, Philippines and Gulf of Mexico.

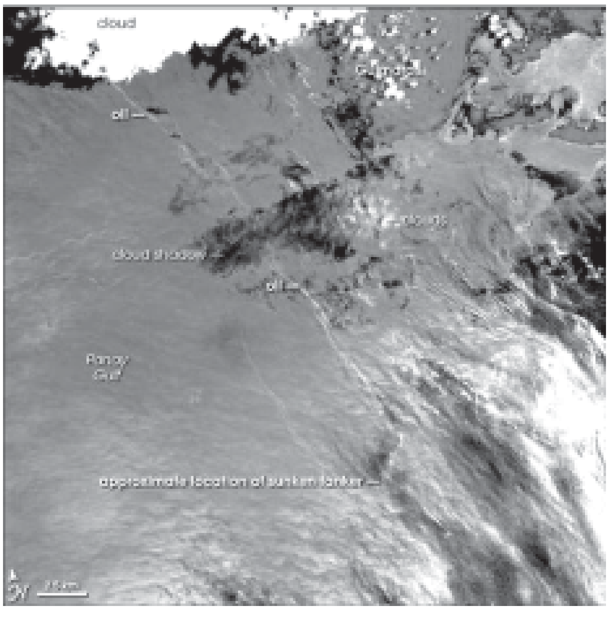
Oil spill in Panay Gulf, Philippines

Strong winds and high waves capsized a tanker off Guimaras Islands in the Philippines on August 11, 2006, spilling more than 200,000 litres of bunker oil into the Panay Gulf, said the Philippines National Disaster coordinating Council. Long strings & patches of oil still drifted, over the water on August, 2006, when the Advanced Space borne Thermal Emission & Reflection Radiometer (ASTER) on NASA's Terra satellite captured this image (http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=17279).

The oil is grey white against the mirror like surface of the water. Dark patches on the water are cloud shadows or areas of still, smooth water. Land is in dark red (Fig. 7).

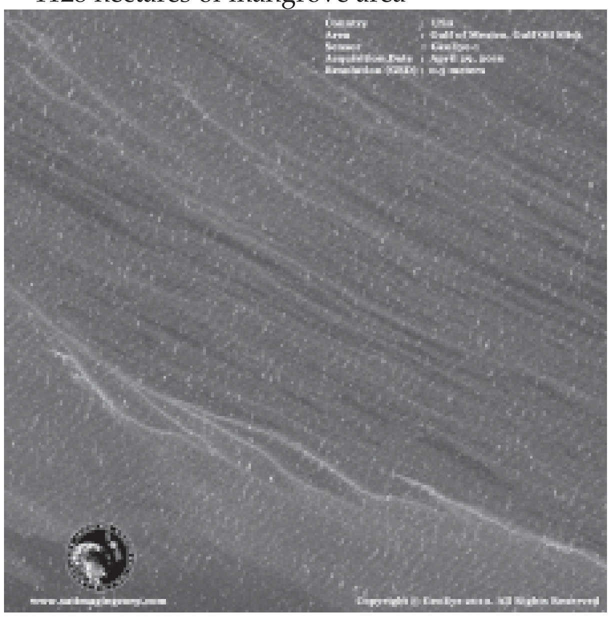
By August 29, the government of Philippines reported that:

- The oil covered 245 km of coast line
- 16 sq. km of coral reef area
- 1128 hectares of mangrove area



Source: http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=17279

Fig. 7: Oil spill in Panay Gulf, Philippines



Source: GeoEye-1,2010

Fig. 8: Sleek of oil at Gulf of Mexico

- 1143 hectares of marine reserve
- At least 17,435 people had been affected by the spill and many coastal residents were evacuated because of toxic substances on the shore.

Oil Sleek in Gulf of Mexico

The Gulf oil spill is recognized as the worst oil spill in U.S. history. Within days of the April 20, 2010 explosion and sinking of the Deepwater Horizon oil rig in the Gulf of Mexico that killed 11 people, underwater cameras revealed the BP pipe was leaking oil and gas on the ocean floor about 68 kilometers off the coast of Louisiana. By the time the well was capped on July 15, 2010 (87 days later), an estimated 3.19 million barrels of oil had leaked into the Gulf.

The well was located over 1,500 meters beneath the water's surface in the vast frontier of the deep sea, a permanently dark environment, marked by constantly cold temperatures just above freezing and extremely high pressures.

Fig. 8 clearly depicts the sleek of oil as linear feature, which was captured by Geo-Eye1 satellite on April 29, 2010 with a spatial resolution of 0.5 m.

CONCLUSION

The above mentioned case studies indicate that environmental hazards can easily be detected and monitored with the help of remote sensing data acquired particularly through different resource satellites. It may be mentioned here that IRS LISS II data sets proved to be extremely efficient and cost effective in this regard. In addition to that Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite system also regularly supplies hazard condition prevailing in different parts of the world. The high resolution data from satellite like GeoEye provides with detail resource information as observed in case of sleek of oil at Gulf of Mexico. The multiband data enhances the basic information, the time series data detect the changing pattern and their combination is very much helpful to assess the natural resource condition and also drawing up management strategies based on available data set.

REFERENCES

1. IPCC (2007), Fourth Assessment Report: Climate Change 2007 Working Group II, "Impacts, Adaptations and Vulnerability", Contents 1010.610.6.2
2. Hasnain, S. I. (2002): "Himalayan glaciers meltdown: impact on South Asian Rivers". IAHS Pub No. 274, pp 1-7.
3. Haq, M.A., Jain, K and Menon, K.P.R. (2011): "Change Monitoring of Gangotri Glacier Using Satellite Imagery", 12th ESRI India User Conference.
4. Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2004): *Remote Sensing and Image Interpretation*, 5th Edition, New York, Wiley, pp.461
5. National Atlas and Thematic Mapping Organisation (2007): *Satellite Atlas of India*, Plate No.18, Kolkata.
6. National Remote Sensing Agency (1989): *IRS Application appraisal card: 002*, Hyderabad
7. — : *IRS Application appraisal card: 006*, Hyderabad
8. ——: (1989): *IRS Application appraisal card: 013*, Hyderabad
9. ——: (1990): *IRS Application appraisal card*: 014, Hyderabad
10. Sarkar, A.K. (2002): "Ravines of Chambal Valley: Reclamation Measures using Remote Sensing Technology", *Changing Environmental Scenario of the Indian Subcontinent*, ed, S.R.Basu, Kolkata, acb publications, pp 203-205.
11. Sarkar, A.K. (2008): "High Resolution Satellite Sensors and their Applications", *The Observer*, Volume 46, The Students' Geographical Association, Kolkata, pp 23-28.
12. Sarkar, A.K. (2012): "Remote Sensing with special reference to High Resolution Satellite Imagery", *Emerging Issues in Geography*, ed, Sukla Bhaduri, University of Calcutta, Kolkata, pp. 203-215.
13. Shen Y, Wang, G, Wu, O and Liu, S. (2002): "The impact of future climate change on ecology and environments in the Changjiang-Yellow Rivers source region", *Journal of Glaciology and Geocryology*, 24(3):308-314
14. Thapliyal, A. and Kimothi, M.M. (2013): "Comparison and Monitoring of Glacier Retreat using Satellite and Ground Method", *International Journal of Soft Computing and Engineering* (IJSCE), Volume-3, Issue-1.
15. WWF (2005): An Overview of Glaciers, Glacier Retreat, and Subsequent Impacts in Nepal, India and China.
16. http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=17279
17. http://earthobservatory.nasa.gov/IOTD/view.php?id=2499
18. https://nsidc.org/cryosphere/glaciers/questions/climate.html
19. *https://simple.wikipedia.org/wiki/Natural_resource www.un.org/documents/ga/res/41/a41r065.htm*

ASSESSMENT OF NATURAL GROUNDWATER RECHARGE IN SELECTED AREAS OF BARDDHAMAN DISTRICT, WEST BENGAL, INDIA

Biswajit GHOSH[1] and Namita CHAKMA[2]

ABSTRACT

Climate change poses uncertainty to the supply of groundwater resource in areas where demand of groundwater is large and supplies of this resource is the key to economic development. So quantification of temporal and spatial distribution of natural groundwater recharge should be given priority for efficient management of this resource. The present work intends to study the groundwater recharge by using the method of soil moisture balance in two selected community development blocks namely Manteswar and Memari-II. Areas have been selected on the basis of their more dependency on groundwater resources. It has been identified that rainfall in monsoon period is the key factor for recharge of groundwater resources and the amount of annual recharge varies from 10% to 20% of the annual rainfall in selected areas.

Keywords: *Groundwater, Climate Change, Recharge, Soil Moisture Balance.*

INTRODUCTION

Increasing population and demand of food are accelerating the stretch of agricultural dimension which in turn are creating severe stress on availability of water. Food and Agricultural Organisation in a report stated that food production will be required to increase by 70% by mid of this century (www.fao.org/docrep/016/.../i3027e.pdf.). This will indeed create additional pressure on already stressed water resource due to which ecological supply system and ecological balance of water will get destroyed. Therefore, assessment and management of groundwater resources need a careful attention at this juncture for sustenance of human being.

Apparently, quantification of spatial and temporal rate of recharge of groundwater should be the fundamental pre-requisite for proper management of this important natural resource particularly in those areas where groundwater is in high demand as the key natural resource to economic development. Particularly, measurement of the rate of aquifer recharge is one of the most difficult tasks (Kumar, 2003).

Therefore, the present article attempts to estimate a comprehensive and holistic picture of recharge of groundwater resources in relation to different climatic parameters in some selected areas of Barddhaman district, West Bengal, India.

STUDY AREA

Barddhaman district holds prime position in rice production in West Bengal, India and therefore, precisely known as 'rice bowl' of the state. In the district about 58 percent of the total population are engaged in agricultural and allied activities (Census of India, 2011).The hydro-geological setting of Barddhaman district has created abundant groundwater resource. But intensive uses of groundwater for irrigation purposes and conventional agricultural practices particularly, in last two decades have caused significant reduction of this natural resource. Most of the C.D.Blocks in eastern Barddhaman produces three crops in a year. As per a report of the State Water Investigation Directorate (Ray and Shekhar, 2009), five C.D.Blocks in eastern part of the district namely, Bhatar, Ketugram-I, Mangalkot, Memari-II, Monteswar are at 'semi-critical stage' (based on stage of ground water development and long term pre-monsoon and post monsoon water level trend). In Manteswar 66.64% and in Memari-II 80.74% of net shown area are irrigated by groundwater which clearly manifests the importance of assessment of recharge of groundwater resource in these blocks (Fig.1).

OBJECTIVE OF THE STUDY

The objective of the present study is to estimate the amount of groundwater recharge in the study area.

MATERIALS AND METHODS

To assess the recharge rate of groundwater different climatic data have been collected from secondary source (http://122.176.66.254/GISWEB/map1.htm). The date ranges from January, 2014 to September, 2015. Collected data have been analysed and represented using Microsoft Office Excel 2003, SPSS-16, and Map-Info professional (0.7) software. Recharge rate has been assessed using water balance approach applied by Kumar (2003) and the formula is as follows:

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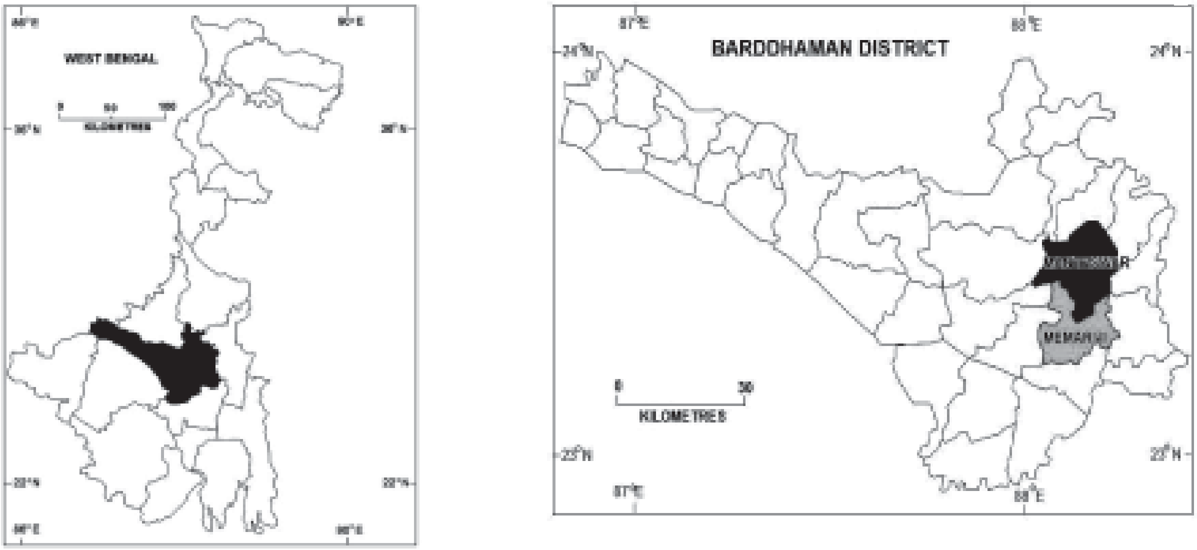


Fig.1 Location of the Study Area.

Gr = P - Ea + ÄS - Ro

Where,

Gr	=	recharge;
P	=	precipitation;
Ea	=	actual evapotranspiration;
ÄS	=	change in soil water storage; and
Ro	=	run-off.

Recharge co-efficient has been calculated as a ratio between total amount of rainfall and total amount of recharge at a particular period of time.

RESULTS AND DISCUSSION

Recharge of groundwater is a natural phenomenon and it is dependent on a number of climatic variables like temperature, precipitation, surface runoff, soil moisture storage, evapotranspiration of the area concerned. The characteristics of these variables have been analysed in the selected blocks namely, Manteswar and Memari-II of Barddhaman district.

Temperature Estimation

Being located in the same tropical region, Manteswar and Memari-II C.D.Blocks are experiencing similar temperature condition throughout the year. Temperature distribution in both the blocks is negatively skewed indicating dominance of summer. Average temperature is 27.17^{o}C where eight months (March to October) experience temperature more than average and rest four winter months (November to February) experience temperature less than average. The month of April shows the maximum temperature (33^{o}C) whereas; the minimum temperature is experienced by the month of January (Fig. 2).

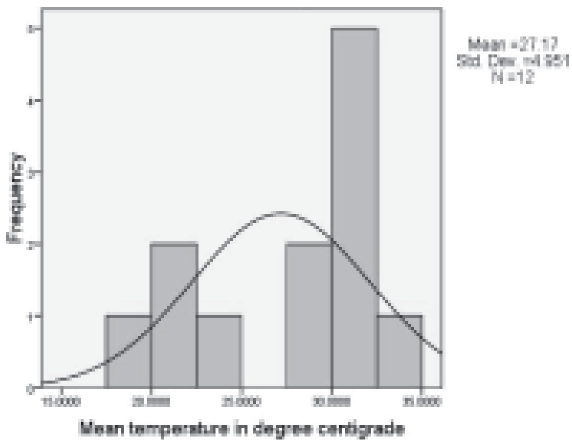
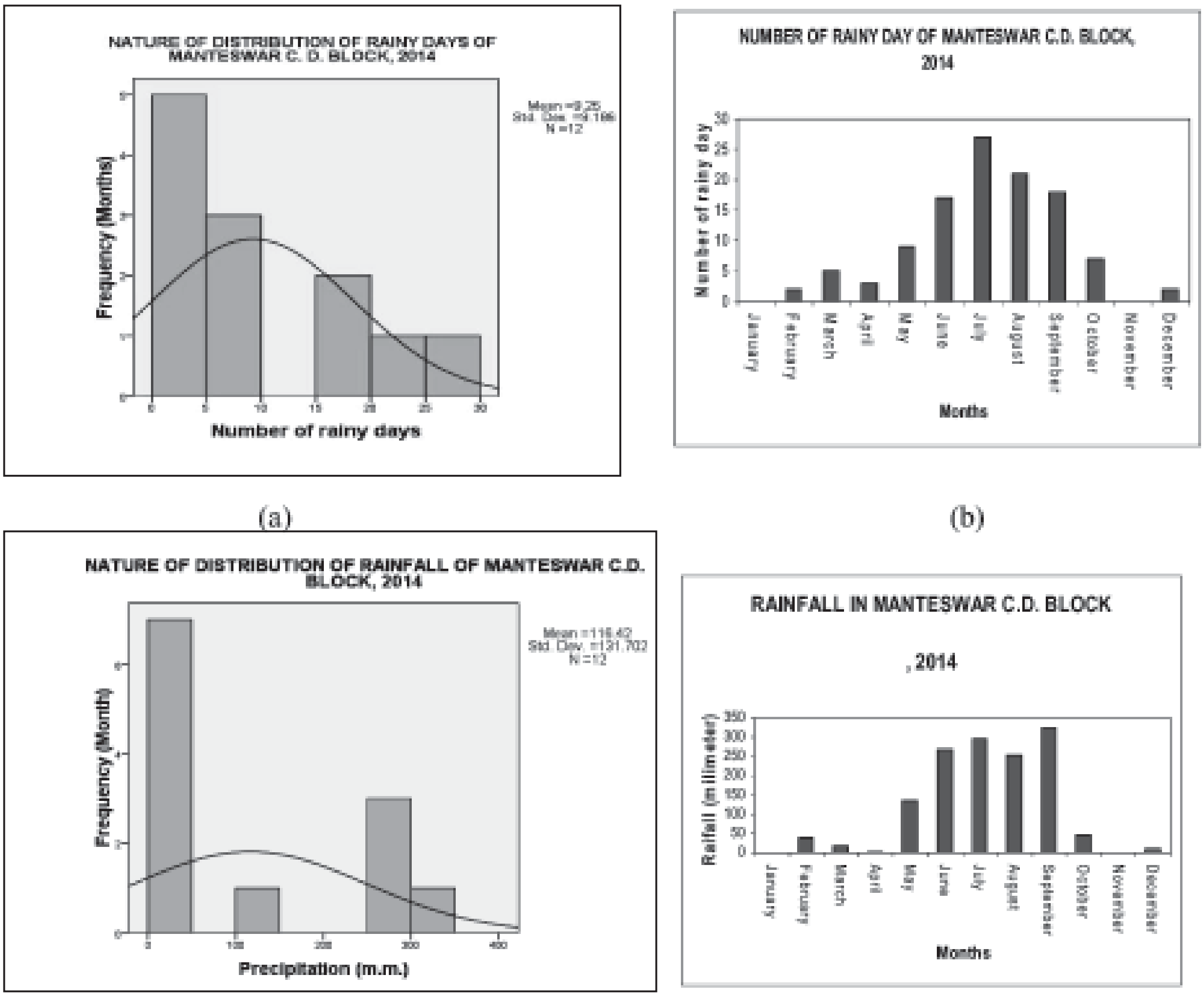


Fig. 2 Distribution of Temperature in the Study Area, 2014

Rainfall Estimation

Due to monsoon climatic condition rainfall is not uniformly distributed throughout the year. 82% of rainfall occurs in summer i.e. from the month of July to September in Manteswar block and because of this positive skewness of both the distribution of rainy days and distribution of amount of rainfall have been observed. Total rainfall of this block recorded as 1397 millimeters in 2014. Maximum rainfall occurred in the month of September (326 mm). In winter (December to February) number of rainy days and amount of rainfall are minimum. The months of January and November are devoid of any rainfall. Such uneven distribution of rainfall play important role in creating an uneven pattern of recharge of ground water (Figs. 3: a,b,c, & d). Due to similar

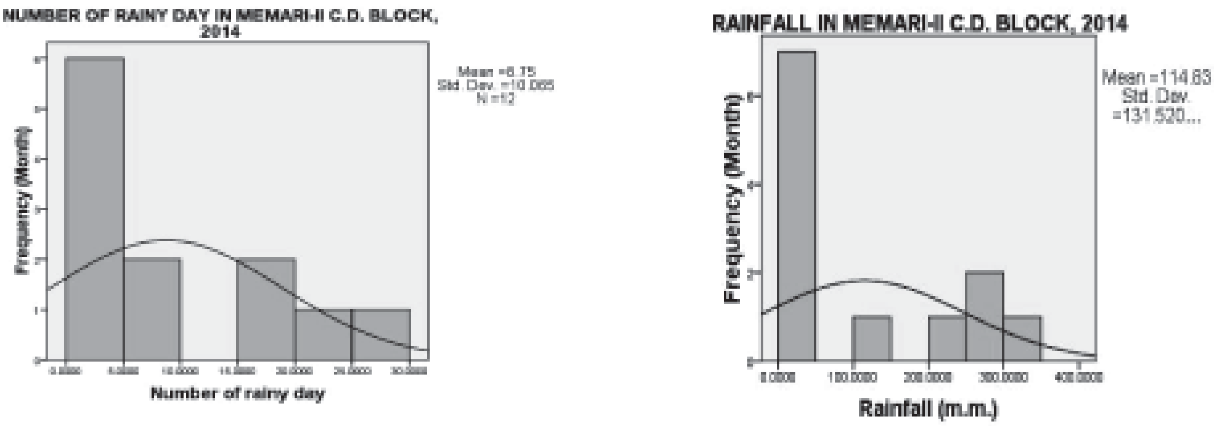


(a) (b)

(c) (d)

Fig. 3

geographical condition we observe same characteristics in the perspective of rainfall in Memari-II C.D.Block. The mean rainfall per month in Manteswar is 116.42 mm whereas; in Memari-II it is 114.83 mm. Both the blocks are showing same deviation in its distribution (see Fig. 4: a, b).

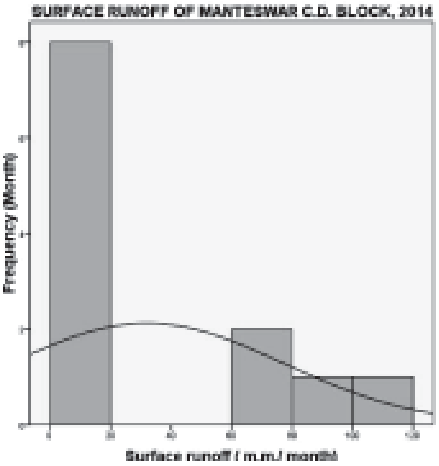


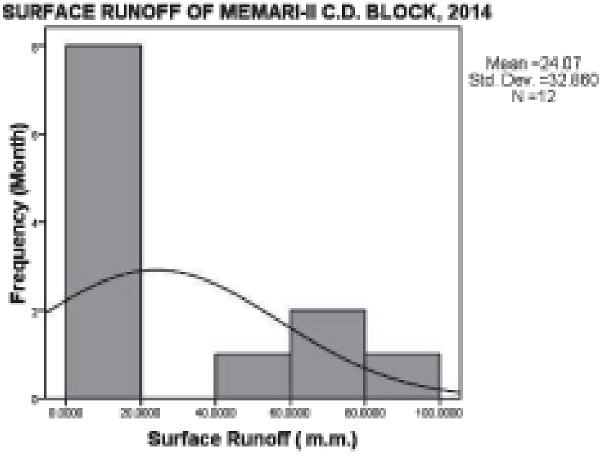
(a) (b)

Fig. 4

Surface Runoff Estimation

Surface runoff in both the C.D.Blocks is positively related with the pattern of rainfall throughout the year and distribution pattern is not normal. It is significant in rainy season (June to September) and



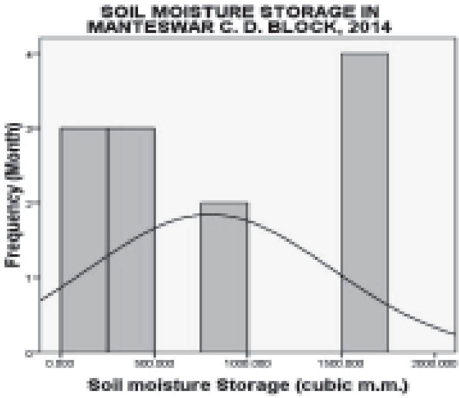


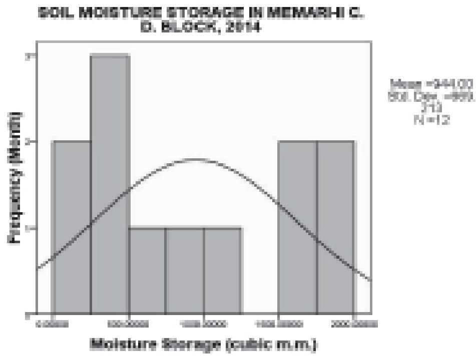
(a) Fig. 5 (b)

creates a favourable condition for groundwater recharge. In both the blocks it is positively skewed but the mean surface runoff in Manteswar is 31.98 mm/month whereas, in Memari-II, it is 24.07 mm/ month¯it is due to the existence of Khari river in Manteswar block. It has also been found that Memari-II, is showing less deviation in terms of distribution than Manteswar. Eight months (October to May) with very low surface runoff in both the C.D.Blocks, creates an unfavorable condition with more discharge than recharge (Fig. 5: a, b).

Soil Moisture Storage Estimation

Soil moisture storage is dependent on the quality of soil and infiltrated water increases the level of groundwater. Such recharge of groundwater is high in rainy season due to increased amount of rainfall. The rainy season records more storage of soil moisture in both the blocks and its pattern of distribution is positively skewed throughout the year. The mean value of this variable is more in Memari-II (944 mm^3) than Manteswar (798.2 mm^3) but Memari–II, is showing more deviation than Manteswar (Fig. 6: a, b).





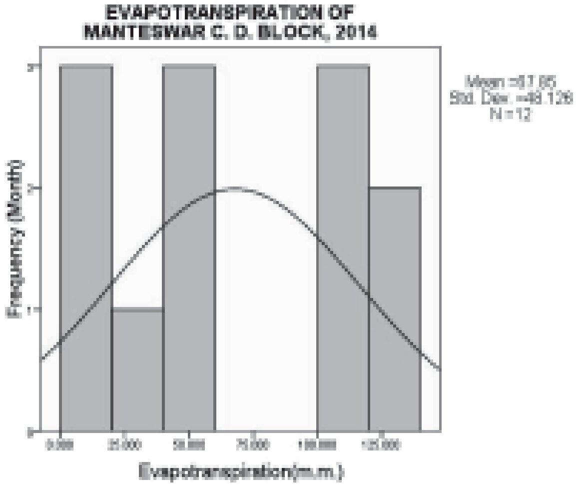
(a) Fig. 6 (b)

Evapotranspiration Estimation

Evapotranspiration is positively related with temperature and rainfall in both the C.D.Blocks. It is very high in rainy season when both rainfall and temperature are high whereas, when temperature is high and rainfall is low in summer then evapotranspiration is found to be low. In winter evapotranspiration is normally low due to decreased temperature and rainfall. Its distribution is positively skewed in these two blocks. Its mean value is more in Memari-II than Manteswar but deviations from mean are equal (Fig. 7: a,b).

Groundwater Recharge Estimation

Therefore, groundwater recharge is a combined effect of temperature, rainfall, surface runoff, change in soil moisture storage and evapotranspiration. Amount of recharge in Manteswar is 14.42% of the total rainfall and in Memari-II, it is 16.86%. Due to lack of rainfall, loss of soil moisture caused by evapotranspiration and withdrawal of groundwater; the months of January, March, April, October, November and December experience discharge of groundwater. Discharge is maximum in the months of October and November which is caused by lack of rain and relatively high temperature than winter season. High amount of rainfall by summer depression in the month of May and by south-east monsoon in the month of June, July, August and September; groundwater is recharged significantly in both the



(a)

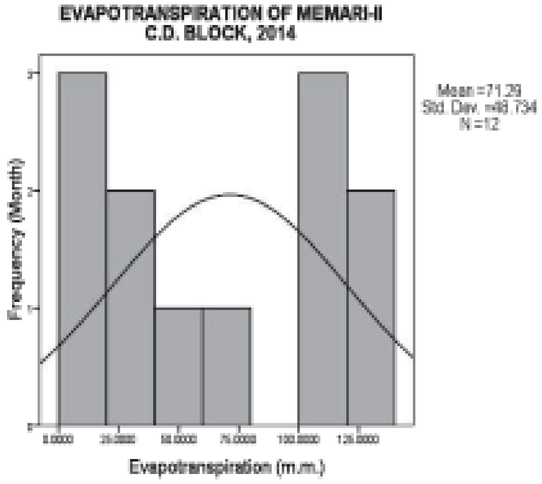
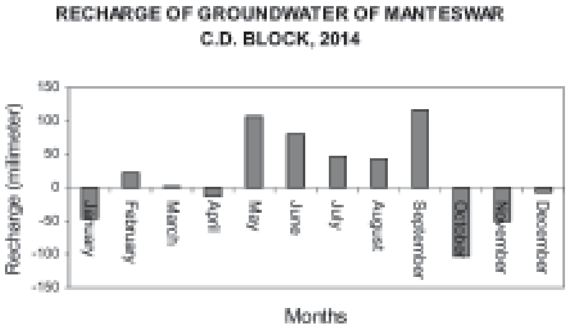


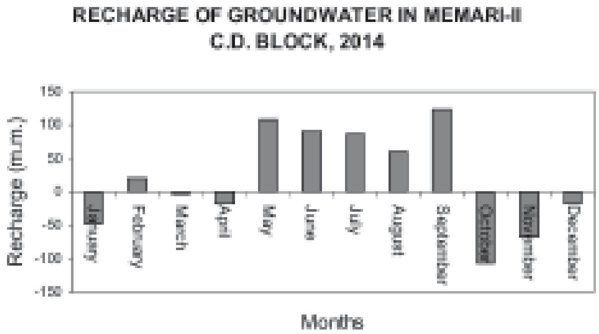
Fig. 7

(b)

C.D.Blocks. Average recharge of groundwater in Memari-II is 19.36 m.m./month and in Manteswar it is 16.78 m.m./month. The distribution of recharge is positively skewed throughout the year but deviation of recharge from average value is more in Memari-II, than Manteswar (Fig. 8: a,b,c,& d).



(a)



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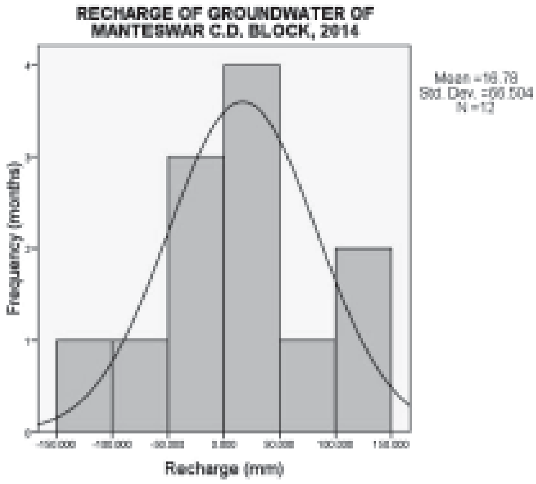

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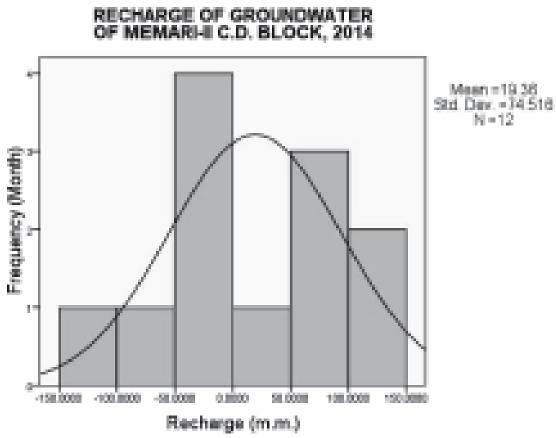


Fig. 8

(d)

Relationship among Variables and Identification of Principal Factors through PCA Technique

To find out the dominant climatic factors influencing the recharge of groundwater, Principal Component Analysis (PCA) technique has been applied using SPSS 16 software. For the C.D.Block of Manteswar, results show that the selected variables have extracted 96.037 % of the variance up to tertiary loading. In primary and secondary loadings variables have extracted 87.537% of the variance. In primary loading, variables have extracted 64.716% of the variance with strong positive linkage with other variables. All

Table-1
Correlation matrix for Manteswar and Memari-II C.D.blocks, Barddhaman

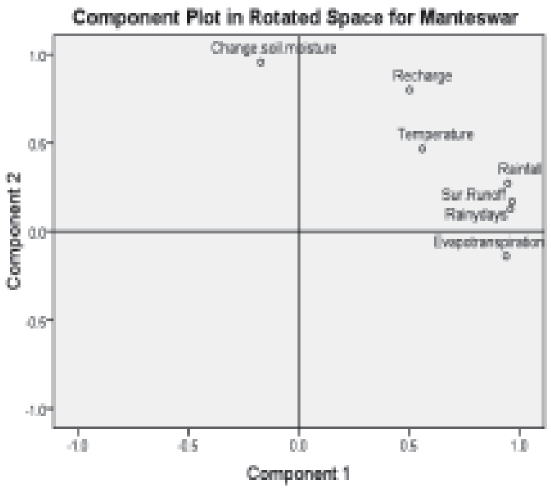
Correlation Matrix for Manteswar

Statistics							
	.000	597	481	312	499	554	491
	597	.000	961	007	857	947	606
	481	961	.000	.044	824	960	617
	312	007	.044	.000	.249	090	643
	499	857	824	.249	.000	838	314
	554	947	960	090	838	.000	747
	491	606	617	643	314	747	.000

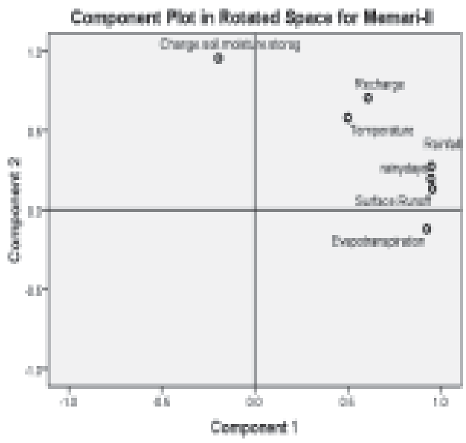
Correlation Matrix for Memari-II

Statistics							
1	.000	534	497	407	489	549	517
2	534	.000	892	022	859	950	725
3	497	892	.000	.082	802	971	731
4	407	022	.082	.000	.240	076	539
5	489	859	802	.240	.000	811	372
6	549	950	971	076	811	.000	823
7	517	725	731	539	372	823	.000

Note: Where, 1 = temperature in degree centigrade, 2 = number of rainy days, 3= surface runoff, 4 = change in moisture storage, 5= evapotrans-piration, 6= rainfall, 7= recharge of groundwater.



(a)



(b)

Fig. 9

factors except change in soil moisture storage (mm) have been loaded positively in primary loading, so these are the dominant factors in this loading. In secondary loading, only one factor like evapotranspiration has been loaded negatively. Therefore, the rest of the variables have become dominant in secondary loading. Five factors like recharge, temperature (°C), surface runoff (mm), rainfall (mm) and number of rainy days have been loaded positively in both primary and secondary loading. Therefore, we can say that variables like temperature (°C), surface runoff (mm), rainfall (mm) and number of rainy days are more significant for controlling the recharge of groundwater than other variables. As evapotranspiration and soil moisture are controlled by rainfall and temperature so, these variables are less significant than others. For the C.D.Block of Memari-II, results show that the selected variables have extracted 95.986% of the variance up to tertiary loading. In primary and secondary loadings variables have extracted 87.434% of the variance. In primary loading, variables have extracted 65.640% of the variance with strong positive linkage with other variables. Therefore, same result has been found for Memari-II also. (Table-1 and Fig. 9: a,b).

Groundwater Recharge Estimation During 2014 And 2015: A Comparison

To make a comparative study, data have been collected for 2015 also (up to September) and groundwater recharge has been estimated applying the same method. Finally, the results of both the years along with other climatic parameters have been compared using ‘z’ test (Das, 2010) as follows:

Let us take the *null hypothesis* that there is no significant difference in average temperature (°C) between the year 2014 and 2015 in Manteswar, against alternative hypothesis that average temperature (°C) is less in 2014 than that in 2015. That is symbolically we can write as,

H_0: $\mu_1 = \mu_2$, against alternative, i.e., H_1: $\mu_1 < \mu$

$$z = \frac{\overline{X_1} \quad \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} \quad \frac{S_2^2}{n_2}}} \qquad 0.9936$$

Where, H_o is null hypothesis and H_1 is alternative hypothesis; $\overline{X}$ the mean, *S* the standard deviation and *n* is the sample size. (The same statistics has been applied in all other cases.)

Since, the calculated value of | Z | = 0.9936 is greater than the critical value of 1.64 at 5 % level of significance, the *null hypothesis* is accepted. Hence, it is inferred that there is no significant difference in average temperature (°C) between the year of 2014 and 2015 in Manteswar. Similar calculation has been used for other cases. Thus the result is showing that recharge of groundwater along with other climatic variables differ significantly between the year 2014 and 2015 in both the C.D.Blocks and are more in intensity in 2015 than in 2014 (Table-2, 3; Fig. 10: a,b).

Though temperature in both the years are similar but number of rainy days and amount of rainfall in 2015 are more than in 2014, therefore, intensity of surface runoff, soil moisture storage have been increased in 2015 with the resultant increase in recharge of groundwater. Groundwater in the month of January in 2015 is experiencing recharge instead of discharge

Table-2

Comparison of recharge and other climatic factors, Manteswar C.D.Block (2014-2015)

Climatic factors	Manteswar, 2014 Mean	S.D	No. of month	Manteswar, 2015 Mean	S.D	No. of month	|z| value	Tabulated |z| value at 5%level of significance	Difference at 5% level of significance
Temperature (°C)	27.17	4.95	12	28.11	3.86	9	0.9936		No difference
No. of rainy day	9.25	9.19	12	11.89	9.89	9	1.8658		Differs significantly
Surface runoff (mm)	31.98	45.02	12	85.42	126.42	9	12.085		Differs significantly
Soil moisture (cubic m.m)	798.2	649.33	12	1022.18	737.85	9	18.515		Differs significantly
Evapotranspiration (m.m)	67.85	48.13	12	77.01	50.56	9	2.8499		Differs significantly
Rainfall(m.m.)	116.42	131.7	12	229.89	319.29	9	15.907		Differs significantly
Recharge of groundwater	16.78	66.5	12	50.26	202.61	9	6.026	1.64	Differs significantly

Source: Calculated by authors

Table.3

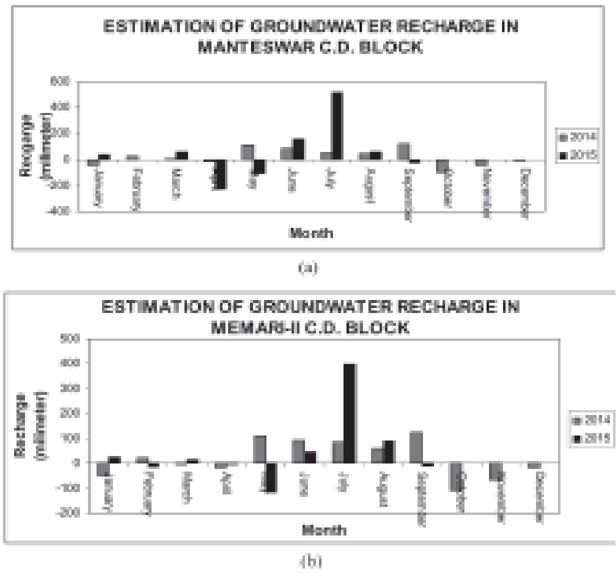
Comparison of recharge and other climatic factors of Memari-II C.D.Block (2014-2015)

Climatic factors	Memari-II, 2014 Mean	S.D	No. of month	Memari-II, 2015 Mean	S.D	No. of month	|z| value	Tabulated |z| value at 5%level of significance	Difference at 5% level of significance
Temperature	27.17	4.95	12	28.11	3.86	9	0.993611		No difference
No. of rainy day	8.75	10.06	12	11.33	9.18	9	1.830831		Differs significantly
Surface runoff	24.07	32.86	12	80.29	130.6	9	12.87758		Differs significantly
Soil moisture	944	669.21	12	1213.8	666.8	9	22.87722		Differs significantly
Evapotranspiration	71.29	48.73	12	85.03	46.6	9	4.369986		Differs significantly
Rainfall	114.83	131.52	12	206.67	289.8	9	13.36995		Differs significantly
Recharge of groundwater	19.36	74.52	12	47.5	142.4	9	5.743605	1.64	Differs significantly

Source: Calculated by authors

in 2014. Due to more intensive rainfall, the months of March, June, July and August in both the C.D.Blocks are experiencing more recharge of groundwater in 2015 than 2014. Highest amount of recharge is found in the month of July, 2015. Because of higher rate of evapotranspiration caused by prevailing dry condition and very low amount of rainfall, the months of April, May and September of 2015 have experienced more discharge of groundwater in Manteswar and Memari-II C.D.Blocks.

Fig.10



CONCLUSION

Manteswar and Memari-II C.D.Blocks are situated in alluvial tract of Ganga Delta and fall under monsoon type of climate. Temperature in nine months (April to November) is relatively high than three winter months (December to February). Four months (July to September) receive excessive amount of rainfall. Thus temperature and rainfall are two important variables that determine other variables which control the amount of recharge and discharge of groundwater. Both the C.D.Blocks account for 10% to 20% recharge of the total amount of rainfall in 2014 and 25% in 2015 which fulfill the actual norm of recharge of an alluvial tract.

REFERENCES

1. Das, N.G. (2010). *Statistical Method*, Combined Edition (Volume I & II), Tata McGraw Hill Education Private Limited, New Delhi

2. Kumar, C. P. (2003). Estimation of Ground Water Recharge Using Soil Moisture Balance Approach, *National Institute of Hydrology, Technical Report No. TR-142*, pp: 66

3. *Provisional Census, 2011*, Barddhaman District. Retrieved on August 10, 2015 at 10:45 am URL-www.censusindia.gov.in

4. Ray, A. and Shekhar, S. (2009). Ground Water Issues and Development Strategies in West Bengal, *Bhujal News*, Vol.24(1), pp.1-17

5. The state of food insecurity in the world-2012-*Food and Agricultural Organisation*. Retrieved on February 2, 2015 at 10:25 am, www.fao.org/docrep/016/.../i3027e.pdf

6. WEB GIS of West Bengal Accelerated Development of Minor Irrigation Project. Retrieved on August 12, 2015 at 10:15 am, http://122.176.66.254/GISWEB/map1.htm

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TEMPORAL LAND USE LAND COVER CHANGE DETECTION FOR THE NATURAL RESOURCE MANAGEMENT AND MONITORING USING GEOSPATIAL TECHNOLOGY- A CASE STUDY FROM "KANNAN DEVAN HILLS" WESTERN GHATS REGION OF KERALA

B.K. JAYAPRASAD[1] & R. ANILKUMAR[2]

ABSTRACT

Kannan Devan Hills (KDH) village in Idukki district of Kerala state is a bio-diversity hotspot situated in southern Western Ghats bounded by National Parks of Eravikulam, Anamudi Shola, Pambadum Shola and Mathikettan Shola. Geologically this area is coming under the Pre-Cambrian granulite terrain. Planters from Europe and labourers from eastern Tamil plains moved to KDH in the late 19th century and extensively converted forests and grasslands for tea plantation. Munnar in KDH became a bustling tourism destination paving the way for massive infrastructure development. An attempt has been done to analyse the temporal land use and land cover change using geo-spatial technology tools such as Remote sensing, Global Positioning System and Geographical Information System in order to understand the trend of land use/land cover changes of this ecologically sensitive area. The data base used for the analysis are Survey of India Toposheets 1920-21 (1:63360), SOI-Open Series Maps published in 2010 (updated 2005-2006) and latest Geo-Eye Satellite data with a spatial resolution of 0.5m. Common Ground Control Points (GCPs) with WGS 84 Datum have been established using Dual frequency Global Positioning System (DGPs) for image registration. The digital database was integrated in a GIS platform. The land use / land cover vector data generated using Arc GIS software for the study area is categorized in to 10 classes. The results show that during the last nine decades settlement area has been considerably increased to 9971.17 % and there is a decline in natural forest area by 28.77%. Rocky surface / Rocky cliff area have also been exposed to 29.43% due to erosion in highly undulated fragile terrain and which reduced the growth of natural grass. There were 314.09 hectares of Eucalyptus plantation in 1920s but at present there are 9879.60 hectares i.e 17.82% of total Geographical area of KDH has the same. Eucalyptus is planted for fuel wood for processing tea. Agriculture areas have found increased to 600.29 %. Area and amount of change in different land use/ land cover categories are presented in tables and maps. Temporal landuse/landcover change detection is essential for understanding the degree of fragility of ecologically sensitive areas for monitoring and managing natural resources for its sustenance.

***Keywords**: Kannan Devan Hills (KDH), Ground Control Points (GCPs), WGS 84 Datum, Ecologically Sensitive Area, Dual frequency Global Positioning System (DGPS).*

INTRODUCTION

Land use land cover change is one of the main driving forces of global environmental change including the climate change. Land use and land cover change is scalar and dynamic. The in Land cover changes occur by natural processes in the absence of human activities. Many socio economic and environmental factors are also involved for the change in land use and land cover. Land use land cover manifests the level and degree of human intervention on environment. The land use land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land use land cover changes are the major issues and challenges for the eco-friendly and sustainable development for the economic growth of an area. The growing population, anthropogenic activities such as deforestation and mining, soil erosion, global warming and environmental pollution are very harmful for the natural environment. In order to improve the economic condition of the area without further deteriorating the bio-environment, every bit of the available land has to be used in the most rational way. This requires the present and the past land use / land cover data of the area. (Chaurasia et al.1996). The land cover of the Earth has a central role in many important biophysical and socioeconomic processes of global environmental change. Contemporary land cover is changed mostly by human use; therefore, understanding of land-use change is essential in understanding land-cover change (Turner et al., 1995). Land use is defined through its purpose and is characterized by management practices such as logging, ranching, and cropping. Land cover is the actual manifestation of land use (i.e., forest, grassland, cropland) (IPCC,

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2000). Land-use change and land-cover change (LUC-LCC) involve several processes that are central to the estimation of climate change and its impacts (Turner et al., 1995). Land use applications involve both baseline mapping and subsequent monitoring. The timely information is required to know the current quantity of land which is in use and to identify the land changes from year to year (Kumaraswamy and Narayanakumar, 2005). Detection of long term changes in land cover may reveal an idea for the shift in local or regional climatic conditions and analyzing the basis of terrestrial global monitoring (Navalgund, R.R., et al., 2007). Land use and land cover mapping serves as a basic inventory of land resource for all levels of government, environmental agencies and private industries throughout the world (Vijith and Satheesh, 2007). Change detection in land use and land cover can be performed on a temporal scale such as a decade to access landscape change caused due to anthropogenic activities on the land (Gibson and Power, 2000). Change detection in the land use/ land cover involves use of at least two period data sets (Jenson, 1986). Land use changes have potentially crucial anthropogenic influences on the terrestrial water cycle.

Remote Sensing (RS), Global Positioning System (GPS) and Geographic Information System (GIS) are now inevitable tools for advanced eco-natural resource management and monitoring. The remotely sensed data facilitates the synoptic analyses of natural resources/ cultural resources, function, patterning, and change at local, regional and global scales over time. These types of data integrated with legacy historical data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity. The present study describes changes in various landuse/ landcover categories of the study area "Kannan Devan Hills" village in Idukki district of Kerala state, which is one of the bio-diversity hotspots in southern Western Ghats in India. The present study has been taken up in order to understand the amount of change in different land use/land cover categories in the study area for about a century. The study area was a completely virgin tract covered with thick forest until 1879, when Mr. J.D. Munro and Mr. A.W. Turner formed the North Travancore Land Planting and Agricultural Society and started planting crops like sisal, coffee, cardamom, etc. Then, in the year 1897, Finlay Muir & Co. of Glasgow became interested in this area & formed the Kanan Devan Hills Produce Co. Ltd. Thus the flagship company KDHP was formed, and its two subsidiaries – the Anglo-American Direct Tea Trading Company and the Amalgamated Tea Estates Company – were formed subsequently, became more interested in the development and cultivation of tea among all other crops.

OBJECTIVES

The major objective of the present investigation is to assess the temporal land use/ land cover change detection in Kannan Devan Hills Village, a most fragile and ecologically sensitive zone in the southern Western ghats in Kerala using geospatial technology for providing suggestions for natural resource management. It is also aimed to evolve a sound methodology for monitoring changes in land use/ land cover of fragile ecosystems.

The study area (fig.1) "Kannan Devan Hills" village in Kerala State extends between 76°53' 57.53" and 77° 14′ 42.97" East longitudes and 10° 02′ 5.08" to 10° 18' 51.08" North latitudes. Total area covered is 554.290 Sq:kms. KDH is the part of Western Ghats represents geomorphic features of immense importance with unique biophysical and ecological processes. It controls the mountain weather pattern. It is a part of hottest hotspots of biological diversity and having high geological, cultural and aesthetic values.

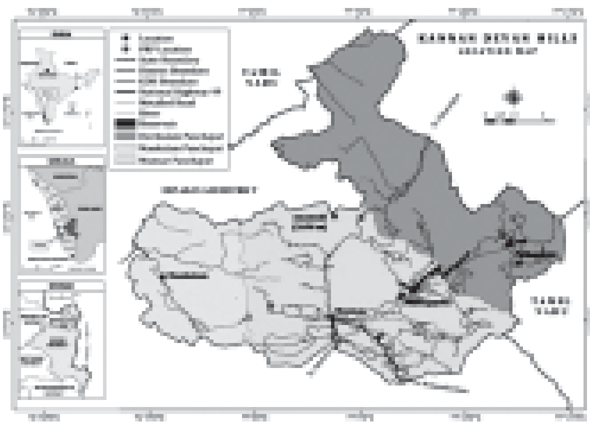

Fig.1 Study Area

The climate in the High Ranges is subtropical to temperate, due to the high elevation, causing a drop in air temperature. Being located at the edge of the escarpment which faces the Arabian Sea, the annual rainfall shows a wide variation - from 130cm in the eastern end to 600cm in the western end, all within an aerial distance of 26km. The annual precipitation varies between 160 cm and 250 cm. The annual average minimum temperature is 13° C and the annual average maximum temperature is 22° C, with the maximum temperature varying between 18° C to 28°C during a year. During the winter season, the minimum temperature drops below freezing point in a few locations, resulting in frost. The humidity levels drop significantly during the dry weather period, especially during February-March. The west facing areas are exposed to moderate to severe wind during the south-west monsoon period.

The area falls within the highest hill ranges and peaks of the Western Ghats. Anaimudi 2695 m, which is the highest peak in Peninsular India, is situated within this rugged hilly terrain. Geologically this area is part of the Archaean system. The rocks formed in this area are made up of Metamorphic Archaean i.e. Precambrian rocks represented by Charnockite, Granite, Silimanite, Gneiss, Biolicgneis and Magnatites. Most of the exposed gneiss, which is 2500 million years old, has undergone metamorphism. The area is mainly composed of layered gneiss, granites and migmatites. Gneisses of granitic composition, migmatites and granite are the predominant rock units in the area whereas biotite gneiss and calc granulite occur as bands and lenses within these rock units. The regional foliation seen in the area is the main structural element which deciphers the interrelationship and structure of these gneissic rocks.

The study area has seven extensive tea gardens owned by KDHP Ltd, Eravikulam National park, Natural forests and Munnar town spread in three local bodies viz, Munnar, Devikulam and Mankulam with a population of 65,333 persons (Census of India 2011)

DATABASE AND METHODOLOGY

Data used:

(a) Survey of India toposheets nos. 58B/16, 58 F/3 and 58 F/4 in 1:63,360 published during the year 1920-21 with Modified Everest Datum & Poly Conic Projection

(b) Survey of India OSM (Open Series Map) nos. C43 K16, C43 L3& C43 L4 in compiled on 1:25,000 scale during 1982-83 and updated for major details during 2005-2006 and published in 1:50,000 scale during 2010 with WGS 84-Datum and UTM Zone 43 Projection

(c) High resolution image downloaded from Google Earth, GeoEye –World View image using the Time Slider for the year 2014

(d) Post processed PRP (Principal Reference Points) and GCP values generated through DGPS (Differential Global positioning System) survey in Kannan Devan Hills Village during the year 2010 by NCESS (Four PRPs and 116 GCPs (Ground Control Points).

A standard vector outline shapefile with 12.5 Sq.Km grids with unique Column and Row numbers of the study area has been converted to KML using ArcGIS 10.3 and imported in Google Earth. Each Square Grids has been zoomed in to an appropriate Eye Altitude (4.8 Km) to get High Resolution images with the "Save image option" available in Google Earth and saved in .jpg format. Thus the downloaded seventy seven image frames from the Google Earth have been cleaned and mosaiced without loosing the pixels of the adjacent features. The mosaic image has been geo-referenced in ERDAS Imagine 2015 software using the Principal Reference Points values (post processed) of the objects from where PRPs were captured and rectified using the post processed GCP values, by pointing the objects which are discernible in the mosaic. The mosaic has been projected in WGS 84 Datum and UTM Zone-43 projection. The scanned and cleaned images of topographical sheets have been registered and rectified with reference to the projected mosaic by image to image registration and saved in .img format in ERDAS.

Onscreen vectorizations have been carried out to generate ten categories of land use/ land cover layer for the study area from the rectified topo images for the periods 1920-21 & 2005-06 and satellite image for the year 2014 using ArcGIS 10.3. Topo images were interpreted based on the symbology, colours and other information available in toposheets. Eight interpretation elements such as size, shape, shadow, tone, color, texture, pattern and association have been considered for the on screen interpretation of rectified satellite imagery. Topology has been validated for computing accurate geometry and area for the geodatabase generated for all three periods.

DISCUSSION AND ANALYSIS

Based on the temporal data base LULC for the study area with an area of 554 Sq:Kms has been classified into ten categories: Agricultural land, Cardamom, Forest, Grassland/Scrub land, Eucalyptus plantation, River/Water body, Rock Outcrops, Rubber Plantation, Tea Plantation and Settlements (Table 1). The annual rates and cumulative amounts of Landuse/Land cover changes were estimated over the time periods: 1920 to 2006 (Period1), and 2006 to 2014 (Period 2). It is observed that rate of change for Forests, Grass lands, Rock outcrops and Agricultural land are negative. Forest area has been reduced at an average rate of 108.82 hectares per year for the period 1920 to 2006. Grass land also showed a reduction in extent i.e @ 66.80 hectares per year. The area under eucalyptus plantation increased to 9879.60 hectare in 2014 from 314.09 hectares in 1920. It shows that the area of eucalyptus plantation has been increased at the rate of 101.76 hectare per year. The increase in water body noted is due to the construction of the two reservoirs, viz., Mattuppetty and Kundala dams. This is also cause for the reduction of natural forest. The area under tea plantation, rubber, cardamom and settlement has been considerably increased during the period under investigation (Table 1). The reason

Table 1
Detection of 94 Year Changes in LULC in KDH based on Time Series Toposheets and Images of 1920, 2006 and 2014 (Negative Values Indicates a Decrease)

Landuse/ Landcover	Land area (ha)			Rate of LULC change (ha yr -1)			Amount of LULC change (%)
	1920	2006	2014	1920 -2006	2006 -2014	1920 - 2014	1920 -2014
Forest	22795.18	13436.50	16237.73	-108.82	350.15	-69.76	-28.77
Grass Land/Scrub Forest/Scrub Land	19700.75	13955.78	10230.24	-66.80	-465.69	-100.75	-48.07
River/Waterbody	11.44	529.50	541.03	6.02	1.44	5.63	4627.76
Rock Out Crops / Rocky Cliff	2002.00	1100.74	2591.13	-10.48	186.30	6.27	29.43
Tea Plantation	10219.13	13931.83	10599.62	43.17	-416.53	4.05	3.72
Eucalyptus Plantation	314.09	9305.18	9879.60	104.55	71.80	101.76	3045.44
Rubber	239.18	1324.87	1021.86	12.62	-37.88	8.33	327.23
Cardamom Plantation *	0.00	1526.90	2635.58	17.75	138.59	28.04	72.61
Agriculture Land	140.27	117.75	982.30	-0.26	108.07	8.96	600.29
Settlements	7.05	200.08	710.02	2.24	63.74	7.48	9971.17
Total	55429.10	55429.10	55429.10				-

* Amount of LULC change % for 8 years only

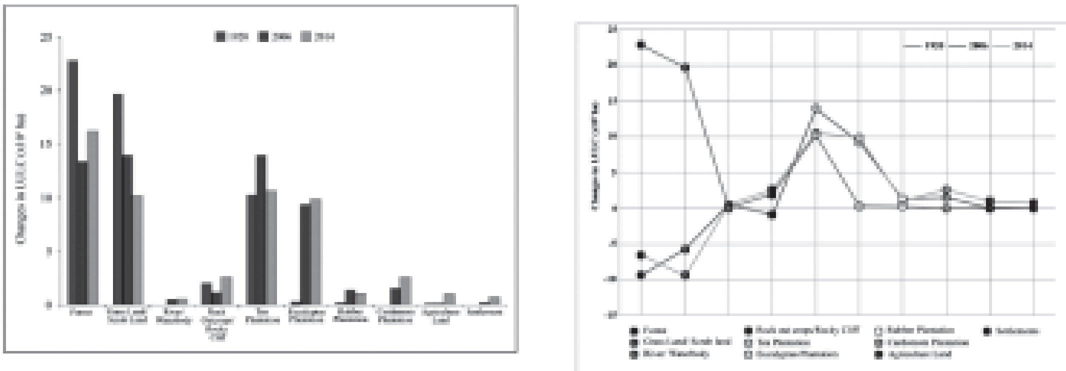

Fig: 2 LULC Changes- 1920-2014

for reduction of Forest and Grass land are the alteration of natural areas for planting tea and eucalyptus during the period. The settlement growth is also remarkable during the period. During 1920 there was only 7.05 hectares of settlement area but in 2006 it had grown to 710.02 hectares in 2014 i.e 9971.17%. This clearly shows the alteration of natural landscape and development of infrastructure in the study area during 1920 to 2014.

The temporal LULC change of 2006 to 2014 shows a positive growth for Forest, Water body, Rock outcrop, Eucalyptus plantation, Cardamom plantation, Agricultural land and Settlement (Table 1) . Grass land had been considerably reduced at the rate of 465.69 hectare per year for the last eight years and at the same time Forest area had been indicated a positive growth of 350.15 hectare per year. This may be due to the afforestation programmes implemented

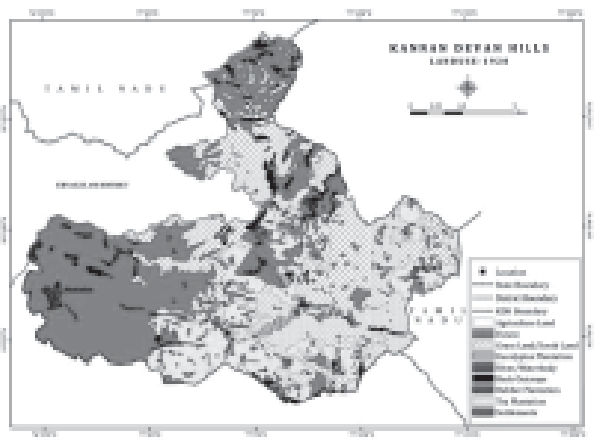

Fig: 3 LULC 1920

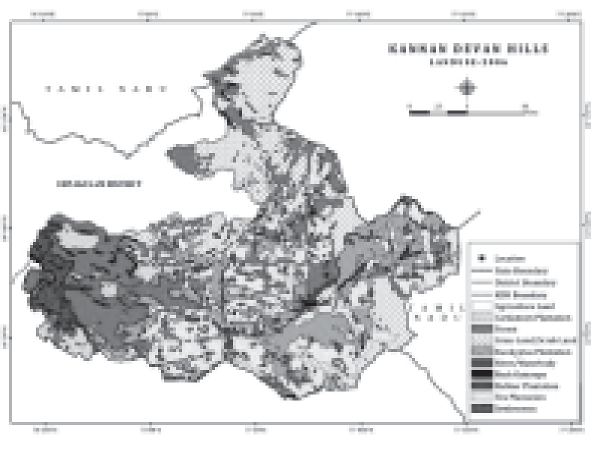

Fig : 4 LULC 2006

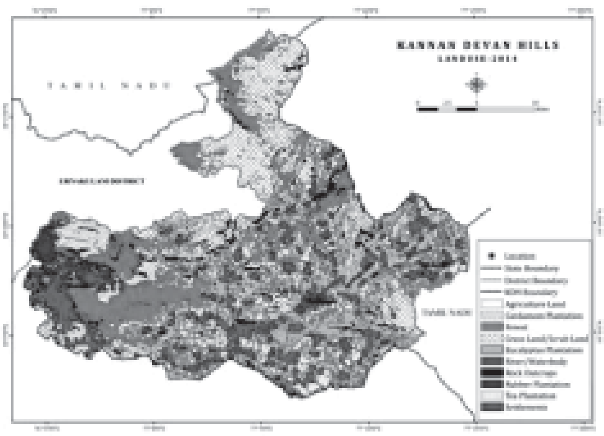

Fig : 5 LULC 2014

by the government during the period. Tea plantation areas had been reduced due to abandonment of certain tea plantations, whereas area under settlements, agriculture and eucalyptus plantations in the study area has recorded a significant increase. Built up area for the development of Infrastructural facilities has increased significantly at Munnar, Mankulam, Mattuppetty and Yellappatty divisions. Rock out crops increased due to soil erosion and as an out come of landslides occurring in the area during monsoons. It warrants attention to control soil erosion and to promote afforestation acivities in the deteriorated Grass lands and Shola forests.

When we consider the LULC change for the period 1920-2014 (Fig.s 3,4& 5), there is an annual reduction in Forest and Grassland area at the rate of 69.76 and 100.75 hectares respectively. When we consider amount of land use change in percent during the period 1920-2014, settlement area has been increased 9971% (7.50 hectare in 1920 to 710.02 in 2014) followed by water body 4627%, Eucalyptus 3045.44%, Agricultural land 600.29%, Rubber plantation 327.23%, Cardamom 72.61 %, Rock outcrop 29.43% and Tea plantation 3.72%. The result clearly show that the degradation of natural ecosystem, fragmentation of forest, soil erosion/ landslide, and development of infrastructure for the settlement areas and tourism activities in this fragile landscape.

CONCLUSION

The Kannan Devan Hills village became a bustling tourism destination paving the way for massive infrastructure development. The temporal and spatial land use/ land cover change analysis made for the study area helped in understanding land transformation processes and changes made in natural eco-system structures. It is identified that development of plantation agriculture, urbanisation, development of Tourism and population growth were the drivers of land use land cover change in the KDH village. It is to be viewed in the context that LULC changes have produced about 36% of CO_2 emissions in the earth since 1850, the beginning of the Industrial Revolution, thus contributing to global climate change. Though the eucalyptus is an efficient bio-mass producer it may cause adverse environmental impacts for competition for water with other species, increased incidence of allelopathy and loss of soil fertility. Therefore alternative to Eucalyptus have to be introduced in the study area. Eco tourism has to be promoted in the place of present unrestricted mode of tourism in the area under investigation and to take care not to alter the integrity of the eco-system. Eco-tourism would entail a reduced impact on environment. The present investigation made through the methodology detailed above has categorically proved that it is more suitable in temporal land use / land cover change detection which is essential for understanding the degree of fragility of ecologically sensitive areas for monitoring and managing natural resources for its sustenance.

Acknowledgement

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REFERENCES

1. Anurag Ohri and Poonam Urban Sprawl Mapping and Land Use Change Detection using Remote Sensing and GIS International Journal of Remote Sensing and GIS, Volume 1, issue, 1, 2012, 12-25
2. Bhagavat Rimal. Application of Remote Sensing and GIS, Landuse / Land Cover Change in Kathmandu MetropolitanCity, Nepal Journal of Theoretical and Applied Information Technology pp.80-86
3. Binutha, R & Somashekhar R.K Future Prediction of landcover in Devikulam Taluk, Kerala International Journal of Science and Nature VOL.5 (4) 2014: 677-683
4. Chaurasia R., Closhali D.C., Dhaliwal S.S., Minakshi Sharma P.K., Kudrat M. and Tiwari A.K (1996), ' Landuse Change Analysis for Agricultural Management - A Case Study of Tehsil Talwandi Sabo, Punjab'. Journal of Indian Society of Remote Sensing, Vol. 24, No.2. pp. 115-123.
5. Gibson and Power, 2000 Introductory Remote

Sensing: Digital Image Processing and Applications Routledge, London (2000)

6. J. R. Jensen 1986. Introductory Digital Image Processing. A Remote Sensing Perspective
7. J.S Rawat, Vivekanand Biswas, Manish Kumar 2013 Changes in landuse/cover using geospatial techniques: A case study of Ramnagar town area, district Nainital, Uttarahkhand, India, The Egyptian Journal of Remote Sensing and Space Sciences (2013) 16, 111-117
8. Khawanruthai Bunruamkaew and Yuji Murayama. Landuse and Natural Resources Planning for Sustainable Ecotourism using GIS in Surat thani, Thailand. Sustainability 2012, 4,412-429
9. Monica Praisy , Jayaprasad B K , Karuppasamy S Impacts of Digital Elevation Model in Land Degradation Assessment – A case study of Munnar. International Journal of Remote Sensing & Geoscience (IJRSG) Volume 4, Issue 3, May 2015 53-58
10. Natural Resources and Environmental Atlas of Kerala: Idukki District 2008. Centre for Earth Science Studies, Kerala State Remote Sensing and Environment Centre, Kerala State Planning Board, Govt.of Kerala, Indian Space Research Organisation.
11. Navalgund, R.R., Jayaraman, V. & Roy, P.S. (2007). Remote Sensing Applications: An Overview. Current Science , 93: 1747-1766.
12. S.Narendra Prasad, L. Vijayan, S.Balachandran, VS Ramachandran and C.P.A Verghese. Conservation planning for the Western Ghats of Kerala: I. A GIS approach for location of biodiversity hotspots Use of GIS&RS in Ecology & Conservation Biology. Current Science, VOL. 75, No.3, 10 August 1998, 211-219
13. Sujitha P R, Jayaprasad B.K, Karuppasamy S Slope Stability Analysis for identifying Landslide Prone Areas using Remote Sensing and GIS Techniques in Munnar International Journal of Engineering Research and Management Volume 02, Issue 05, May 2015 207-211
14. Turner II, B.L., Skole, D.L., Sanderson, S., Fischer, G., Fresco, L.O., Leemans, R., 1995. Land-use and land-cover change. Science/Research Plan. Stockholm and Geneva: IGBP Report No. 35 and HDP Report No. 7, 132 pp.

IN ANDHRA PRADESH WATERSHED MODELING OF USING GIS AND REMOTE SENSING TECHNIQUES OF KRISHNA WATERSHED

Chanchal Kumar TRIPATHI[1]

ABSTRACT

Management of water resources and planning of water resources for sustainable use, a complex task. Therefore, it is essential to make measurement of factors such as size, slope, soil type and land use, vegetation and flow capacity of the channel. The drainage Hydrological Details, Administrative Details, Command Area Map, Land Use/Land Cover Land Use/Land Cover, Wasteland Details, Soil Texture Map, Soil Productivity Details etc.

Remote Sensing integrated with Geographical Information System has been efficiently used in generating input parameters of hydrological models. In the present investigation, an attempt has been made to develop a GIS based Watershed Model for the assessment of spatial distribution of the Krishna Middle Sub basin in Andhra Pradesh, India. The GIS layers namely stream network were prepared including watershed boundary gene rated using QGIS open source software.

Keywords*: DEM, Digitization, Geographical Information System, Remote Sensing, SWAT, Watershed.*

CHARACTERISTICS OF THE STUDY AREA

Geology

The delta is a gently rolling low lying plain with a maximum altitude of 16 m above the MSL near Vijayawada and minimum of 3.50 m above the MSL at Machilipatnam. The general slope of the terrain is towards south and south-east. Most of the delta region is overlain by the river alluvium (clay, sand & gravel) and beach alluvium (sand).

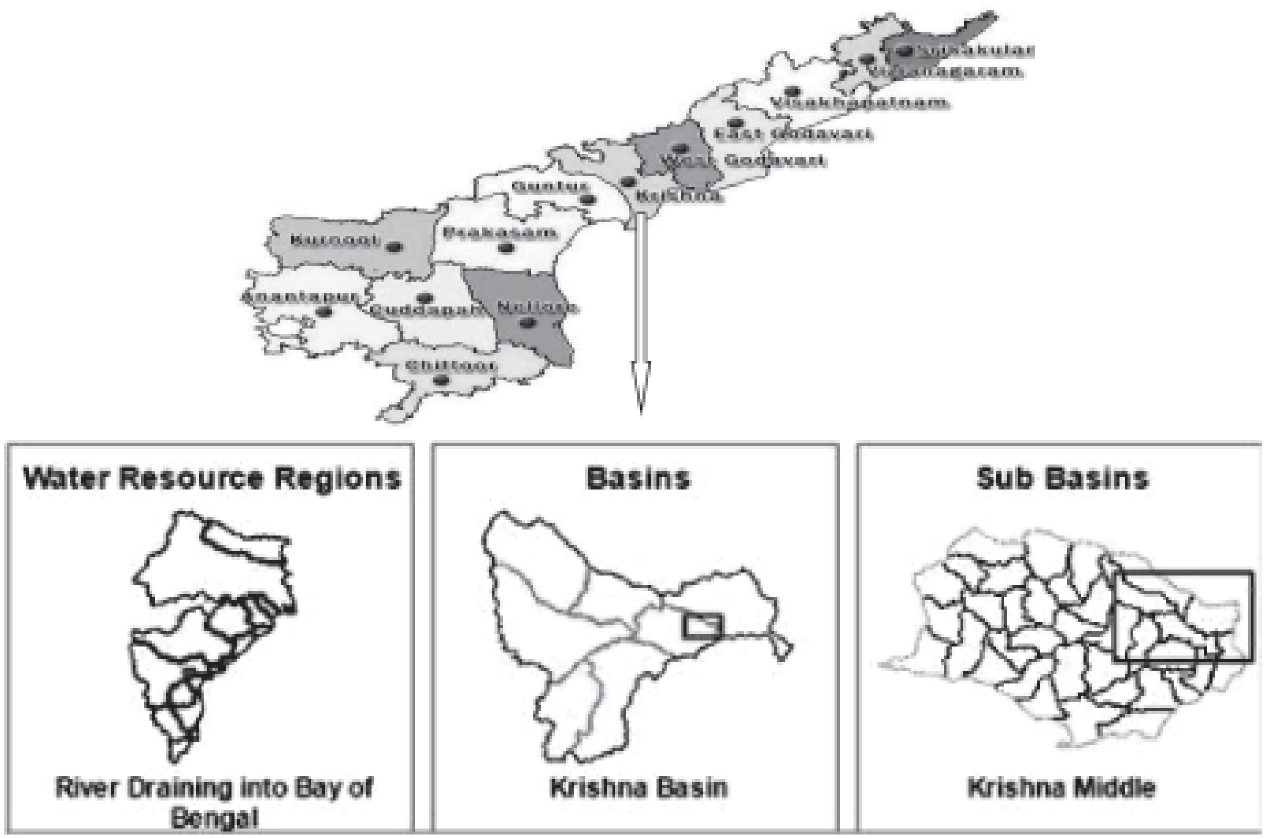

Fig. 1 Study Area Boundary

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Table 1
Hydrological Details

Name/Code	*C04KRM36*
Area (Sq. Km)	699.13
Total Drainage Length (Km)	
No. of Waterbodies	16
No. of Dams	2
No. of Barrages/Weirs/Annicuts	0
CWC HO Sites	0

Table 2
Administrative Details

Name	*C04KRM36*
No. of Cities	0
No. of Towns	2
No. of Industrial Town	0
No. of Settlements	97
No. of Tourist Stations	2
No. of Airports	0

Table 3
Dam Details

Sl. No.	*Dam*	*Dam Name*	*Nearest Location*
1.	D00690	Nagarjuna Sagar Dam	Guruzala
2.	D04582	Perval Dam	Devarkonda

Soils

The soils of Krishna Delta are very deep and dark brown to grayish brown in colour. The soils are very high in clay content, which ranges between 50 and 75 percent. Soils differ in their infiltration capacity in different parts of the delta depending upon the kind of soil.

Agriculture

Main Occupation of the people is Agriculture, which is dependent on the vagaries of monsoon

Climate

The delta region is influenced by tropical semi-arid type climate. The mean annual temperature is about 290 C. The delta receives rainfall mainly from south-west monsoon (June-September) and from North-East monsoon (October-December). The mean annual precipitation is about 800 – 1000 mm.

Streams

The watershed has a well-defined stream network draining the precipitation into River Krishna.

DATA USED

SOI Toposheets pertaining to the area on 1:50,000 scale. LISS-3 satellite data used.

FLOW CHART OF METHODOLOGY

The base map of the study area was prepared from the Topographic maps (1:50,000 scale), which were collected from the Survey of India. The SOI Toposheets were first rectified and then georeferenced to the Geographical Coordinate System. Then the georeferenced SOI Toposheets were mosaiced to form a single image of topomap for delineating the study area. The mosiaced toposheet was further georeferenced and then considered for digitization of contours of the study area so as to generate Digital Elevation Model (DEM) using automated procedures with the use of spatial analyst tools. Here SWAT (Soil Water Assessment Tool) is used as watershed delineator to delineate the watershed boundary of the study area and stream network model has been developed correspondingly. Slope and Aspect maps for the study area were then prepared from the generated DEM.

Flow Chart

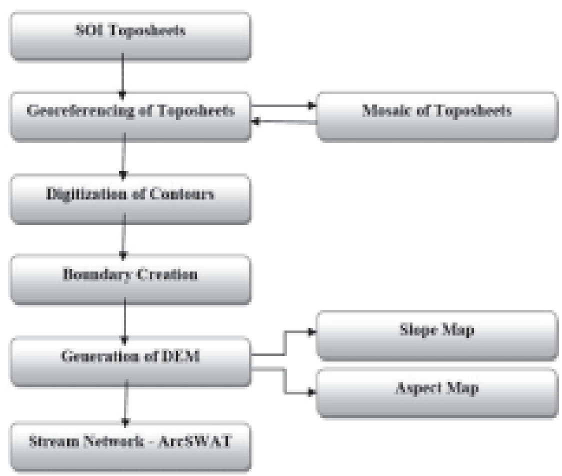
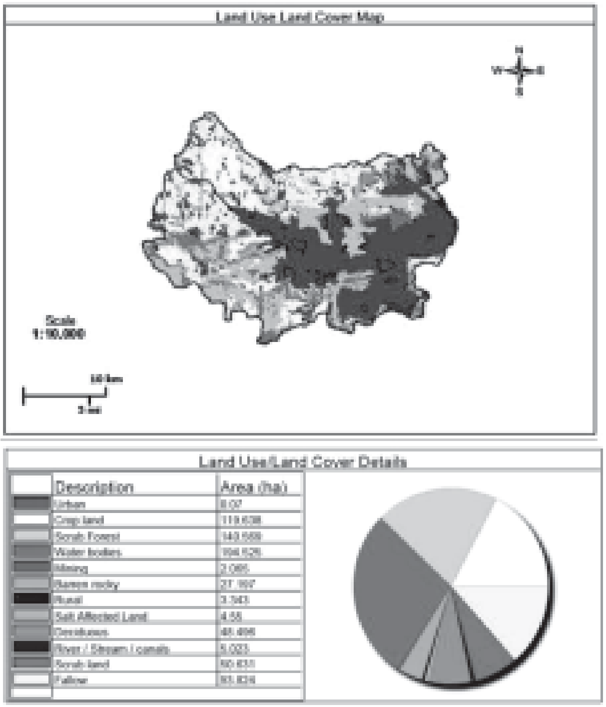


Fig. 2 : Flow Chart of Watershed Map Generation

Land use Land cover Map

Land use is a description of how people utilize the land and socio-economic activity. Urban and agricultural land uses are two of the most commonly known land use classes. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension. Land cover is the physical material at the surface of the earth. Land covers include grass, agriculture, trees, bare ground, water, etc.

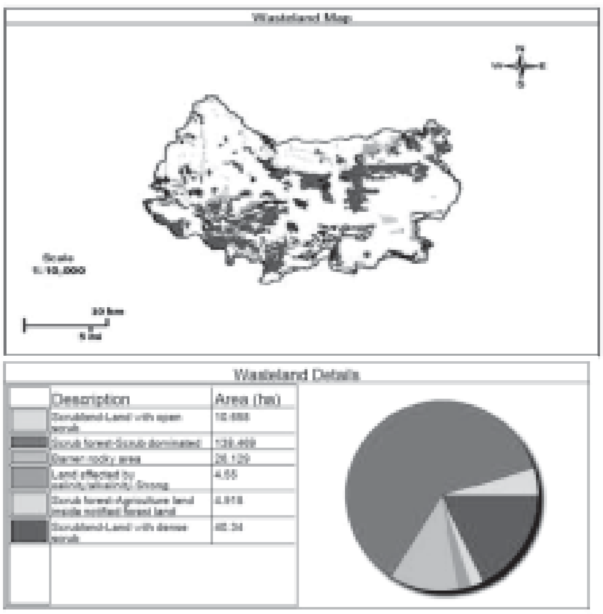


Source from Open Source Google Earth and Q-GIS

Fig. 3 : Map Layout Data

Waste Land Map

Increasing demand for food, fodder, fuel and fiber has necessitated adoption of scientific measures for increase in land productivity and bringing more areas under cultivation/forests. However land degradation due to desertification, soil salinity, water logging, floods/drought, excessive soil erosion due to deforestation, unscientific agricultural practices etc. have resulted in the creation of vast stretches of wastelands and a decrease in per capita cultivable land besides ecological imbalance.



Source from Open Source Google Earth and Q-GIS

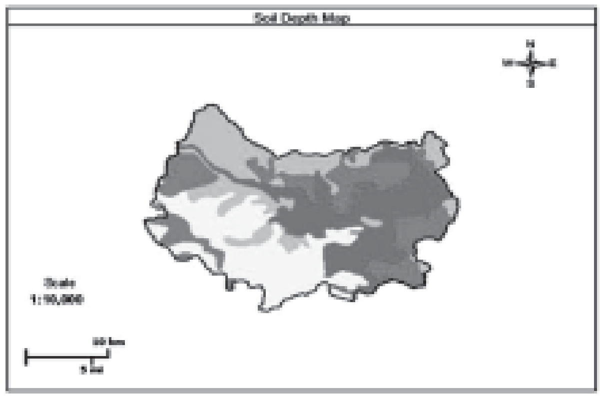
Fig. 4 : Map Layout Data

Soil Depth Map

Soil depth is one of the most important input parameters for hydroecological models. Spatial patterns in soil depth arise from complex interactions of many factors topography, parent material, climate, biological, chemical and physical processes.

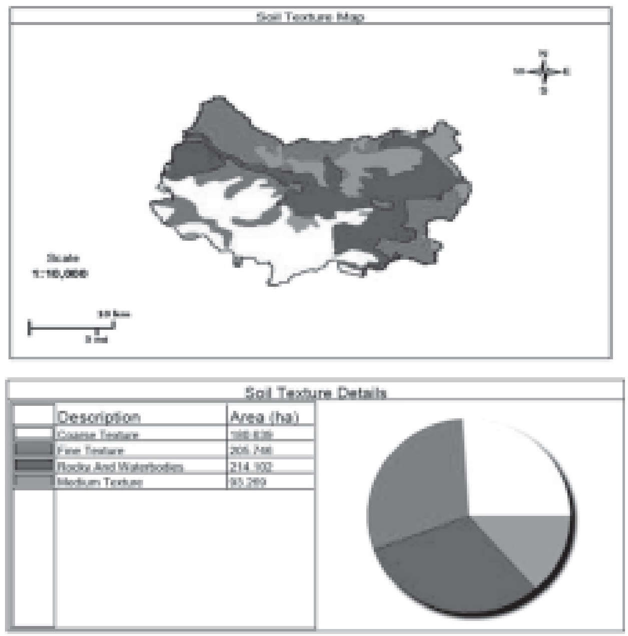
Soil Texture Map

Soil texture is a qualitative classification tool used in both the field and laboratory to determine classes for agricultural soils based on their physical texture. The classes are distinguished in the field by the "textural feel" which can be further clarified by separating the relative proportions of sand, silt and clay .



Source from Open Source Google Earth and Q-GIS

Fig. 5 : Map Layout Data



Source from Open Source Google Earth and Q-GIS

Fig. 6: Map Layout Data

Slope Map

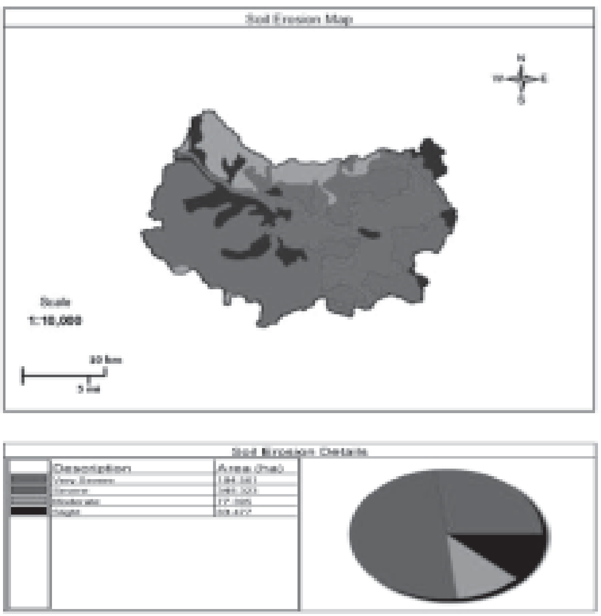
The incline, or steepness, of a surface. Slope can be measured in degrees from horizontal (0–90), or percent slope (which is the rise divided by the run, multiplied by 100). A slope of 45 degrees equals 100 percent slope. As slope angle approaches vertical (90 degrees), the percent slope approaches infinity. The slope of a TIN face is the steepest downhill slope of a plane defined by the face. The slope for a cell in a raster is the steepest slope of a plane defined by the cell and its eight surrounding neighbors.

Source from Open Source Google Earth and Q-GIS

Fig. 7 : Map Layout Data

Soil Erosion Map

Soil erosion and nutrient loss are two important aspects influencing crop production and water quality in the Dan River. In this study, a field experiment was conducted in the Krishna Watershed.

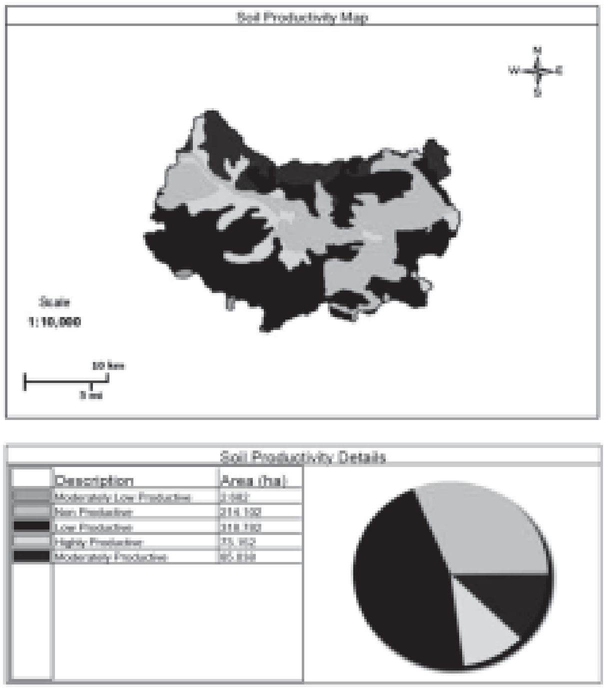


Source from Open Source Google Earth and Q-GIS

Fig. 8: Map Layout Data

Soil Productivity Map

Land Parcel Identification Service (LPIS) data show the farm outlines of all land held by farmers who have applied for support Data are held electronically on maps are updated annually by different Technology were reclassified on the basis of the main land uses.



Source from Open Source Google Earth and Q-GIS

Fig. 9. Map Layout Data

CONCLUSION

The Krishna and its tributaries are an inter-state river system flowing through the states of Maharashtra, Karnataka and Andhra Pradesh. Its principal tributaries joining from right are the Ghatprabha, the Malprabha and the Tungabhadra whereas those joining from left are the Bhima, the Musi and the Munneru.

As per the assessment of LULC Major part of the basin is covered with Agricultural area 119.638 (ha).This basin area is covered by scrub forest 140.569 (ha) and basin area is covered by water bodies 194.525 (ha) and many different details.

Dams are situated in the basin, it is necessary for the systematic data to be collected of the sediment carried by the river waters, which would be of considerable use in working out dead storages and live of reservoirs. It will also reveal the effect of soil conservation works carried out in the basin.

REFERENCES

1. C.T. Anuradha and S. Prabhavathy (2010), Water Resources Management for Virudhunagar District using Remote Sensing and GIS, pp 55-61, International Journal of Earth Sciences and Engineering, 3(1) – Spl issue, January, 2010.

2. Saxena, R.K., Verma, K.S., Chary, G.R., Shristava, R. and Barthwal, A.K. (2000). IRS-1C data application in watershed characterization and management, Int. Jl. of Remote Sensing, 21(17), pp 3197-3208.

3. Tripathi, M.P., Panda, R.K, Pradhan, S. & Sudhakar, S. 2002. Run-off modeling of a small watershed using Satellite data and GIS. Journal of Indian Society of Remote Sensing, 30(1 & 2).

4. Chakravorty, A.K., 1993. Strategies for Watershed Management Planning using Remote Sensing techniques. Journal of Indian Society of Remote Sensing, 21(2):87-98.

5. India-Water Resources Information System: www.india-wris.nrsc.gov.in

6. P. Balakrishnan, Issues in Water Resources Development and Management and Role of Remote Sensing, ISRO Publication, ISRO, Bangalore, 1986.

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TARGETING AND MANAGEMENT OF GROUND WATER RESOURCES BY USING REMOTELY SENSED DIGITAL DATA AND GIS TOOLS IN DOON VALLEY, UTTARANCHAL

D. K. MANDAL[1]

ABSTRACT

Realizing the importance of Remote Sensing and GIS technology, the present study has been undertaken to study the geomorphology and delineate the prospective ground water zones in the Eastern Doon Valley and its surroundings falling in the newly formed State of Uttaranchal. For this purpose, the satellite imagery (PAN and LISS III) provided by IRS have been digitally enhanced using various techniques to improve the visual interpretability. These enhanced images were visually interpreted to map different landforms and geomorphic units existing in the area and to understand the processes of their evolution. Other parameters which control the occurrence and movement of groundwater, such as Lithology/Rock type, structure, land use/land cover, drainage density were also interpreted using satellite imagery in conjunction with the existing maps and literature, and different overlays were prepared. Well data were collected from different government departments and analyzed. Based on the Well data, different maps like Static Water Table Map, Aquifer Thickness Map, Well Discharge Map, Well Specific Capacity Map and Well Yield Factor Map were prepared. Subsequently, all the layers important from groundwater occurrence and movement point of view were digitized and integrated into the GIS environment using index overlay method. The weights to different units/ parameters and themes were assigned depending upon their importance. With this integrated GIS analysis, ground water prospects map of the study area was prepared. The ground water prospects have been classified qualitatively as Excellent, Very Good, Good, Moderate and Limited. The groundwater prospective zones are essentially located in the intermontane Doon Valley Area, especially in the lower part under semi-confined to confined conditions. The denudo-structural hills of the Siwaliks and Pre-Tertiary rocks and residual hills of old Doon gravel form essentially the run-off zones, wherein the prospects exist only along the valleys/ topographic lows, suitable geological structures, springs and seepage zones.

Keyword(s): *Ground Water Exploration, management, Digital database and GIS tools.*

INTRODUCTION

Lack of adequate potable and agricultural water supplies inhibits the progress of developing countries and is the cause of considerable hardship to humans worldwide. A thorough hydrogeologic understanding is often critical for cost-effective water resources development projects designed to alleviate these hardships. Since last decade, the value per barrel of potable ground water has outpaced the value of a barrel of oil in many areas of the world. Therefore, the importance of ground water in various fields like domestic, industrial and agriculture and recycling of wastewater requires an emphasis. Establishing relationship between Remote Sensing data and hydrologic phenomenon can maximize the efficiency of water resources development projects. In spite of extensive research and technological advancement, the study of groundwater has remained more of a speculative and intuitive science, as there is no method to facilitate direct observation of water below the surface. Its presence or absence can only be inferred indirectly by studying the geological framework through which it flows. There are a number of factors that control the ground water regime in a given area such as Lithology, Stratigraphy, Structure, Landforms/ Geomorphology, Recharge Conditions, Slope, Soil, Land use/Land cover, etc. Remotely Sensed data by virtue of its synoptic coverage and multispectral nature help in identification and mapping of most of the above factors with selective ground checks in a cost-effective manner. An integrated analysis of these factors and the available well and ancillary data in the GIS environment helps in identifying the potential ground water zones.

OBJECTIVES

The prime objectives of the present study are as follows:

1. To identify and map different landforms/ geomorphic units and understand the geomorphic processes involved.
2. To identify and map other parameters controlling the groundwater occurrence and movement, such as lithostratigraphy, structure, drainage density, slope, land use/land cover, etc.
3. To understand the nature and performance of aquifers based on tube well and dug well data.

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4. To delineate the prospective ground water zones by integrating different controlling parameters along with the Well data in the GIS environment.

STUDY AREA

The study area covers the eastern part of Doon valley and its surroundings having an association with lesser Himalayas in the north, Siwalik Hills in the south, River Ganga in the Southeast and Dehra Dun town in the west. It covers about 740 sq. Km and is bound between 78º05′N and 78º25′E longitude, and 30º05′ and 30º30′N latitude. It falls in SOI Toposheet Nos. 53J/3, 4, 7 and 8.

DATA USED

The following data have been used in the present study:

IRS-1C/1D PAN & LISS-III data

SOI Toposheets (53J/3, 4, 7 & 8)

Well data from UP Jal Nigam & Garhwal Jal Sansthan.

Information collected during selective field checks.

METHODOLOGY

The methodology adopted in the present study is given as a flow chart in fig. 2. *The various steps involved are briefly described below*:

Problem Identification Water Resource is more versatile, vital and abundant for the existence of all forms of life. With increasing demands on water by growing world population and increased modern industrial and agricultural activities, no natural resources have perhaps given rise to deeper concern about its over-exploitation & conservation, than good clean water. It is in this context that the immense possibilities of utilizing the modern techniques of remote sensing and GIS as an aid in the water resources survey are presently being realized and accepted. Considering the usefulness of remote sensing and GIS techniques coupled with the availability of data, approachability, etc., the eastern Doon Valley and its surroundings has been selected as a study area for geomorphological and ground water studies.

Pre-Field Interpretation The following procedure was adopted for preparing pre-field maps. Digital image processing, especially georeferencing, digital image enhancement and merging of PAN & LISS III data to improve visual interpretability. Visual Interpretation of IRS-IC/1D (LISS III) & PAN imagery of the study area for preparation of geology, structure, geomorphology, hydrology, and land use/Land cover maps taking the help of existing map and literature. Preparation of base map with the aid of SOI toposheet Nos. 53J/3,4,7 and 8 of Survey of India. Data transfer on base map in order to prepare the overlays of geology, geomorphology, land use, etc. derived from imagery. Selection of critical traverses for field checks.

Field Survey *The following procedure has been adopted during the fieldwork.* A collection of existing well data from Govt. Depts. (UP Jal Nigam and Garhwal Jal Sansthan) Verification of lithological and geomorphological units, geological structures land

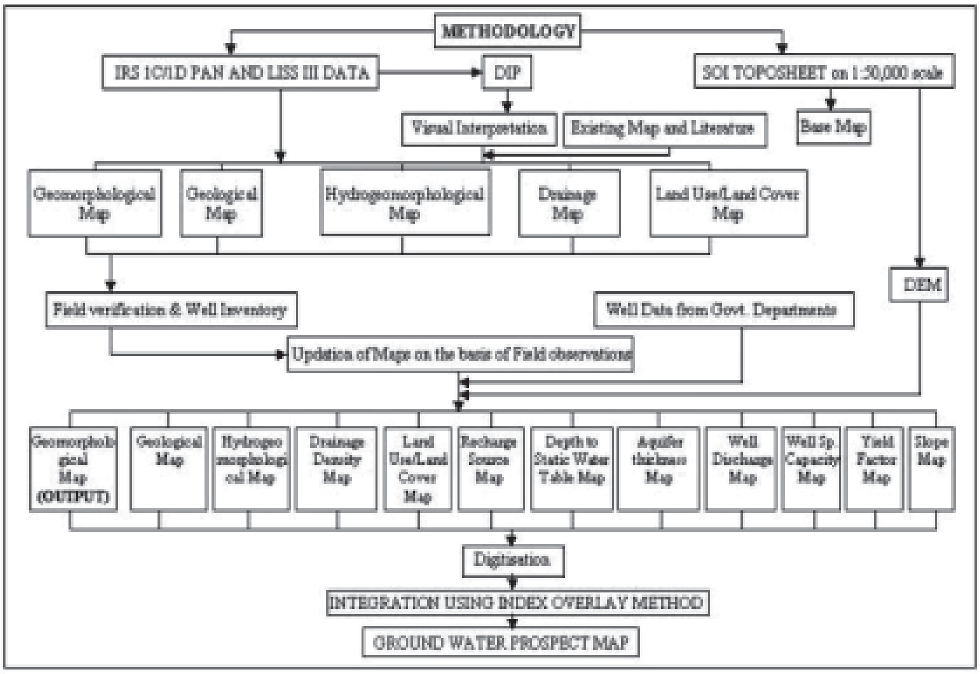


Fig. 1: Flow Chart Showing Methodology .

use/land cover, etc. by taking traverses mainly along the roads. Well inventory of tube wells and dug wells in the field.

Post-Field Interpretation and GIS Analysis *The following procedure has been adopted in this stage:* Correction of pre-field maps by incorporating field observations. Tabulation of well data and preparation of (a) iso-depth to static water table map, (b) iso-discharge map, (c) iso-aquifer thickness map, (d) iso-specific capacity map and, (f) iso-yield factor map. Preparation of slope map (amount and aspect) based on SOI toposheets. Digitization of thematic layers. GIS analysis using index-overlay method. Output generation and report writing.

INTEGRATED ANALYSIS IN GIS ENVIRONMENT

A direct consequence of integrated geo-investigation approach has been the realization of Geographic Information System (GIS). A GIS can be defined as an automated tool for efficient storage, analysis and presentation of geographi-cally referenced data. In a comprehensive sense, GIS means identifying data needs, acquisition of data, management, processing and decision-making. In the present study, various thematic maps have been integrated in GIS environment in order to delineate the prospective ground water zones. The details are given in this chapter. For digitization and integration, ARC VIEW (Version 3.2a) software has been used.

Themes Used for Integration

The following themes which are important for characterizing the groundwater regime of the study area have been digitized in different layers:

1. Hydrogeomorphology
2. Drainage density
3. Depth to static water table
4. Well discharge
5. Well aquifer thickness
6. Specific capacity
7. Yield factor
8. Slope
9. Recharge Source
10. Land use/Land cover

All the above themes have multiple classes. These themes/layers have been converted to raster form before doing the integrated analysis.

Method of Data Integration

In order to integrate various thematic layers, index overlay method has been used. A rating has been developed for the integration of these thematic maps. A numerical rating system ranging from 1 to 10 have been assigned to various classes of individual themes; it is based on the degree of influence of individual categories on groundwater regime of the region. These are given in the tables below: Table 4 (1-10). Secondly, all the thematic maps have assigned a weightage factor, depending on the importance of themes. The final integrated output in raster format was classified into classes showing different ground water prospectives.

Table 4
Numerical Rating System (NRS).

1. *Hydrogeomorphology Layer*

Unit	*Score*
Channal Bar	10
Active Flood Plain	10
Alluvial Plain	8
Palaeochannel	8
Lower Doon Valley Fan (Gullied)	5
Lower Doon Valley Fan	6
Upper Doon Valley Fan(Gullied)	2
Upper Doon Valley Fan	3
Residual Hill	0.1
Denudo-structural Hill of Middle Siwalik	0.1
Valley (Pre-Tertiary)	5
Denudo structural Hills (Subathu & Pre Tertiary)	0.1

2. Drainage Density

Unit	*Score*
High Drainage Density	2
Medium Drainage Density	5
Low/very low Drainage density	8
River Bed	10

3. Recharge Source Map

Unit	*Score*
Only rainfall	5
Rainfall + canal irrigated	7

4. Depth to Static Water Table

Unit	*Score*
< 20 m	6
20 – 45	4
> 45 m	2
Run off zone	0.1

5. Well Aquifer Thickness

Unit	*Score*
< 20 m	2
20 – 30m	4
> 30 m	6
Run off zone	0.1

6. Well Discharge

Unit	*Score*
< 1000 lpm	2
1000 – 2000 lpm	4
> 2000 lpm	6
Run off zone	0.1

7. Specific Capacity

Unit	*Score*
< 500 lpm/m	2
500-800 lpm/m	4
> 800 lpm/m	6
Run off zone	0.1

8. Yield Factor

Unit	*Score*
< 25 lpm/m/m	2
25 – 40 lpm/m/m	4
> 40 lpm/m/m	6
Run off zone	0.1

9. Land use

Unit	*Score*
Settlement	2
Agriculture land	6
River/ water body	10
Aerodrome	2
Plantation	6
Dense Forest	8
Open forest	6
Wasteland	3
Fallow land	5
Barren land	3

10. Slope

Unit (In degree)	*Score*
0°-1°	10
1°-2°	8
2°-5°	6
5°-10°	4
10°-20°	2
20°-45°	1
> 45°	0.1

Index Overlay Method

This model is applied where maps are added together in a weighted combination. In this simplest type of weighted model, input maps are binary and each map carries a single weight factor. However, multi-class maps are also can be used, each class of every map is given a different rating score. This method allows more flexible weighting system. In case the map classes occurring in each map are assigned different score, as well as the map themselves receiving weights, the average score can be defined as:

Formula Used

$$S = \frac{\sum_{i=1,\, j=1}^{n,\, m} S_{ij} W_i}{\sum W_i}$$

Where, S is the Weighted Score

W_i is the weight of the i^{th} input map

S_{ij} is the rating score for the j^{th} class

Note: here, S is the weighted score for our area object (polygon, pixel), Wi is the weight of ith input map, and S ij is the rating score for the jth class of the ith map. The value of J depends upon the class actually occurring at the current location. Each map must be associated with a list of scores, one per map class. Class scores can be put into an attribute table of the individual layers.

RESULTS

After assigning the score to different units/classes in occurring in each theme, ***all the 10 layers were integrated*** in the ***ArcView*** software using index overlay method described above. Here towards giving the weights each theme, we followed two methods-

All the themes were given the same weights.

Different weights were given to different themes depending upon the themes importance.

Using the above two weighting systems, weighted scores were worked out and reclassified to represent different ground water prospects existing in the area. These classes are Ground Water Potential Zone, Excellent, Very Good, Good, Moderate to Good, Moderate, Limited to Moderate, Limited Mainly run-off zone(Prospects limited to valleys).

The final ground water prospects are shown in Fig. 3. As evident in this Fig., high ground water prospects mainly exist in the lower part of the Doon Valley fan and alluvial/flood plains of present rivers. The denudo-structural hills of Siwaliks and Pre-Tertiary rocks, and residual hills of old Doon gravel and essentially from the run-off zones. The ground water prospects in these zones are limited to only along valleys/ topographic lows, suitable geological structures, the areas near the springs, also form the suitable zone for water resources development.

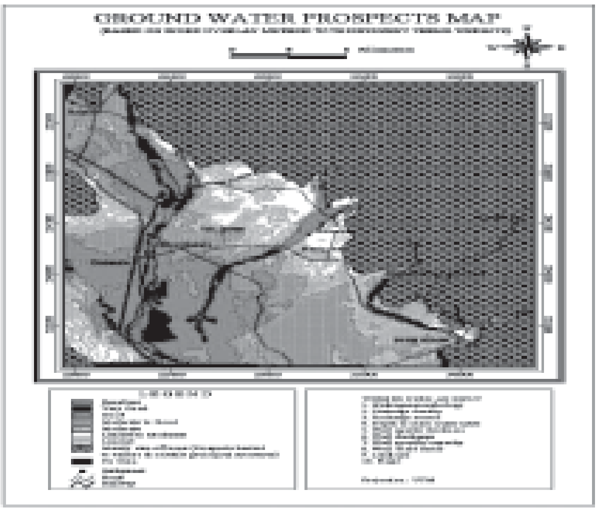


Fig. 3 Map showing Ground Water Prospects zones.

CONCLUDING REMARKS

Remote Sensing and GIS techniques are useful tools in geomorphological and ground water studies. Based on the visual interpretation of satellite, different landforms/geomorphic units have been identified and mapped in the study area, viz. Denudo-structural hills-moderately/Highly dissected, Residual Hills, Upper Doon Valley Fan, Alluvial Plains, Flood Plains, Channel/ Point/ Braided Bars, plaeaochannels, etc. The denudo-structural hills are basically formed by the Siwaliks and Pre-Tertiary rocks. Residual hill is formed by the old Doon gravel. The central and southern hill is formed by the old Doon gravel. The central and southern part of the area is occupied by the Doon Fan. The area on either side of the major rivers like Song and Jakhan Rao is characterized by fluvial deposits. The distribution and type of landforms/geomorphic units as mapped from the satellite data in conjunction with the field checks helped understanding the geomorphic processes involved in carrying out the present-day topography. The integrated approach of Remote Sensing and GIS in conjunction with the available well data helped in delineating the prospective ground water zone in the study area. Productive aquifers in the study area are mostly confined to the lower part of the Doon Valley Fan and the active flood plains/ alluvial plains of major rivers like Song River and Jakhan Rao River, wherein the ground mainly occurs in unconfined and semi-confined conditions.

REFERENCES

1 Barry, S. Siegal and Gillespie, Alan R., 1979: *Remote Sensing in Geology*. John Wiley & Sons, New York, pp. 1-164.

2. Burrough, Peter A. and McDonnell Rachael A., 2000: *Principles of Geographical Information System;* Spatial Information Systems and Geostatistics. Oxford University Press, Noida, India, First Edition, 333p.

3. Campbell, James B., 1996: *Introduction to Remote Sensing,* Taylor & Francis, Second Edition, pp. 1-107.

4. Cromley, Robert G., 1992: *Digital Cartography,* Prentice Hall, New Jersey, 317p.

5. Davis, John C., 1986: *Statistics and Data Analysis in Geology,* John Wiley & Sons, New York, Second Edition, 646p.

6. Davis, Kenneth P., 1976: *Land Use,* McGraw-Hill Book Company, New Delhi, pp. 1-43.

7. Doornkamp, John C. and King, Cuchlaine A., 1970: *Numerical Analysis in Geomorphology; an introduction,* Edward Arnold (Publishers) Ltd., London, pp. 115-203.

8. Graeme F. Bonham-Carter, 1993: *Geographic Information Systems for Geoscientists; Modeling with GIS,* Pergamon (Elsevier Science Ltd.), New York, pp. 1-335.

9. Hemphill, W. R., 1958: *Small-scale Photographs in Photogeologic Interpretation,* Photogrammetric Engineering, 24: 562-567.

10. Hutchinson, M. F. and Gallant, J. C., 1999: *Representation of Terrain, In: Geographical Information Systems,* Edi. By Longley, Paul A., Goodchild, Michael F. Maguire, David J. and Rhind, David W., John Wiley & Sons, Inc., New York, Vol. I, pp. 105-124.

11. Jensen, John R., 1996: *Introductory Digital Image Processing; A Remote Sensing Perspective,* Prentice Hall, New Jersey, 316p.

12. Joshi, R., 2000: *Geology of Doon Valley; A review,* Quarternary Journal of Geological Association & Research Centre, Balaghat (M.P.), Misc. Pub. No. 12, pp. 1-24.

13. Karunakaran, C. and Rao, A., 1979: *Status of*

Exploration of Hydrocarbons in the Himalayan region–contributions to stratigraphy and structure, Miscellaneous Publication, Geological Survey of India, 42, 1-66.

14. Kesseli, J. E., 1950: *Geographic Geomorphology,* Yearbook of Association of Pacific Coast Geographers, Presidential Address, 8p.
15. Lillisand, T. M. and Keifer, R. W., 2000: *Remote Sensing and Image Interpretation,* John Wiley & Sons, Fourth Edition, pp. 1-205.
16. Lee, J. B., Woodyatt, S., and Berman, M., 1990: *Enhancement of High Spectral Resolution Remote Sensing Data by a Noise-adjusted Principal Components Transform,* IEEE Transactions on Geoscience and Remote Sensing, 28(3):295-304.
17. Miller, C. L. and Laflamme, R. A., 1958: *The Digital Terrain Model; theory and application,* Photogrammetric Engineering, 24(3): 433-42.
18. Nakata, T., 1972: *Geomorphic history and crustal movements of the foothills of the Himalayas,* Report of Tohoku University, Japan, 7th Series (Geography), 22, 39-177.
19. Peltier, L. C., 1954: *Geomorphology,* in: American Geography: Inventory and Prospect. Syracuse University Press, pp. 362-381.
20. Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P., 1992: *Numerical Recipes in FORTRAN: The Art of Scientific Computing,* 2nd ed., London, Cambridge, 963p.
21. Roscoe, John H., 1960: *Photo Interpretation in Geography, Manual of Photographic Interpretation,* American Society of Photogrammetry, Edited by Robert N. Colwell, pp. 735-792.
22. Rupke, Jan 1974: *Stratigrapic and Structural evolution of the Kumaon Lesser Himalaya,* Elsevier Scientific Publishing Company, Amsterdam, Structural Geology. 11: 81-265.
23. Russell, R. J., 1949: *Geographical Geomorphology,* Annals of the Association of American Geographers, 39: 1-11.
24. Sabins, F. F., 1996: *Remote Sensing; principles and interpretations,* W. H. Freeman & co., San Francisco, 3rd ed., pp. 1-304.
25. Savigear, R. A. G., 1960: *Slopes and hills in West Africa,* Zeit. Fur Geomorph. Suppl. I, 156-71.
26. Savigear, R. A. G., 1965: *A technique of morphological mapping,* Annals of Association of American Geographers, 55, 514-38.
27. Singh, A. and Harrison, A., 1985: *Standardized Principal Components,* International Journal of Remote Sensing, 6:883-896.
28. Smith, H. T. U., 1949b: *Physical effects of Pleistocene Climate changes in non-glaciated areas; eolian phenomena, frost action and stream terracing,* Bulletin of the Geological Society of America, 60: 1484-1516.
29. Stout, K. J. and Blunt, L., 2000: *Three Dimensional Surface Topography,* Penton Press, London, Second Edition, 285p.
30. Strahler, A. N., 1952: *Dynamic basis of Geomorphology,* Bulletin, Geological Society of America, 63, 923-38.
31. Thakur, V. C., 1995: *Geology of Dun Valley, Garhwal Himalaya: Neotectonics and coeval deposition with fault – propagation folds,* Journal of Himalayan Geology, Vol. 6, No. 2, pp. 1-8.
32. Valdiya, K. S., 1980: *Geology of Kumaon and Lesser Himalaya,* Wadia Institute of Himalayan Geology, Dehra Dun, India, pp. 1-158.
33. Weibel, R. and Heller, M., 1990: *A Framework for Digital Terrain Modeling,* Proceedings of the 4th International Symposium on Spatial Data Handling. International Geographical Union, Columbus Ohio, pp. 219-29.
34. Weibel, R. and Heller, M., 1991: *Digital Terrain Modeling,* In: Geographical Information Systems. Edi. by Maguire, David J., Goodchild, Michael F. and Rhind, David W., Longman Scientific and Technical, Longman Group UK Ltd., England, Vol. I, pp. 269-297.
35. Yeats, R. S. and Lillie, R. J., 1991: *Contemporary Tectonics of the Himalayan frontal fault system; folds, blind thrusts and the 1905 Kangra Earthquake,* Journal of Structural Geology, 13, 215-225.

ANJANA – A THREATENED WETLAND A CASE STUDY OF KRISHNANAGAR TOWN, NADIA DISTRICT, WEST-BENGAL

Indira Samajdar GANGOPADHYAY[1]

ABSTRACT

Wetlands are one of the most productive ecosystems on earth with multiple utilities in terms of ecology, economy and sociology. Hence this calls for a comprehensive study on the ecology and conservation of wetland. But irony lies in the fact that wetlands have not been given importance that they deserve and they are under constant threat.

The present paper is concerned with degradation of wetland ecology of Anjana*, an abandoned river channel which is a floodplain wetland situated in* Krishnanagar town*, of Krishnanagar1 block of Nadia district in West Bengal. The primary objectives of the study are to analyze the impact of loss of this wetland on the surrounding environment and to suggest measures for conservation of this fragile ecosystem. The research work is based on modern methodology including G.I.S and Digital image processing techniques as well as intensive field work, sample survey and collection of primary data.*

In Nadia, the shifting nature of the river Bhagirathi and its tributaries to some extent, along with its meandering course has created several fresh water wetlands, locally called as of 'bils' and' khals'. *Dead and old river beds and marshes lie scattered all over the district. Ever increasing population urban development and developing agrarian economy has led to conversion, encroachment and pollution of the wetlands leading to its loss. Similarly at present the studied wetland is also under threatened condition. It is affected by several serious problems of siltation and excessive pollution. This in turn leads to decrease of water area and deterioration of water quality. In view of the fact proper planned harnessing of its resources is necessary.*

Some steps have been taken by the Government for conservation, upgradation, pollution control and improvement of the pattern of utilization of the water resources from the existing water bodies. Wetlands play certain vital functions in maintaining environmental sustainability. Full implication of wetland values and losses are to be undertaken.

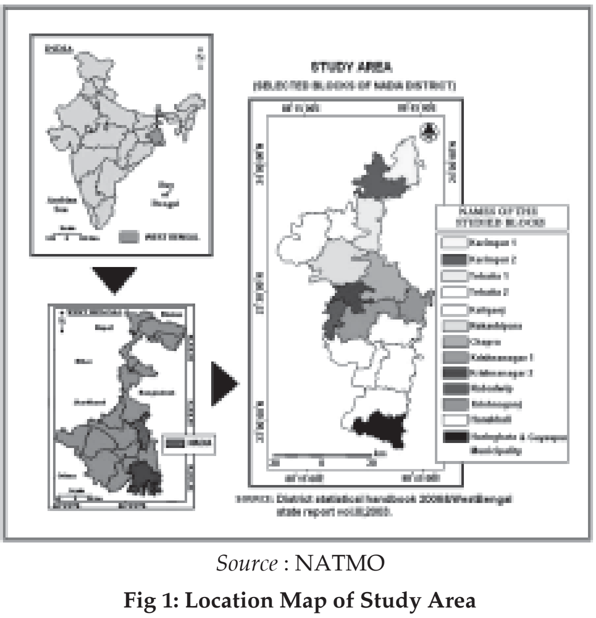
Keywords*: Threatened Wetland, Abandoned River Channel, Bils, Khals Conversion, Encroachment, Planned Harnessing.*

INTRODUCTORY REMARK

Wetlands are one of the most productive ecosystems on earth with multiple utilities in terms of ecology, economy and sociology. Hence this calls for a comprehensive study on the ecology and conservation of wetland. They are defined as "Areas of marsh, pen, peat land or water, whether natural or artificial, permanent or temporary with water i.e. static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6 m." according to Ramsar convention(1971). But irony lies in the fact that wetlands have not been given importance that they deserve and they are under constant threat. The present paper is concerned with this contemporary environmental issue i.e. degradation of wetland ecology of Anjana , a fresh water wetland, situated in Krishnanagar1 block of Nadia district in West Bengal.

AREA AND LOCATION

Anjana bil is situated in Krishnanagar1 block under Krishnanagar Sadar subdivision in Saktinagar area. Its latitudinal and longitudinal extension is from $23^{0}22^{/}$N to $88^{0}30^{/}$ E Some of its portion is vested and is under the control of Fishery Department of the State Government and is managed by New Saktinanagar Fishermen's Cooperative Society.(Fig. 1)



Source : NATMO

Fig 1: Location Map of Study Area

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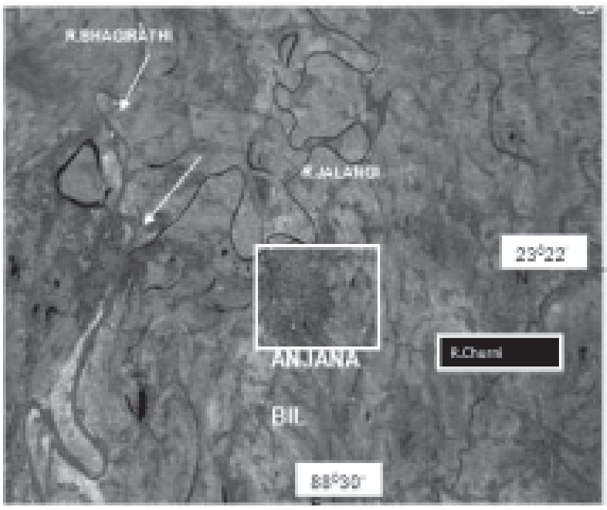
SIGNIFICANCE OF THE STUDY

Wetlands in West Bengal deserve special attention in order to understand their environmental consequences as well as socio economic impacts. In Nadia district wetlands are landscape systems relating to fluvial processes under humid environment of the part of lower Ganga basin. Nadia is the land of rivers like the River Bhagirathi, the River Jalangi, the River Bhairab, the River Mathabhanga, the River Icchamati and the River Churni. River Bhagirathi along with its meandering course and its tributaries to a little extent is constantly shifting towards east having an impact on the nature of wetlands. The natural process of shifting of the River Bhagirathi and its tributaries has formed several fresh water wetlands. They are mainly floodplain wetlands i.e. cut off meanders, ox bow lakes, dead and old river channels and marshes lying scattered all over the district locally called bils and khals. The studied wetland i.e Anjana is similarly an abandoned river channel. (Fig. 2)Urban development, population pressure and developing agrarian economy have lead to conversion, encroachment and pollution of these wetlands leading to its loss. Similarly at present the studied wetland is also under threatened condition. It is affected by several serious problems of siltation and excessive pollution. This in turn leads to decrease of water area, deterioration of water quality, eutrophication and algal bloom. In view of the fact proper conservation and management of this wetland and planned harnessing of its resources is necessary.



Source : www.bhuban.nrsc.gov.in 2014

Fig 2: Satellite Imagery of Anjana Wetlandand its Catchment area

OBJECTIVES AND METHODOLOGY

The primary objectives of the study are as follows:-

- To analyse the impact of degradation of the ecology of Anjana leading to its loss.
- To assess the effects of such loss on its biodiversity and stakeholders.
- Lastly to suggest measures regarding the conservation of this fragile ecosystem.

The present research work has involved certain methodological procedures. They are as follows:-

- The first phase includes collection of secondary data and information like maps, literature and data from different libraries, NATMO, the district fishery office.
- Second phase has been based on study of wetland ecology of Anjana bil which involved intensive field study and collection of primary data and
- Finally analysis and preparation of the final report.

Geomorphological Type, Sources of Water, Total Area and Depth of Wetland

Anjana is an abandoned channel of River Jalangi almost dying. The wetland is mainly rainfed and is connected with River Churni at present. The depth of water varies seasonally. (Table 1)

Table1
Total Area and Depth Covered by the Water Body

BIL	*AREA (ha)*	*DEPT H (ft)*
ANJANA	16.5ha	4-6

Pattern of Utilisation of the Wetland

The wetland is mainly utilized for fishing, domestic work, irrigation, immersion of deities and other activities. Anjana is owned by the fishery department of West Bengal Government and fishing right is given to the cooperative society. Around 160 Quintal of fishes are produced from this Wetland and the average annual income of the fishermen is around Rs.1.2 million. (Plate 1, 2)

Species Diversity

There is great diversity in floral and faunal species of the surveyed wetland in this block. The common flora of the wetland are Water Hyacinth, rooted submerged Hydrophytes like Hydrilla, Ottelia,Vallisneria etc.which grows at various depth. There are also plant species rooted in the mud but their leaves reach water surface and float .They are Nelumbo, Nymphaea, Trapa etc.There are free floating plants that are not fixed in the mud like Lemna, Wolfia, Pistia, Salvinia, Azolla etc.(table 2 and 3). Other fauna are Zooplanktons like Daphnia lumhaltazi, Moina micrura, D.carinata etc. Insects like May fly, Dragon fly, Water stridergerris,Water boatman, Whirling bettle,Leaf insect, Spiders ,Crab are common. Annelids like Earth worm, Leach are common. Molluscs like Lymnaa, Pila globosa etc are common. (plate 3, 4)

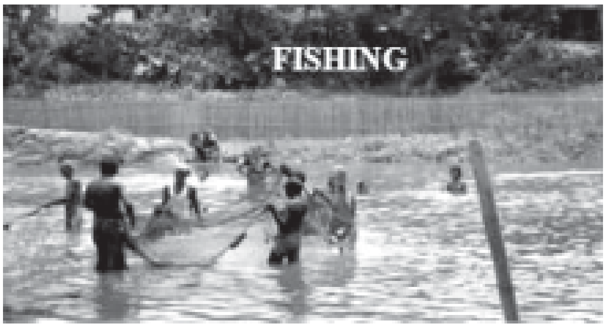


Plate 1

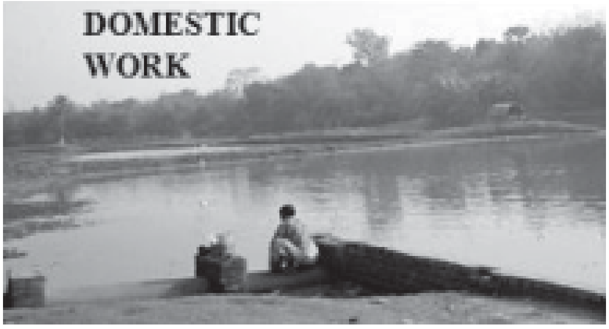


Plate 2

Plate 3

Plate 4

Table 2
Fauna- The Common Fish Species

Scientific Name	*Local Name*
Major Carps	
Catla Catla	Catla
Labio Rohita	Rohu
CirrhinusMrigale	Mrigal
Silver Carp	Silver Carp
Minor Carp	
Puntius Ticto	Tit Punti
Puntius Stigma	Punti
Chaniformes	
Ophicephalus punctattus	Lata
Ophicephalus' striatus	Shole
Siluriformes	
Wallago attu	Boyal
Mystas mystas	Tangra
Osteoglossiformes	
Natopterus Chitala	Chital

Table 3
The Common Bird Species

Scientific Name	Local Name	Status
Phalacrcorox carbo	Boro pankauri	Resident
P.furcicollis	Majhari pankauri	Resident
P.niger	Choto pankauri	''
E.garzetta	'' bak	''
E.intermediae	Majhari bak	''
Nettapus	Bali hansh	Mrigratory
Anasacuta	Dighi ''	''
Alcedohercules	Choto machranga	Resident

Source : www.bhuban.nrsc.gov.in 2014

DISCUSSION AND ANALYSIS

Problems

Anjana is affected by high or medium rate of siltation which has resulted in gradual rising up of the bottom of wetland, decrease of water holding capacity and reduction of water area during summer. The command area for the water body is around 4 to6ha. Moreover the water body is affected by intensive pollution. The main source of pollution is sewage pollution like hospital effluent and domestic sewage. The part of Anjana which flows through Krishnanagar town is highly affected by pollution from sewage of Saktinagar jilla hospital, hospital marg and domestic sewage which includes human and animal excreta of the surrounding settlements of Krishnagar sadar area. This abandoned river channel provides the space for dumping purpose of municipal wastes of the locality,which not only pollute the water but also encroached some portion of the wetland and has profound negative impact on its environment.

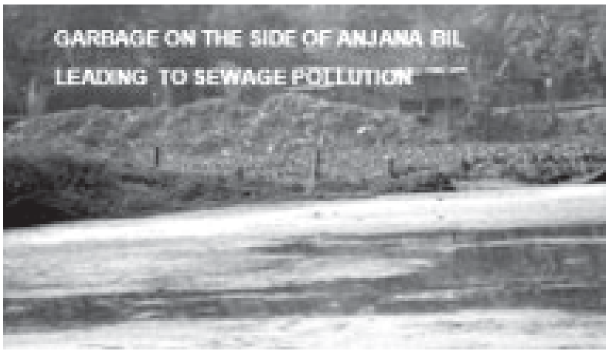


Plate 5

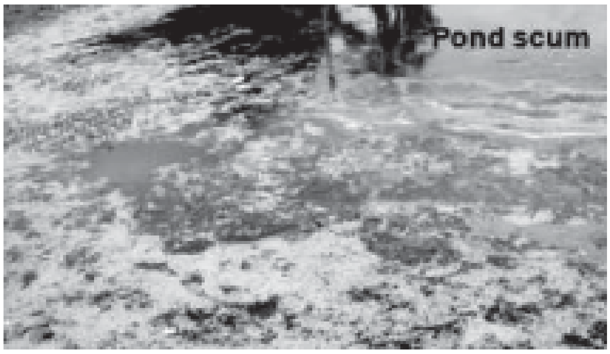


Plate 6

These in turn causes accelerated eutrophication and algal bloom leading to diverse ecological changes within the system. High nutrient inputs are characteristics of Eutrophic condition. Nutrients such as, Nitrate and Phosphates are present in domestic sewage which also greatly increase the nutrient load in water bodies. Sewage, other organic wastes, animal and human excreta are classified as oxygen demanding waste. These organic wastes provide good substrata for the luxuriant growth of aerobic bacteria which decompose the waste and deplete oxygen. When these sewage and organic wastes are broken down, inorganic nutrients enrich the water. In this way, the mineral and salt contents of water body increases. This nutrient load greatly increases the productivity of water as these are essential for plant growth.

It promotes algal bloom and other macrophytes. The growth of algae and other organic matter promotes that of a large decomposer population which breaks down dead algae and other organic matter using oxygen from the water. Living organisms and the algae also consume oxygen at night for respiration .In this way, oxygen is greatly depleted from the wetland which causes serious problems to fish and other organisms. On the other hand this problem of excessive nutrient load accelerates the process of Eutrophication. (Plate 5, 6) At the Eutrophic extreme of the scale water becomes turbid, support dense algal growth but have a very low oxygen content supporting few animals. This Eutrophic wetland shows proliferation of Green algae, Blue Green algae which form a continuous mat commonly known as Pond Scum over the water surface. Light penetration and oxygen diffusion to the water below are greatly reduced to near zero, creating conditions that prove deleterious for most forms of aquatic life. Development of high concentration of $NH_3$and H_2S at the pond bottom due to accumulation of sludge endangers fish life. Parasitic infection in fish stock causing various diseases like tail and fin rot, worm diseases, potential microbiological problems are well observed by the researcher during her survey work. Due to the flow of domestic sewage in the bil transmission of human pathogens are also associated with the health of the fishes which is well documented in the water sample testing by the researcher. These toxic substances are highly persistent and thereby contaminate the entire biogeochemical cycle of the bil ecosystem which is a static system. The capacity of the ecosystem to satisfy the Biological Oxygen Demand (BOD) is exceeded and the condition deteriorates rapidly. The polluting power of different sources of wastes is reflected in the BOD values of the water sample test. The fishes and other biotic communities come under physiological stress. It kills aerobic organisms including some micro organisms and invertebrates. It affects the growth and reproduction cycles of the majority of aquatic animals. Such a situation does not only result in low fish output or fish mortality but is also responsible for transport of toxic materials in the users. It affects fish growth and gill, scales and muscle of fish which in turn affect human being when consumed i.e. accumulation of non biodegradable pollutants at different trophic levels. Eggs of fish are also affected decreasing fish production. Smell of medicine in water and fish is also reported by the users and is also observed by the surveyor. Some of the fish species like Mourala, Nadosh, Khaira, Sarpunti, Chital, Boyal and Shoal are now become endangered species as being reported by the fishermen. Such pollution problems are also liable to affect faunal density and the users of this wetland .These are evident from decrease in the number of migratory birds and skin diseases of the users. The researcher is well documented about the toxicity of municipal residue and hospital effluents in her study which is analysed below.

Analysis of Physico Chemical Characteristics of Anjana, Wetland

Anjana is situated in the urban areas and are affected by urban effluents. . The water of this wetland is sampled for physical and chemical properties and bacteriological analysis. Analysis of these parameters has helped the researcher for highlighting the total picture of the physico - chemical characteristics of the bil.

Sample collected on 23/1/2014 at 12.00 Noon

- Temperature 24 degree c - It is low and cooler water declines fish growth.
- Dissolved Oxygen (D.O.) 5.6 - The value is lower and sub optimal. It may be due to the fact that the sample is collected at noon and more organic load is in the bil leading to algae and macrophyte bloom.
- Biological Oxygen Demand (B.O.D) 4.8 - It is high due to presence of organic matter in heavy amount.
- pH (water) 7.81 – The value is optimal for fish production.
- Free Carbon dioxide 1 ppm - This value is optimal.
- Phosphate 0.29 – This value is higher due to presence of organic load in the form of domestic sewage leading to algal bloom.
- Nitrate Nitrogen 0.007 – The value is below the limit but more or less good for fish production.
- Bacteriological analysis – Sample collected and analysed on 23/1/2014

Faecal coliform bacteria – 20 CFU/100 ml water.

Faecal Streptococci bacteria – 30 CFU/100 ml water.

Both the values are very high due to domestic sewage pollution and due to infiltration of sewage from Saktinagar Jilla hospital. It is of mixed origin due to the presence of human and animal excreta. Water is highly contaminated and not suitable for human use and aqua culture. Due to the presence of these bacteria, fishes are affected by bacterial diseases.

Fishes are suffering from environmental stress due to depletion of oxygen and bacteriological diseases like tail and fin rotting, soar on body. Other aquatic organisms are also affected due to very low amount of D.O. and high B.O.D. From the above analysis it is observed that the water of the wetland, Anjana is highly contaminated and is not suitable for aquatic ecosystem and for domestic use by human being.

Analysis of Turbidity Status and Weed Infestation

The turbidity status and weed infestation is studied in the wetland and analysed with the help of remote sensing software.It is observed that deeper the shade of green lower the turbidity i.e. more clear water, less sedimentation and less vegetative cover. This indicates higher absorption of light and more transparent water. On the other hand, higher turbidity and areas of macrophyte - algae bloom are indicated by light and lighter green shades. It shows greater reflectance of light and high rate of siltation. After classification the fourth class indicates higher turbidity values and first class shows lowest values. i.e the pixel values ranging between 1 and 2 indicates low turbidity, between 2 and3 indicates medium turbidity and between 3 and4 indicates highly turbid water quality. It is observed from the diagram that most part of the wetland is highly turbid and is infested with macrophytes. The main cause is high rate of suspended clay, silts and organic load due to sewage pollution leading to algal boom and weed infestation. (Fig 3)

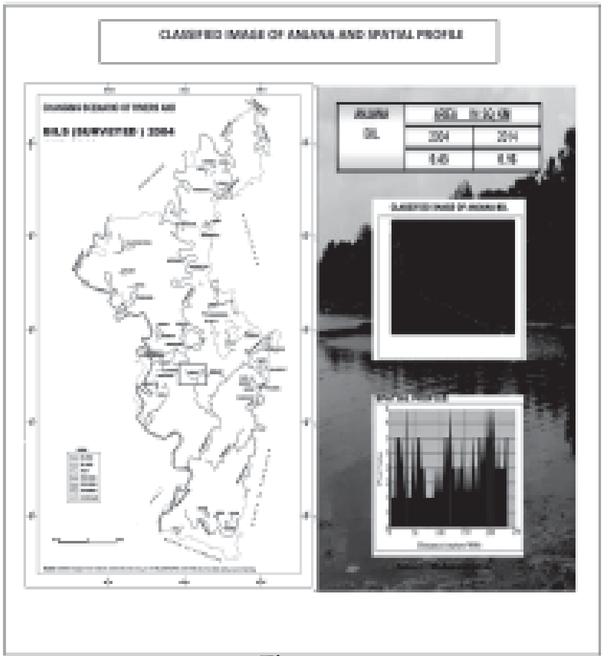


Fig. 7.3

CONSERVATION AND MANAGEMENT

Wetland resource management implies sustainable use of its resources for maximization and long term benefit of society and minimization of waste products. In this context proper conservation and management of the wetland and planned harnessing of its resources is needed. In view of the fact, firstly the problems should be identified and accordingly management programmes should be taken up. Here the Micro level planning needs**:**

- Holistic approach for development of this flood plain wetland is a must with proper identification of activities to be implemented.
- Required and timely arrangement of finance by the State Government for effective execution of project.
- Limitation of fish mortality by controlling water pollution, construction of sewage treatment ponds for the treatment of polluted water, restriction on numbers and types of gears, closed season and closed areas.

- Proper monitoring of the activities by the fishery department in the frame work of environmental variables.

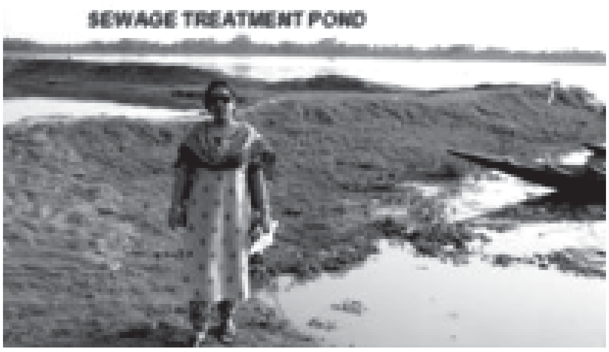


Plate 7

- Steps to strengthen the extension services to make it more user friendly.

Development of Eco-aquaculture is a suggestive

Plate 8

measure in maintaining good health of the aquatic ecosystem but also to sustain the farmer's interest in long run.

Eco- aquaculture implies enhancing productivity of aquaculture systems as well as scope of enhancing the income of the farmers through maintaining a sustainable ecosystem with a safe limit of biodiversity.

Several steps have been adopted for conservation, up gradation and improvement of the pattern of utilization of the resources from the existing water body. They are as follows:-

- Dredging work to remove siltation particularly in dry parts of the bil.
- Digging and financial assistance of Rs 32lakhs for maintenance and fishing in the bil has been carried out by the Govt.
- Several Government schemes have been carried out by the Govt. Since 2009 the schemes are in vogue. They are Duck cum Fishery, Social forestry, Air breathing fish culture.
- Pension schemes for old fishermen, improved extensive fish culture, improved fish feed and water quality management.
- Pollution is controlled by bleaching and clearing the wetlands with lime, potassium permanganate and organic material like cowdung.
- It also includes construction of sewage treatment ponds for treating polluted water. Social forestry and plantation of useful trees around the bil is needed for conservation purpose.(Plate no.7,8)
- Testing of water of the wetlands frequently to know the water quality.
- As far as the biodiversity is concerned this wetland has immense economic potential. So it is urgently needed to prepare a list of threatened species.
- Efforts should be made to restore the habitat of flora and fauna for conservation of the biodiversity.
- Moreover this wetland's resources are being used by the local people as a means of their sustenance so sustainable use and management of its resources is immediately needed.

FINDINGS AND CONCLUDING REMARKS

The main Findings are as follows:-

1. The wetland is mainly used for pisciculture, domestic work and immersion of deities etc.
2. The wetland is owned by the Fishery Dept. of Govt. of West Bengal and fishing right is given to the cooperative societies.
3. The bil is affected by siltation and pollution mainly due to draining of hospital and municipal sewage and dumping of town garbage leading to profound negative impact on biodiversity and its users.
4. So the wetland at present is losing its effective water area and is under constant threat.
5. State Govt. has adopted some steps regarding its pattern of utilization, up gradation and management but these are not enough to resuscitate this ecosystem.

Wetlands play certain vital functions in maintaining environmental sustainability. So full implication of wetland values and losses are to be undertaken in perspective of attempt for its conservation and development by Government and non Governmental Organizations This research work may be viewed as a step forward towards sustainable utilization and conservation of this fragile ecosystem in Nadia district.

REFERENCES

1. Annual Plan for 2007-08 and 11th five year plan-2007 to 2012 District Nadia office of the D.M., Development and Planning section - Krishnanagar - Nadia.(pp 1to7) Publication Govt .of West Bengal.
2. Bhatt S.C (1997)-The Encyclopedia District Gazetteer of India vol 9 (pp945to951)
3. Bhattacharya S, Mukherjee K,Garg J K (1992) – Wetlands of West Bengal.- Institute Of Wetland Management and Ecological Design Calcutta and Space Application Centre, Ahmedabad. (pp 1to9,25to34 &87to92) Published by Institute Of Wetland Management and Ecological Design.
4. Biswas Kumud Ranjan(1915)- Rivers of Bengal(Report on the Nadia Rivers) vol 3. West Bengal District Gazetteer, Dept. of Higher Education Govt. of West Bengal..
5. Biswas Kumud Ranjan(1919) Rivers of Bengal - vol 2 (pp1to28 & pp 34to76) Published by K.R.Biswas , State Editor , West Bengal District Gazetteer, Dept. of Higher Education Govt. of West Bengal..
6. Garrett J.H.E (1910)-Nadia –Bengal District Gazetteer. (pp1to28 & pp87to123) –Published by K.R Biswas State Editor, West Bengal District Gazetteer, Dept. of Higher Education Govt .of West Bengal.
7. Ghosh A K and Khan D K –Fresh Water Wetland Loss in Nadia District West Bengal Published by Journal of Landscape System And Ecological Studies –vol .27 no.2 December 2004 (pp170 –179)
8. Ghosh Dhrubajyoti (2005)- Ecology and traditional wetland practice (pp1to23) Published by Worldview publishers. Higher Education Govt .of West Bengal.
9. Kundu N –Management of Wetlands : A Case study of West Bengal(pp 164to 179) –Changing Environmental scenario(2002) Edited by Subhashranjan Basu - acb Publications
10. Kundu N, Bhattacharya M, Mukherjee A(1997) - Managing Wetlands.(pp1to162) -Published by Institute Of Wetland Management And Ecological Design.
11. Majumdar Durgadas(1978)-West Bengal District Gazetteer Nadia(pp1to31&pp116to145)- Published by K.R Biswas ,State Editor, West Bengal District Gazetteer , Dept. of Higher Education Govt .of West Bengal .
12. Meenbarta -special issue on wetland -Department of Fisheries -16th June 1998 (pp3to4, 11to14&24to28) Publication Govt .of West Bengal.
13. Samajdar Gangopadhyay I –Problems of Wetland Ecology of Krishnanagar Block 1 of Nadia, West Bengal -. Published by Journal Of Landscape System And Ecological Studies Vol.31 No.2 December 2008 (pp.39 to 46)
14. Vinci, Jha, Bhowmick, Mitra (Edited) - Fisheries Management of Floodplain Wetlands in India(2003)— (pp1to5 &14 to 55) , Publication – Central Inland Fisheries and Research Institute - Barrackpur , West-Bengal.
15. West Bengal State report (2003) –Volume 3 – Directorate of animal resource and animal health (pp5to9) -Publication Govt .of West Bengal.

WATER RESOURCES MONITORING AND MANAGEMENT USING ADVANCED GEO-SPATIAL TECHNOLOGY OF ARAKHASA WATERSHED IN BANKURA AND PURULIYA DISTRICTS, WEST BENGAL, INDIA

Jatisankar BANDYOPADHYAY[1], Kartic BERA[2], Kunal Kanti MAITI[3]

ABSTRACT

The integrated approach to water resources management is to ensure increased coordination in development planning between water managers and the various development planners. An integrated water resources management and their temporal and spatial distribution within a river catchment is need of the day. This should be based on its physiographic and socio-economic conditions, and integrated with water demand and utilisation analysis. Parameters relevant for hydro-geology are spatially distributed and may show significant temporal variability. Earth Observation (EO) data, when used jointly with in situ data, can provide an essential contribution for the creation of inventories of surface water resources. The large area coverage of each observation, on the one hand, helps moving beyond the point-based readings provided by gauge networks to –for instance- basin-wide measurements of discharge and storage. Repeatability of observations allows the generation of a time-series of observed parameters and may result in an improved capability to analyse, monitor and forecast the evolution of phenomena, facilitating water resources management. The villages of the study area are fast heading towards a water crisis. The most part of the area have traditionally relied on local rainfall for meeting the water requirements for drinking, washing and other purposes and also for agriculture. Its' shortage is likely to be so acute that the future may fight on sharing of water resources among various villages. Geographical Information System (GIS) with its capability of integration and analysis of spatial, multi-layered information obtained in a wide variety of formats both from remote sensing and other conventional sources has proved to be an effective tool in planning for micro-watershed development. In this study geospatial technology has been applied to identify the natural resources management problems at micro-watershed level. Micro watershed management through the geospatial technology is developed and tested for the evaluation of the water resources of the study area. The present study reveals the availability of water is quite less on the surface as well as at sub-surface. The ground water level is more than 100 meters from sea level and even more than 200 meters also at some places. It is also observed that Hura and Kasipur block is under high scarcity. Chatna, Indpur have good water potentiality because of low slope, high drainage density, infiltrated soil, porous and soft lithology. On the other hand, Hura, Indpur have low water potentiality because of high slope, low drainage density, hard lithology, non porous soil etc.

Keywords: *GIS, Multi-layered, Micro-watershed, Surface, Sub-surface, Management.*

INTRODUCTION

Water resources affect all social economic sectors and sustainability of the natural resources base. Presently surface water addressing requires an intersectional and multidisciplinary approach. Managing of water resources is in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Remote Sensing data and GIS is a flexible, efficient, speedy, cost-effective and reliable technology for obtaining information on Water resources, forest and agricultural research and natural resource management (Jain-2011). In this study, an attempt has been made to assess the Water Resources monitoring and Management using shape, size, texture and tonal variations from remotely sensed images (Bandyopadhyay and Bera 2015). Natural resources are useful raw materials that we get from the earth. They occur naturally, which means that humans cannot make natural resources. In the past decade, water resources management has faced multiple paradigm shifts: from supply to demand management, from engineering to an environmental perspective, from a top-down to a participatory management. There is a broad consensus on the need

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to achieve a better balance between economic efficiency and environmental quality in the sense of the sustainable development of natural resources. The development of water resources and its utilisation in appropriate manner in the context of "climate change" have been expressed as "conserve, water beneath the ground water, water within the plant bodies, water up in the sky and the water is the atmosphere, may all quarters of the earth be full of following water for us".

OBJECTIVES

- Preparation of Drainage Network map from SRTM DEM Data.
- Geology and geomorphology mapping from Geology map of GSI.
- Mapping of relief, soil, slope, aspect, LU/LC & Surface water body.
- Identification of ground water potential zone.

STUDY AREA

The present study area belongs to the Arkasa in Beko watershed of Dwarakeswar River basin which is located in the Chhatna, Indpur and Bankura-I block in Bankura district and Puncha, Hura and Kashipr in Puruliya district of West Bengal state. The covering study area is located in 22^0 57' to $23^0$31' 38.683 N latitude and $86^0$31' 03.683 to 87^0 02' 45.183 East longitude. The total geographical area of the study is 341.14 KM^2. The location of the study area is shown in Fig. 1.

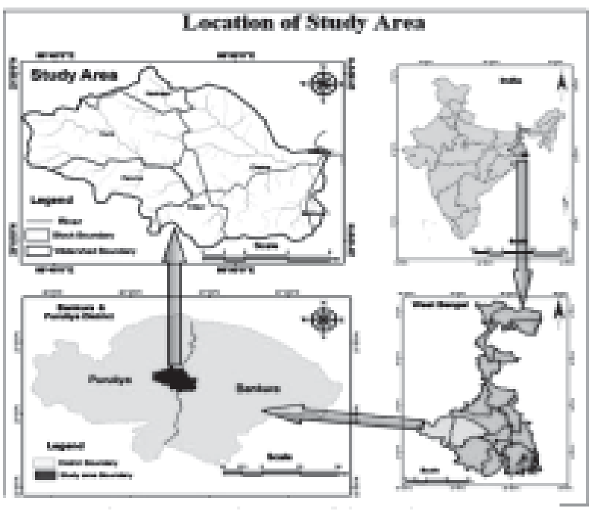

Fig.1: Location Map of the Study Area

DATA USED

Table 1

Sl. No.	Data	Source of Data	Year of Published
1.	SOI Toposheet (1:50000)	Survey of India, Kolkata	1975
2.	DPMS	Survey of India (Purulia District) and NATMO (Bankura District).	2001
3.	Metrological Data	IMD, Shivanagar, Pune 411005, Maharastra.	2015
4.	LISS-IV	NRSC Hyderabad	2012 and 2015
5.	SRTM DEM	USGS website	2008

METHODOLOGY AND ANALYSIS

Ground Water

The study area is known as drought prone area. Ground water availability of Pre-monsoon period is varying with depth and Post Monsoon time that in some parts of the study area quiet shallow than pre-monsoon. In maximum part of the study area, ground water level is more than 100 meters from sea level and even more than 200 meters also (Bera 2013). But due to high altitude and hard rock terrain, it is difficult to access the ground water.

Surface water body

Drainage of the study area is under rain fed regime. Therefore very little normal flow of water in the drainage throughout the year. Due to lean flow of water and undulated high altitude regime, other surface water body plays very important role in their daily life in semi arid regions like Bankura and Puruliya district. The different types of surface water management plan have been observed like Happa, Percolation tank, Farm ponds, Check Dam, Small Reservoir Irrigation Tanks, Contour Bunds etc in the study area of Arkasa sub-watershed (Fig. 2).

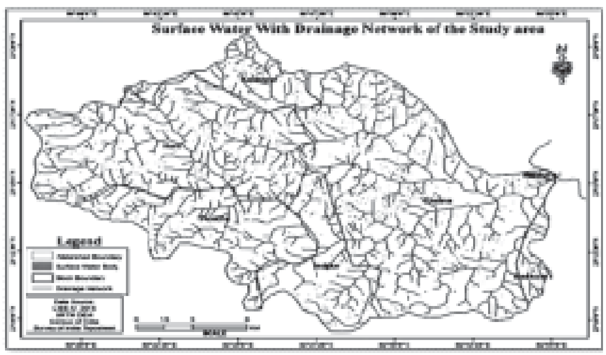

Fig. 2

DISCUSSION AND MANAGEMENT

Surface Water management

The body of surface water means a discrete and significant element of surface water such as a reservoir, a stream, river or canal, part of a stream, transitional water or a Pond (Bandh), a Percolation Tank, Nala Baund, Check Dam, Reserve or a small storage system.

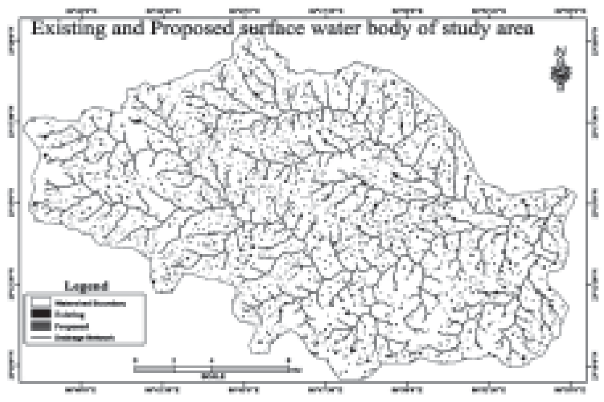

Fig. 3

In the study area, drainage water availability depends on the rain. Therefore, the very little normal flow of drainage water throughout the year. Due to lean flow of water and undulated high altitude regime, other surface water body plays very important role in their daily life in semi arid and arid regions like Bankura and Puruliya district. Various types of small model and management plan had been taken for surface water management particularly in this area (Semi arid region) i.e 5% model, 30-40 models, **Happa, Nala Baund** etc (Bandyopadhyay et al. 2015). Fig. 3 is showing the existing and proposed surface water body of the study area.

Happa

One of the surface water management plan happa is used here for domestic and irrigation purpose. A happa is a mud-excavated rain water harvesting structure and does not have any cement work or stone revetment. The sides of a happa are stepped with a slope of 1:1 such that both livestock and human can access the water of happa easily. One of the surface water management techniques named Happa is shown in Fig. 4.

The maximum closed bound surface area of water is 45210.102 sq. m whereas smallest is about 236.326 sq. m and average is about 1200 sq. m. A happa is constructed by the side of the agricultural field of a farmer with an average length of 45 ft, breadth of 50 ft and depth of 12 ft. The total earth extraction of this happa is 17,360 cubic feet. The average command area of a happa is about 0.6 acre. The model is also called 5% model because it occupies 5% of the area of the agricultural plot of the farmer. This model has become successful in some dry zones of West Bengal.

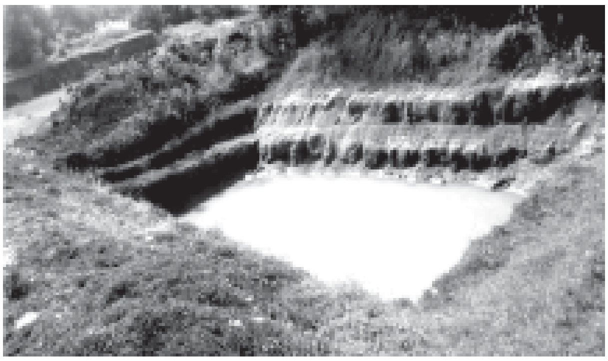

Fig. 4: Field Photographs of Happa

Nala bunds/ Check dam

The nala bunds structures constructed across nalas (Streams) for checking velocity of runoff. It is important as it is reducing the gradient of water flow and soil erosion and increasing water percolation and improving soil moisture regime (Bera 2013). The nala bunds are recommended on first order drainage at a suitable distance on all over the drainage, on the other hand, check dam constructed on the minimum area is 25 hector also in 1st to 3rd stream order. Fig. 5 is showing the Nala bunds/ Check dam.

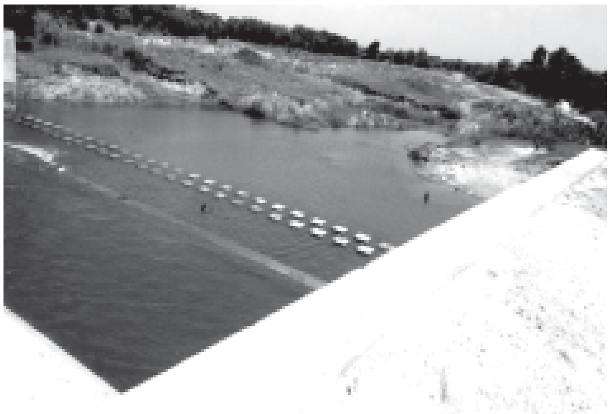

Fig. 5: Field Photographs of Check Dam

Ground Water Management

Ground Water management plan can be done through the identifying potential zone for future prospect. The overlay analysis allows a linear combination of weights of each thematic map with the individual capability value with respect to ground water potential (Bandyopadhyay et al. 2014). Various terrain parameters like Slope, Drainage Density, Soil characteristics, and Land use are prime control on movement of surface and sub- surface water and occurrence of perspective ground water reserves in the region. Fig. 6 is showing the ground water potential condition of the study area. The ground water level is more than 100 meters from sea level and even more than 200 meters also at some places. From the study, it is observed (Fig. 6) that Hura and Kasipur block is under high scarcity (Bandyopadhyay et al. 2014). Chatna, Indpur have good water potentiality because of low slope, high drainage density, infiltrated soil, porous lithology. On the other hand, Hura, Indpur have low water potentiality because of high slope, low drainage density, hard lithology, non porous soil et

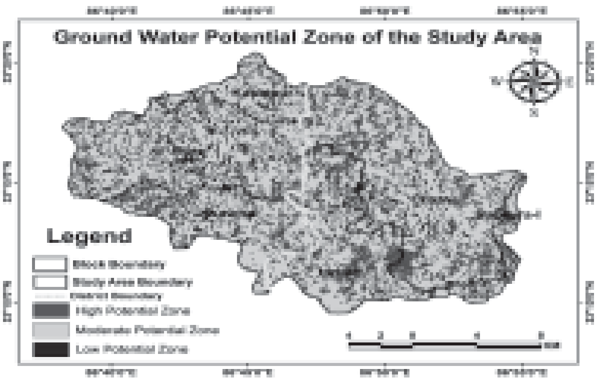

Fig. 6

CONCLUSION

The small irrigation program like Happa has a strong impact on the livelihood security of the rural people. It has improved the productivity, intensity and diversity of crops. The diversification of production of farmers from a single Khariff crop of paddy into other crops like vegetable production and fishery has reduced their vulnerability to climate shock they faced earlier before the construction of Happa. Therefore only the surface water management plan is essential for challenges the water threats and future prospects.

Acknowledgement

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REFERENCES

1. Bandyopadhyay, J. and Bera, K (2015), Geospatial Technology for Sustainable Natural Resource Monitoring and Development, A Case Study of Arkasa Nala, Bankura & Puruliya district, West Bengal, Edited by Dr. D.K Mandal, Published by Registrar University of North Bengal, ISBN 978-81-921692-7-9, page 301-317.

2. Bandyopadhyay, J., Bera, K. and Kola, M (2014), Application of GIS for Monitoring and Management of Ground Water Resources in the Area Surrounding the Arakhasa River, in Bankura & Puruliya districts, in West Bengal, India, Indian Cartographer Vol.34.

3. Bandyopadhyay, J., Bera, K. and Maiti, K.K (2015), Geoinformatics in Surface Water Management for Ground Water Development in Semiarid Terrain of Arkasa Sub Watershed in Part of Bankura and Puruliya District, West Bengal, India. Proc. Int. Sem. Challenges to Ground Water Management: Vision 2050. CGWS 13-14 November, pp. 150-156.

4. Bera Kartic (2013), Geoinformatics in Water scarcity Management by suggest Nala band and Reservoir: Part of Dwarkeswar watershed, West Bengal, India, International Journal of Research in Social Sciences, Volume 3, Issue 1, PP 656-670.

5. Jain-2011, Population Rise and Growing Water Scarcity in India – Revised Estimates and Required Initiatives, Current Science, Vol. 101, No. 3, 10 August 2011, Page 271-276.

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A MICRO – LEVEL ANALYSIS OF SOIL, GEOMORPHOLOGY AND LAND USE IN SARKARA WATERSHED OF VAMANAPURAM RIVER BASIN

G. MANOJ[1] & R. ANILKUMAR[2]

ABSTRACT

The present investigation has been designed to examine soil, geomorphology and land use characteristics of landscape constituting Sarkara watershed in order to understand the existing land use and its degree of correspondence with its inherent potentiality. The Sarkara watershed lies between $8^{0}15'$ N to $8^{0}50'$ N latitudes and $76^{0}42'$ E to $77^{0}12'$ E longitudes. The stream rises from Valiakavuhills (222M) of Vattappara and is an important left bank tributary of VananapuramRiver. It is a fifth order stream which flows in Nellanadu, Mudakkal and Manikkal panchayats of Trivandrum district in Kerala. The four major soil series viz, Marukil-Amaravila, Nedumangad-Kuttichal-Vamanapuram,Trivandrum-Vizhinjam and Varkala Thonnakkal are found in the study area. Flood plains, ridges, isolated hills, valley slopes and river or stream terraces are identified in the watershed. The soil catena of those units has been analysed and understood. The predominant land use categories identified in the watershed area settlement with mixed trees, Rubber plantation, coconuts, built up lands, paddy lands, paddy converted areas, waterlogged areas, fallow lands and scrub vegetation. The soil, land use and geomorphic details were integrated to understand the inherent potentiality of various land units and their suitability for various uses. An environmental appraisal made on the different geomorphologic units showed that in many instances the present practice of land use is either solely or partly crosses the resilience of the environmental set up. Analysis of the existing land use and the result obtained through the integration of physical features revealed that the influence of anthropogenic factors is more prominent than that of either geomorphology/soil characteristics of the landscape constituting the watershed. Based on the analysis a suitable land use plan has been suggested for the basin.

Keywords: *Sarkara Watershed, Soil Catena, Geomorphology, Land Use.*

INTRODUCTION

Land use practices of a region depend on the geomorphology and soil characteristics. Micro-level analysis of geomorphology and soil are considered as an essential prerequisite for the sustainable development of any region. The examination of geomorphology and soil should help to frame eco-friendly land use practices. Sarkara watershed lies between $8^{0}15'$ N to $8^{0}50'$ N latitudes and $76^{0}42'$ E to $77^{0}12'$ E longitudes. The stream rises from Valiakavuhills (222M) of Vattappara and is an important left bank tributary of Vananapuram River. It is a fifth order stream which flows in Nellanadu, Mudakkal and Manikkal panchayats of Trivandrum district in Kerala.

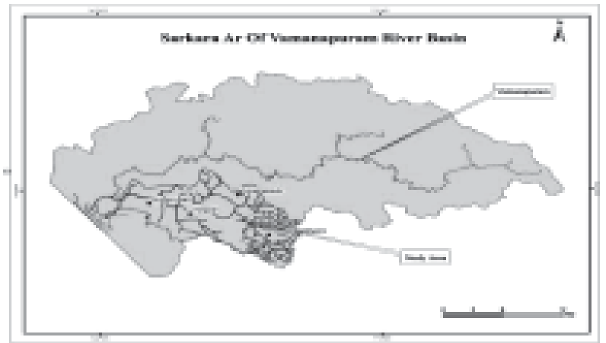

Fig 1

OBJECTIVES

- To examine the geomorphology of the Sarkara Ar water shed
- To analyse the different soil groups in the Sarkara Ar water shed
- To study the present land use
- To propose a suitable land use in accordance with the existing soil and geomorphology.

DATABASE AND METHODOLOGY

The geomorphology map of the watershed was extracted from SOI toposheet of 1:50,000 scale (58 D/14). The soil of the area of investigation was derived from Bench Mark soils map of Kerala (2007) published by soil survey organisation Agriculture (Soil Conservation unit), Government of Kerala. Google image was used for extracting the present land use of the basin. Geomorphology and soil maps were manually superimposed and suitable land use categories were demarcated. Arc GIS 9.3 software was used for data editing and analysis. The extracted maps were geo-referenced and registered in the same

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projection and coordinate system (WGS-1984) and digitised them to prepare the final maps.

DISCUSSION AND ANALYSIS

Geomorphology

Landforms have a profound influence on land use. Six geomorphologic units could be identified in the study area (Table 1). It comprises Flood plains, isolated hill, ridges, gently sloping land, moderately steep land and steeply sloping land. Of these moderately sloping land dominates the study area (51.61 Sq.Km)

Table 1
Geomorphology

Land form	*Area (Sq.Km)*
Flood plain	18.16
Isolated hill	0.14
Gentle slope (<15%)	22.15
Moderate slope (15.30%)	51.61
Steep slope (30.45%)	6.92
Ridges	25.54

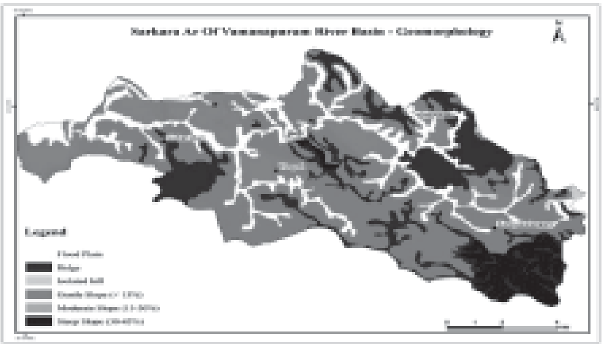

Fig 2

Soil

The soil is the very heart of the lifer layer on the lands (Alan H. Strahler and Arthur N. Strahler) The soil distributed in the watershed mainly belongs to Kazakuttam series, Marukil – Amaravila series, Trivandrum series, Varkala series and Nedumangad series (Soil survey Organization Agriculture Department). The distribution pattern of these soil series in the watershed are illustrated in fig.3 and the share of each of these soils are provided in Table 2. The characteristics of the series of soils constituting the watershed are explained below.

(i) Kazhakuttom series

Kazakuttom series are loamy, course-loamy, loamy sand and sandy loam in texture. These soils are formed on the coastal alluvial sediments of coastal areas in Thiruvananthapuram district. It is well drained and supports coconut, vegetables and floriculture.

(ii) Trivandrum series

Trivandrum series are very strongly acidic, excessively gravelly, sandy loam to gravelly sandy clay loam in texture. It is well drained with moderate to moderately slow permeability. It supports coconut, rubber and tapioca.

(iii) Marukil-Amaravila series

These soils occur along the wet valleys and suitable for paddy cultivation. It shows clay loam to clay texture with slow permeability and poor drainage.

(iv) Nedumangad series

Nedumangad series are strongly acidic and gravelly in texture. It is well drained with moderately to moderately slow permeability. Rubber is the predominant crop. Coconut, tapioca, pepper etc. are also cultivated.

(v) Varkala series

Varkala series are strong to slightly acidic, gravelly sandy clay loam to gravelly clay in texture. It is well drained with slow permeability. It is suitable for coconut, banana, pepper and tapioca.

Table 2
Soils and their Distribution in Sarkara Ar water Shed

Soil	Area (sq.km)
Kazhakuttom Series	4.04
Marakil – Amaravila	1.49
Varkala	17.51
Trivandrum	34.05
Nedumangad	67.48

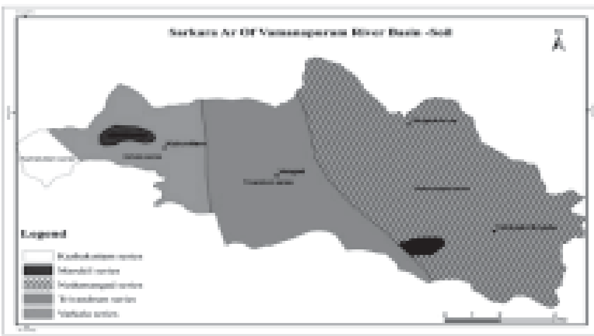

Fig 3

Land use

Land use is primarily an expression of people use natural resources (Srikumar Chattopadhyay and Richard W Franke) Rubber (42.82 sq.km) and mixed crop (32.99 sq.km) are the major categories of land use in the study area. Other existing land use categories are provided in (Table 3) and their spatial distribution is shown in Fig.4.

Table 3
Land Use

Land use	*Area (sq.km)*
Current fallow	0.58
Dense scrub	1.78
Paddy	0.77
Quarry	0.21
Rock	0.19
Canal	0.02
Streams	0.12
Lake	0.07
Pond	0.12
River	0.019
Open scrub	0.62
Cultivable wasteland	4.33
Coconut	2.51
Coconut with mixed crop	15.04
Rubber	42.82
Mixed crop	32.99
Settlement with mixed crop	13.48
Build up land	8.86

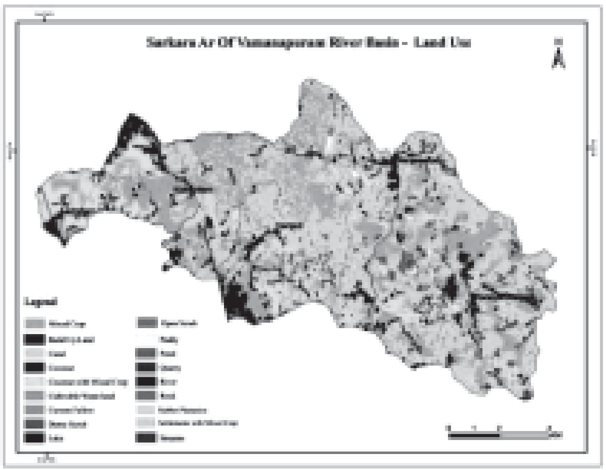

Fig. 4

Proposed Land Use

Based on soil, geomorphology and slope six suitable land use Categories could be delineated for the study area (Table 4). It comprises Forest (3.18 sq.km), paddy (18.19 sq.km), Rubber (18.27), Settlement (2.15), Settlement with coconut (28.62) and Settlement with Mixed trees (54.12).

Analysis revealed that 18.19% of the watershed is suitable for paddy cultivation. Flood plain areas with gentle slopes and clay loamy soil (Amaravila and Trivandrum series) is demarcated for paddy lands.

The study showed that 18.27 sq.km of the area under watershed is suitable for rubber cultivation. Moderately steep and to very steep slopes having Nedumangad soil series and associated groups are suitable for rubber plantation.

Table 4
Proposed Land Use

Land use	*Area (sq,km)*
Forest	3.18
Paddy	18.19
Rubber	18.27
Settlement	2.15
Settlement With coconut	28.62
Settlement with Mixed trees	54.12

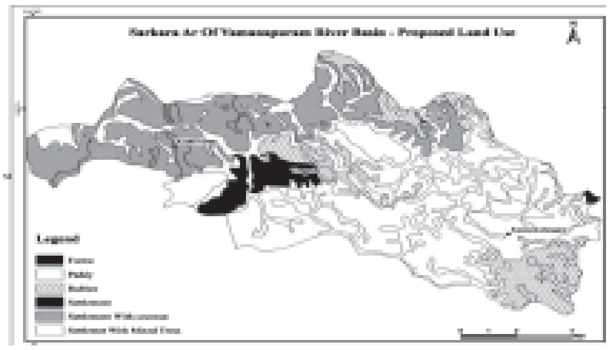

Fig 5

Moderately sloping land with enough roads and water resources is delineated for settlements. The hilly areas with Nedumangad and associated soils are demarcated for the forest.

Gently to moderately sloping terrain with Kazhkuttom & Varkala series is found suitable for settlement with coconut and rest of the moderately sloping lands fall in the entire basin is suitable for settlement mixed trees.

CONCLUSION

The study should that the present land use practices are not in accordance with the existing soil geomorphology and slopes. So a suitable eco-friendly land use plan is proposed for the basin which can ensure sustainable development of the basin

REFERENCES

1. Alan H. Strahler and Arthur N. Strahler (1978), Mordern Physical Geography, John Wiley & Sons.
2. Benchmark Soils of Kerala (2007), Soil Survey organisation Agriculture (S.C. Unit) Department.
3. Srikumar Chattopadhyay, Richard W. Franke (2006), Striving for Sustainability Environmental Stress and Democratic initiatives in Kerala, Concept Publishing Company.

GEO-ENVIRONMENTAL APPRAISAL OF MANGROVE ECOSYSTEM ALONG THE SINDHUDURG COAST OF MAHARASHTRA

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ABSTRACT

Mangrove forests along the coastal tract of Sindhudurg are mainly concentrated in and around estuaries and associated waterbodies. Realizing the multiple functions of mangrove ecosystem the present study essentially captures its geographical distribution in the Sindhudurg District and identified the cradle locations for sensitive mangrove ecosystem. The study brought out the total expanse of mangroves in the district as 14.52 km^2 and there are no serious issues with mangrove ecosystems by comparing time-line Google images. Only minor changes were noted over the period of 12 years in the coverage of mangrove vegetation. Northern half of the district, ie. coastal stretch of Malvan - Vijayadurg area comprises the major mangrove hotspots of the districts. The large Mangrove ecosystems of Sindhudurg are located at Tirlot, Achare, Chander, Aronda and Mumbari regions. Coastal regulation Zone Notifications 1991 and 2011 (Ministry of Environment and Forests, Govt. of India) provides proper management and utilization of vulnerable coastal ecosystems. Adept implementation of the provisions of CRZ Notification using accurately composed cadastral scale CRZ/ CZMP maps with GIS/RS premises shall ensure protection and conservation of mangroves and such other critical habitats for future generation.

Keywords: *Sindhudurg Coast, Coastal Ecosystem, Mangroves, Coastal Zone Management, Cadastral Mapping*

INTRODUCTION

Mangrove, the highly productive tropical ecosystem is of great importance to communities, providing not only a source of food and resources but also protecting coastlines as nature's bioshield which reduces the wave energy and height of storm surges and thus protecting vulnerable coastal communities and regulating climate. Mangrove forests develop in areas where coastal physiology and energy conditions are favorable. Extensive mangrove patches are observed in coastal areas having low shore gradient and with large tidal range (Walsh, 1974).

Sindhudurg in Maharashtra state is a coastal district which forms part of the Konkan Coast having diverse physical environments. As part of the Konkan coast, geomorphic features, like, inlets of creeks, raised promontories, wave-cut notches, embayments, pocket beaches, submerged shoals and offshore islands dissect the coastal zone. The coastline of the Sindhudurg is extending for more than 159 km from Vijayadurga river inlet in north to Teracol river inlet in South. Still it remains as a less developed coastal district of India with high potentiality for growth of different sensitive coastal ecosystems and eco-tourism. Rocks and pocket beaches of Sindhudurg, corals of Malvan and coastal forts offer high tourism potential for the district. Further, the coastal zone of Sindhudurg is a congregation site for migrating marine animals like whales and dolphins, which is also an attraction of tourists.

The coastal zone of Sindhudurg is rich in its affluent biological diversity leading to the formulation of Malvan Marine Sanctuary (MMS) way back in 1987. Besides, the Sindhudurg Coastal and Marine Ecosystem (SCME) has been identified as one among the 11 ecologically and economically critical habitats in India. Identification of Vengurla Rocks as an Important Bird Area (IBA) is yet another acknowledgement implying the potential significance of the ecological communities in the area. Assortment of such vital geo-environmental settings has been essentially leaded to the reckoning of the area (consisting of Malvan and Achare) as Critically Vulnerable Coastal Area (CVCA) under the

Fig. 1: Seen from Dhabole; showing a general coastal morphology of Sindhudurg

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provisions of the Coastal Regulation Zone Notification, 2011. Critical habitats in the area include rocky shore, sandy shore, rocky islands, mangroves, corals, mudflats, etc. Compared to the physiographically distinct plateau and hilly regions, coastal tract of the district is limited to nearly one fifth of its total geographical area.

Sindhudurg has 4 major rivers and more than 20 Creeks, all of which possess parallel drainage pattern. The rivers and creeks are well directed by its relief of hard rocks with west facing escarpments. Creeks and rivers along with their network drainage system consisting of sub-tidal muddy substratum under the influence of meso-scale tidal forcing provided ideal geomorphology for the growth of mangroves. Realizing the multiple ecosystem functions of mangrove ecosystem the present study essentially captured its geographical distribution in the Sindhudurg District as part of the preparation of Coastal Zone Management Plan for the State and presented here on its geo-environmental perspective.

METHODOLOGY

Database Generation*:* Mapping has been done using high resolution satellite images in 1:4000 scale with an appropriately co-registered cadastral overlay. Ambiguity resolved precision GPS coordinates at pre-defined ground control points ensured accurate geo-locationing and registration of satellite images and cadastral maps. Mapping of the geomorphological units and critical ecosystems, such as, mudflats, mangroves, inter-tidal area, etc. were carried out in GIS platform adopting standard remote sensing practices. Field validation of the maps generated was done meticulously following grid-wise ground-truthing procedure. Final maps were composed after closing random-check in the field to compute the geographical extent of different ecosystem components. Also, time-line Google images were made use of to understand *in situ* ecosystem dynamics in the light of anthropogenic pressures being experienced in the area.

Field Mapping: Detailed field mapping was carried out using Terrasync software with precision handheld GNSS receiver. The expanse of ecosystems like mangroves and intertidal zones were identified and validated on the satellite images during field surveys. This has helped to ensure accuracy and to identify the mangrove vegetation and its distribution pattern. The well-distributed ground control points for each coastal village were also located and mapped on the cadastral sheets. Most of the cadastral sheets of Sindhudurg villages are from old surveys and were mapped onto 1:10,000 scale. The cadastral sheets being without any projection, referencing these cadastral sheets on to a descried datum and projection might be lead to certain constraints on its planimetry after projection. These constraints were reduced by limiting the mapping as well as rectification error within the village boundary. For this purpose, village boundaries were identified in the field and marked on the map during ground truth surveys. The mapping of transport and drainage networks supported to rectify cadastral sheets.

RS and GIS Analyses*:* The latest version of Arc GIS and ERDAS IMAGINE were used for processing of the images and GIS-based operations. The recent Google images were downloaded with one minute grids and they were subjected to cross checking and correction for its accuracy, if any. The images were suitably re-rectified with well distributed GCPs to obtain the morphological as well as mangrove distribution details. The cadastral sheets were matched with images and brought them to a common datum with UTM projection. Images came handy to match the plot boundaries of cadastral sheets with accuracy better than 2-3 meter. The pre identified coastal ecosystems and morphological features were extracted from images and overlaid on base map for overlay analysis. The time-line images from Google Earth were used to assess the status of mangroves and morphological features for past 12 years.

The area covered by mangroves was calculated for each administrative village as well as for each geographical location along the Sindhudurg coast. The village boundaries were framed for administrative purpose and hence do not strictly follow the geographical conditions of the area. Most of the river beds, which are the cradles of mangrove, are shared by different villages and ecosystems may spread over many villages. So the mangrove zones were recalculated for each geographical area by taking as a single unit and the most-sensitive areas covering more than 100 hectares were identified.

RESULTS AND DISCUSSION

Socio-Economic Condition*:* The Sindhudurg district has 743 villages of which 214 are coastal villages spread over Devgad, Kankavli, Malvan, Kudal, Vengurla and Sawantwadi Talukas. Malvan Municipal Corporation and Vengurla Municipal Council are the two coastal urban areas in the district. The important livelihoods of coastal community are the plantations like mangoes and cashew nuts, and fishing and related activities. Coastal tourism is one of the emerging activities in the district. The proposed Sindhudurg airport near Malvan is likely to accelerate the growth of tourism in the region. Most of the mangrove concentrated areas of the district are prevailing in the rural area, except Malvan tourist area and Vengurla Bandar. The regulation imposed on exploitation of vulnerable ecosystem with a well-drawn management plan like Integrated Coastal Zone Management Plan (ICZMP) will be helpful for the sustenance of such ecosystems for future. As a fast growing tourism destination in Konkan coast, eco-friendly development plans must be suggested for protecting the natural beauty of mangroves, rocks and pocket beaches of Sindhudurg district.

Table 1
Mangroves and Associated Features in Sindhudurg District

Taluka	*Mangroves (Sq. km)*	*Fort (Sq. km)*	*Intertidal Zone (ITZ) (Sq. km)*	*Saltpan (Sq. km)*
Devgad	6.16	0.01	9.1	-
Kankavli	Nil	-	0.11	-
Kudal	0.02	-	0.14	-
Sawantwadi	1.02	-	0.83	-
Malvan	4.73	0.12	8.1	-
Vengurla	2.59	-	6.62	0.3
Total	14.52	0.13	24.9	0.3

Mangroves of Sindhudurg*:* In Sindhudurg district, 22 mangroves species ~~of~~ under 6 genera were reported, of which, *Avicennia marina* and *Avicenniaofficinalis* L.are most dominant. Mangroves typically occur in association with other coastal

Fig. 2 : Mangrove of Sindhudurg, elevated hillocks are exposed in the back ground.

Fig. 3 : Mud flat in Sindhudurg, which are cradles of mangrove.

ecosystems, such as coral reefs, seagrass beds, algal beds, mud flats and sand flats (Nagelkerken, 2009). While mangroves can persist in isolation, their association with other ecosystems enhances important ecological functions such as fisheries and biodiversity. The mangrove specie *Rhizophoramuconata* and *Bruguieragymnorrhiza* are observed along the creek and waterbed where water flow is predominant. The species *Avicenniaalba* and *A. marina* are found flourishing in the inter tidal areas where saline water reaches during peak flood tides along the creek. Salinity in water also greatly affects morphological and physiological characteristics of mangrove plants. *Excoecariaagallocha* L. and *Acanthus ilicifolius* L. are observed along the river banks and low swampy areas where freshwater discharge occurs. Generally, mangroves are linked to adjacent ecosystems through physical, biochemical and biological interactions, and these interactions facilitate the presence and health of associated ecosystems (Gills et al 2014).

Apart from other geo-environmental entities, total expanse of mangroves in the district is about14.52 km^2. Major mangrove areas are spread over Mumbari creek, Achare, Chander wetlands, Tirlot, Nivti Bandar, Devbag-Tarkarly, banks of Aadari creek, Shiroda creek, Vengurla bandar, Dabholi creek and Tondavali and Vaghotan river extensions. Malvan (4.73 km^2) and Devgad (6.16 km^2) talukas together account for 75% of mangrove vegetation of the district. Wadekarpoi village in Devgad Taluk has the maximum coverage among villages with 0.80km^2 spread of mangroves. All mangrove areas of Sindhudurg are due to the influence of adjacent promontories. Mangroves are concentrated on inter tidal zone of river beds or creeks that experiences tidal action. The annual tidal height of the region varies between -0.10 (Lowest Low tide) and 2.58meter (Highest High Tide) at Marmagoa and 0.06 (Lowest Low tide) and 5.17 meter (Highest High Tide) at Mumbai (Apollo bandar) from mean sea level (*SoI, 2014*). As per the field survey tidal water reached to the maximum landward extent in the creeks and upto 40 to 50 kms in major rivers.

Compared to the earlier published data of 9.55 km^2 (MoEF, 2010) and 3 km^2 (Mangrove Cell, Maharashtra Forest Department) the present investigation depicts an increase in the spread of mangroves. Comparison of time-line Google images nevertheless illustrates only minor changes over the period of 12 years in the coverage of mangrove vegetation. It is presumed that though certain amount of areal expansion of mangroves can be accounted with time, absolute increase of area should also be factorized for larger scale of mapping unlike the earlier studies. As per the time-line Google images, there is no major

Table 2
Location wise Mangrove Area for Sindhudurg District

Sl. No.	*Place*	*Mangrove (sq.m)*	*Mangrove (Hectare)*	*% of mangrove*
1.	Rameswar	198,894	19.89	1.37
2.	Tirlot region	1,814,651	181.46	12.50
3.	Vaghotan River	771,840	77.18	5.31
4.	Fanse creek	597,101	59.71	4.11
5.	Devgad river	984,305	98.43	6.78
6.	Mumbari Creek	1,188,855	118.88	8.19
7.	Naringre river	350,470	35.05	2.41
8.	Achare region	1,611,083	161.11	11.09
9.	Chander wetlands	1,444,320	144.43	9.95
10.	Tondavali (Gad River)	467,380	46.75	3.22
11.	Kolamb Creek	678,009	67.80	4.67
12.	Tarkarli and adjoining area	946,415	94.64	6.52
13.	Nivthi Bandar	310,791	31.08	2.14
14.	Kalchiwadi	45,585	4.56	0.31
15.	Kelus	169,568	16.96	1.16
16.	Dabhole Creek	128,081	12.81	0.88
17.	Vengurla Bandar	175,803	17.58	1.21
18.	Mochemad	360,176	36.02	2.48
19.	Shiroda River	615,630	61.56	4.24
20.	Aronda region	1,209,679	120.97	8.33
Total		14,068,636	1406.87	96.87

destruction or degradation of mangrove ecosystems due to human intervention during last twelve years. This is because of the fact that no major industries or urban development activities took place in those areas. The residential land modifications are limited to mangrove boundaries. In fact, the local residents are aware about the importance of ecosystems for sustainability and degradation of sensitive mangrove ecosystems are not attempted by residents and if at all any such activities happened, it is only because of invaders. From the time-line Google images it is understood there is a slight aerial expansion of mangroves in the river beds of Mumbari creek and Achare region.

Based on the detailed geo spatial assessment of mangrove ecosystems of Sindhudurg, twenty geographical locations of Mangrove hotspots were identified (fig. 4). The names and areas of mangroves for those locations are shown in the table 2. After considering the different morphological features, five major mangrove locations are identified as Very Sensitive Mangrove Ecosystem of Sindhudurg (VSMES) that covers more than hundred hectares. Tirlot creek and adjoining areas, which is a tributary of Vaghotan river accounts 181.46 hectares of mangroves and it forms the largest mangrove area of Sindhudurg (fig. 5). Tirlot region itself consist 12.5% of Total mangrove areas of Sindhudurg. The Tirlot region is followed by Achare, Chander wetlands, Aronda region and Mumbari creek in the descending order. Subtotal of these five areas of mangrove concentration accounts to more than 50% of total mangrove vegetation in the district.

Table 3
Mangroves, ITZ and Waterbed Area of VSMES

Sl. No.	*Place*	*Mangrove (Hectare)*	*Mudflat (Hectare) (Hectare)*	*Waterbed Area*
1.	Tirlot region	181.46	291.06	288.58
2.	Achare	161.11	100.27	76.56
3.	Chander wetlands	144.43	170.84	115.93
4.	Aronda region	120.97	71.80	252.77
5.	Mumbari Creek	118.88	53.58	108.49
	Total	726.85	687.55	842.33

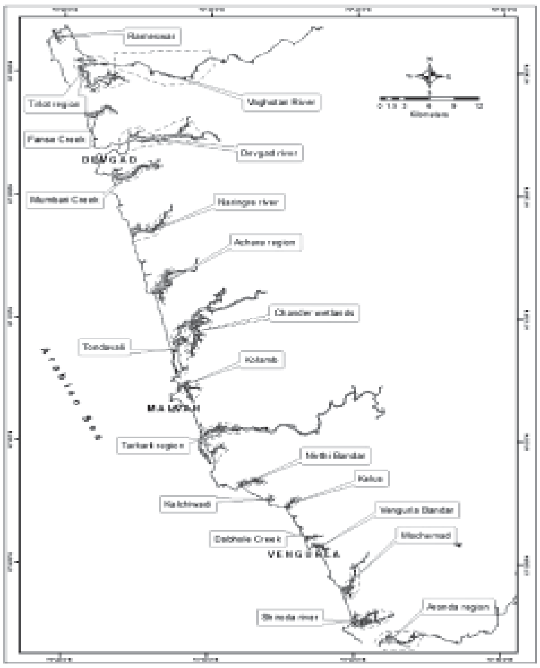

Fig. 4 : Identified geographical locations of Mangrove hotspots in the coastal zone between Vijayadurga river and Teracol river Sindhudurg district, Maharashtra state.

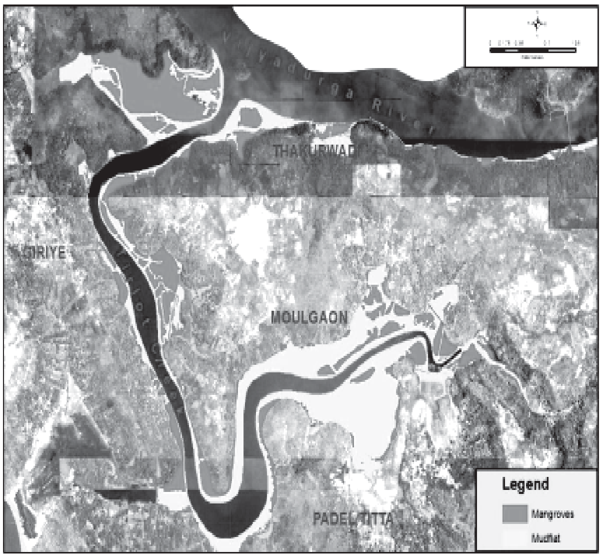

Fig. 5: Mangroves and mangrove potential of Tirlot Creek overlaid on Imagery.

Due to the abundant availability of mud flat (inter tidal zone) and less discharge of freshwater, the Tirlot region has a vast potential for growth of mangrove ecosystem. This region is transformed into a creek, bounded with several promontories like Giriye, Hurshi, Pural-Padel Thitta and Tirlot-Moulgaon. Achare mangroves are grown in river beds and associated water bodies along the downstream segments of Achare river. Chander wetlands or Chander Creek is a tributary of Gad river and the mangrove of Chander also have abundant potential of mudflats. Aronda mangroves are distributed on both sides at lower reaches of Teracol river, which is the boundary between Sindhudurg (Maharashtra) and Goa. There are other mangrove patches on the opposite side of the river in Goa state, which are not considered in this study. Mangroves on Mumbari creek is distributed on both banks of the river throughout its tidal influenced course. The ongoing construction of new bridge across the creek in its downstream portion by connecting Devgad and Kunkeswar may create certain problem for this region, unless the issue of protecting mangroves is not properly addressed.

Mangrove Conservation through Coastal Regulation Zone Notification 2011

Being an undeveloped area, the identified hotspots of coastal ecosystems will have to be protected on a sustainable manner, during development activities in the future. The small scale degradation to the coastal ecosystems, noticed near Malvan and Vijayadurg area, is due to modernization and however, currently is in a controllable stage. The planning and managing developmental activities in those areas at this stage will help to protect the vulnerable coastal ecosystems and reduce coastal hazards. Implementation of Coastal Regulation Zone Notification (2011) of Ministry of Environment and Forests, Govt. of India by local government will be a right step to achieve this aim. CRZ Notification which is intended to protect and conserve coastal environments while ensuring livelihood sustenance of the traditional communities is very specific on regulating activities in the mangrove areas by categorizing them as CRZ-IA (Fig. 5). As an additional measure of conservation, a buffer zone is also provided around mangroves exceeding coverage of 1000 m^2. Mudflats which provide the ideal eco-morphology for mangroves regeneration are protected by categorizing them under CRZ-IB in which certain limited development activities are permitted. Reclamation of inter-tidal zone is a prohibited activity under the Notification to supplement mangrove habitat. Adept implementation of the provisions of CRZ Notification using accurately composed cadastral scale CRZ/ CZMP maps shall ensure protection and conservation of mangroves and such other critical habitats from further degradation. Citizenry shall be made aware on the potential of such mapping practices eventually helping mankind from destruction of such ecological niche that entails multiple services to the society.

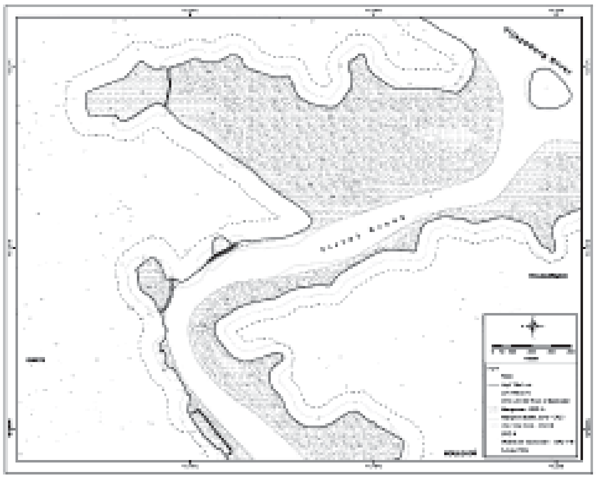

Fig. 6. An example for CRZ/ CZMP maps showing CRZ Categories and regulations

CONCLUSION

The Sindhudurg district in Maharashtra has a vast expanse of pristine mangrove-rich wetland ecosystems all along its coastal zone. This paper has brought out the mapping results on their total geographical spread and also associated geomorphological features. There are several conventional protection measures, which are *in vogue*, for these vulnerable systems and the recent CRZ notification along with the provision for buffer zones would add impetus to the conservation efforts of these mangrove forests. The identification of all the sensitive patches of mangrove ecosystems is expected to form the basis for maintaining its natural beauty and offering scope for large scale ecotourism opportunities.

REFERENCES

1. A report on Coastal Areas – Problems and Conservation (in Maharashtra with special reference to Mangroves).The Mangrove Cell – Maharashtra Forest Department,Government of Maharashtra, India.Nov. 2015. http://www.mangrovecell.org/Attachments/conservation_of_mangroves_maharashtra-1.pdf

2. Duke, N. C., Ball, M. C. & Ellison, J. C. 1998. *Factors Influencing Biodiversity and Distributional Gradients in Mangroves*. Global Ecology & Biogeography Letters.7, 27.

3. Gillis, L. G. et al. 2014. *Potential for Landscape-scale Positive Interactions among Tropical Marine Ecosystems: A Review*. Marine Ecology Progress Series.

4. India State of Forest report 2013, Forest Survey of India, Ministry of Environment & Forest, Government of India, Dehradun. 33-38

5. Indian Tide Tables 2014, The Geodetic and Research Branch - Survey of India. Dehradun

6. Kathiresan, K., B. L. Bingham. 2001. *Biology of Mangroves and Mangrove Ecosystems*. Advances in Marine Biology. 40: 81-251

7. Nagelkerken I, Editor 2009 in *Ecological Connectivity among Tropical Coastal Ecosystems*. Springer Science and Business Media, Dordrecht, the Netherlands, 357–399

8. Nisha R. Mugade, Jagdish B. Sapkale. 2014. *A review of Mangrove Conservation Studies in Maharashtra, India*. International Journal of Engineering and Technical Research, 2 (11): 338-341.

9. Sanjay S. Sathe, Rajendra A. Lavate, Leela J. Bhosale. 2013. *Mangroves as Source of Energy for Rural Development with Special Reference to Ratnagiri and Sindudurg District (MS) India*. Bioscience Discovery, 4 (2): 198-201

10. The Mangrove Cell – Maharashtra Forest Department, Government of Maharashtra, India. Oct. 2015. http://www.mangrovecell.org/mangrove_diversity.aspx

11. Walsh, G. E. 1974. *Mangroves: A review*. in Reimold, R.J., Queen, W.H., (Eds)Ecology of Halopohytes. Academic Press, New York. 51-174.

12. Yeragi SS, Yeragi SG.2014. *Status, Bio diversity and distribution of Mangroves in South Konkan, Sindhudurg District, Maharashtra State India An overview*. International Journal of Life Sciences, 2 (1): 67-69.

IDENTIFICATION OF WATER HARVESTING SITES/STRUCTURES AND DEMARCATION OF THEIR CATCHMENT AREAS IN MORNI SUB-WATERSHED, HARYANA

NEELAM[1] & R.S. HOODA[2]

ABSTRACT

Proper watershed management is a pre-requisite to efficient water use in an area. For this purpose suggesting proper water harvesting (WH) sites/structures and demarcation of their catchment area is required. Therefore, an area with a very undulating topography in the Morni Hills of Haryana was selected. The aim of the present study is to identify WH sites/structure and demarcation of their catchment areas using RS and GIS techniques by integrating various thematic information. The sub watershed comprises of rocky surface and several types of faults and fractures. Use of remote sensing data along with GIS, topographical maps, collateral information and limited field checks, has opened new avenues and made it easier to establish the base line information for water harvesting zones. ARCGIS 10 and ERDAS IMAGINE 11 software's were used for analysing and interpretation of remote sensing data. About 88 water harvesting sites were suggested by overlaying several maps viz. LU/LC, contour, slope, geology and geomorphology, drainage network, stream order, road network and groundwater quality. Based upon the specific criteria provided in the literature various water harvesting structures Nala bund (17), Check dam (12), Inverted/Recharge well (18), Desilting tank (2), Recharge pit (1), Storage tank (38) etc. were suggested on identified WH sites. Results show that about 15.28 km² area contribute direct runoff towards suggested WH structures. Out of this catchment area contributing water towards Nala bund, Check dam, Inverted/Recharge well, Desilting tank, Recharge pit, Storage tanks is 11.02%, 0.35%, 15.51%, 72.99%, 0.05% and 0.08%, respectively.

Keywords: *DEM, Land Use/land Cover, Stream Order, Water Harvesting Site & Structure.*

INTRODUCTION

A watershed is an area that drains surface water to a common outlet. Watershed analysis refers to the process of using DEMs (Digital Elevation Models) and raster operations to delineate watersheds and to derive topographic features such as stream networks (Kang, 2008). Therefore water catchments area is determined on the bases of topographical landscape of the area (William, 2000). Catchments and watersheds define drainage areas of the land surface that contribute flow to particular edges on the Hydro Network. Extensive hydro geological studies have been carried out by several workers in delineating groundwater potential zones in hard rock terrain (Agarwal et al., 1992~ Rao et al., 2001). Remote sensing and GIS technology have opened new paths in water management studies. The catchment area map is a systematic effort and has been prepared considering major controlling factors, which influence the water runoff. The techniques used for delineation of the catchment area by surface drainage (stream network) are ultimately dependent on topographical information generated in a local neighbourhood on the DEM. Advances in the analysis of flow direction and flow networks from DEMs have led to several automated methods for watershed and stream delineation (Jenson and Domingue, 1988; Tarboton, 1997). In the present study, an attempt has been made to calculate the catchment area of the watershed contributing direct runoff towards suggested water harvesting structure in Morni subwatershed of Panchkula district based on remote sensing and GIS techniques.

STUDY AREA

Fig. 1: Study area

The present study was carried out for Morni sub watershed in Panchkula district. It is located at

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latitude 30°40’17”- 30°46’10”N and longitude 77°00’01”-77°09’52”E covering an area of about 6551.40 ha. The study area is divided in 7 micro-watersheds named as M1, M2, M3, M4, M5, M6 and M7. The climate of Morni sub-watershed computerise of hot summers, cool winters and good monsoon rainfall. The average annual rainfall for six year (2008-2013) was found to be 720.68 mm, out of which 80% of annual rainfall is received in June to September months. Area also receives some rainfall in winter months due to western disturbances. Despite heavy rains in the area, water retention is very low because of steep slopes, which causes high surface runoff. Morni hills constitute the highest point of Panchkula as well as of Haryana. Different types of soils noted in the area are fine loamy, clayey loamy, loamy and coarse loamy.

OBJECTIVES

1. To identify potential water harvesting sites
2. To suggest suitable water harvesting structures at identified sites
3. Demarcation and calculation of catchment area of suggested water harvesting structures

DATABASE AND METHODOLOGY

Survey of India (SOI) Toposheet No. 53F/03 on 1:50,000 scale were used to delineate the study area.

The scanned maps were rectified with already geo-referenced image of LISS-IV satellite data. Final boundaries of sub-watershed and micro-watersheds were digitized from rectified maps. Very high resolution data from WORLD VIEW-2 satellite with 8 band multispectral capabilities of April 11, 2012, June 11, 2012 and June 12, 2012 on 1:2500 scale were used for digitization of land use/land cover map. Stereo imagery (WORLD VIEW-2) processed by means of advanced image processing photogrammetric tools were used to extract DEM. On the basis of specified criteria, potential water harvesting sites were identified and suitable water harvesting structures were suggested at identified sites to harvest runoff. Catchment area contributing water towards suggested WH structure was manually digitized by overlaying several maps.

Identification of Potential Water Harvesting Sites

Different parameters were used for the identification of potential water harvesting sites such as land use/land cover, drainage network, contour, flow direction, stream order, groundwater quality, road network, geology, geomorphology and fault/fracture to identify potential water harvesting sites.

Specifications for Different Water Harvesting Structures

Six types of water harvesting structures were suggested such as check dam, Nala Bund, Storage Tank, Inverted Well/Recharge Well, Percolation Tank and Recharge Pit. Except storage tank, criteria recommended for all other structures were as given in “Groundwater prospects mapping for Rajiv Gandhi National Drinking Water Mission (2008)”. For Storage tank, site selection criteria given in “Soil & Water Conservation Engineering (Suresh,1993)” was followed.

Demarcation of Catchment Area of Suggested Water Harvesting Structures

Based upon the identified potential water harvesting sites, suggested water harvesting structure, land use/land cover, flow direction, DEM, slope, Groundwater quality, drainage network, geography and geomorphologic features and stream order, catchment area of each site was manually digitized and then area of each digitized field was calculated.

DISCUSSION AND ANALYSIS

Morni sub watershed has a total geographical area of 6551.40 ha. Fig. 2 shows that forest land is the predominant land cover accounting for about three fourth part (78.18%) whereas scrub forest was found on only 0.24% of total geographical area. Agricultural land covered almost 16.31% of total area. Only 0.06% of land is occupied by built up area and 5.21% area is occupied by water bodies. Only 2 natural ponds were observed in the study area.

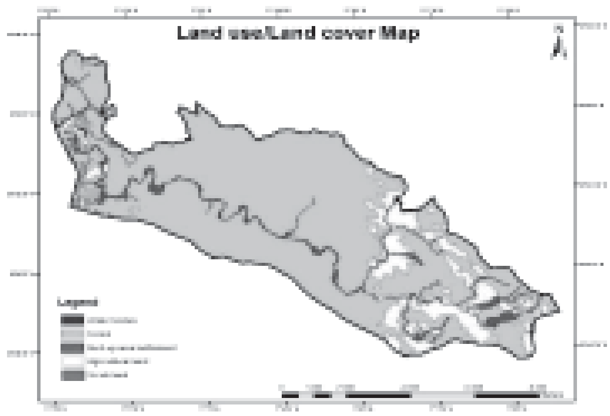
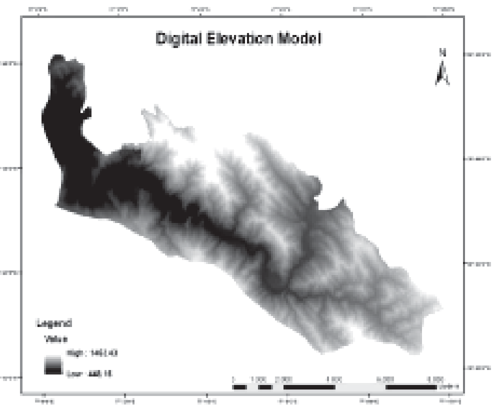
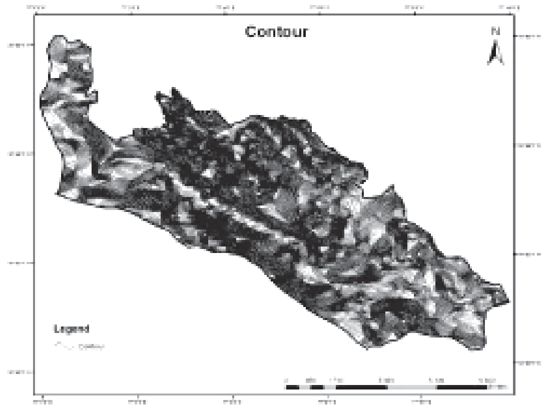


Fig. 2

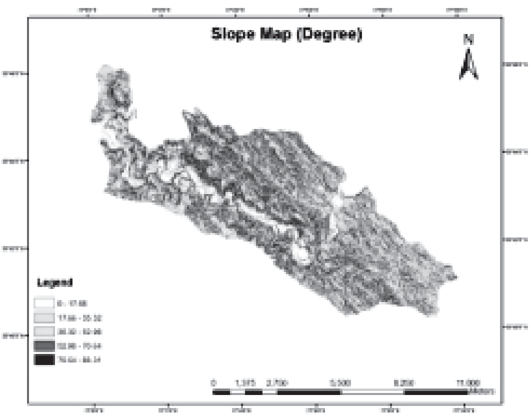
Digital elevation Model (DEM) as shown in Fig. 3a, was extracted from the WORLD VIEW-2 (black and white image) satellite data using 3 ground control points (GCPs) and 117 tie points to provide maximum reduction in error. Elevation of high quality generated DEM ranges from 448.15m to1453.43m with mean elevation of 925m and has a higher special resolution



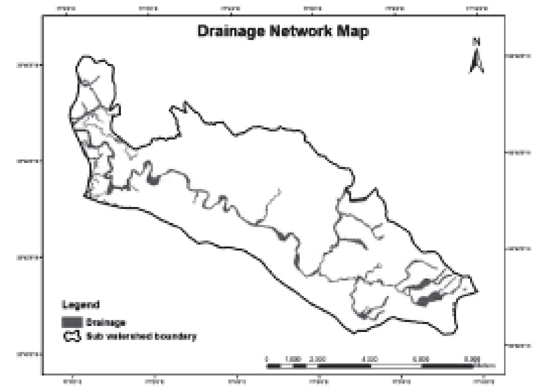
(a) DEM Map



(b) Contour Map



(c) Slope Map



(d) Drainage Network Map

Fig. 3 : DEM (a), Contour (b), Slope map (c) and Drainage Network (d) map of Morni Sub watershed

of 0.46m. Result shows that topography of study area (Fig. 3b) has a series of hills and ridges towards northern and southern-eastern part of the area, whereas western part has less undulating topography. Slope map (fig. 3c) shows that slope varies from 0° to 88.31° of the Morni sub watershed. Flow accumulation was derived to check the flow accumulating area whose pattern is same as flow direction. The water is accumulating in a main stream facing from west to southern east (fig. 3d).

A total 12,10,741 tributaries were observed in the sub watershed. Out of which maximum number of tributaries were of first order rank (697887) followed by second order rand (246721) and thirds order rank (122725) respectively. Number of tributaries goes on decreasing as rank of tributary increased. Hence result shows that rank order no. ninth (3104) has the minimum no. of water tributaries followed by eighth (7592) and seventh order (10920), respectively. It was found that all lower rank drainage tributaries terminate in respectively higher order tributary .

Total 133 number of minor fractures/faults and only six trend lines were noted in the study area. But these minor faults were assumed to have negligible adverse effect on the research work but can help to suggest water harvesting structures at identified sites. Morni sub watershed mainly consisted of four types of road network i.e District road, footpath in hill, pack tracks in hill and village roads. As the physiographic of the study area is hilly so it was observed that pack tract network is spread in almost area as a road network.

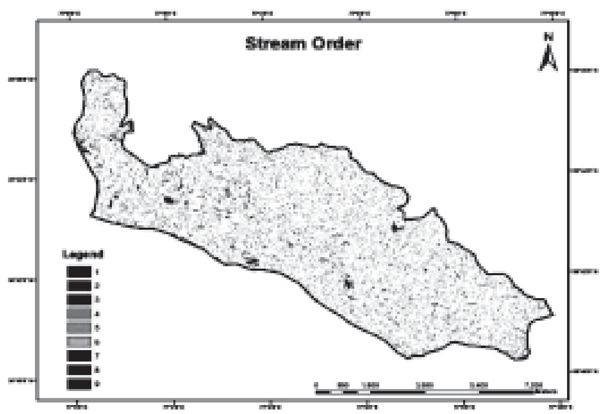


Fig. 4

Location of WH sites and storage structures of Morni sub watershed is shown in Fig. 5. Based upon the specific criteria about 88 WH sites were identified by overlaying various parameters such as explained in the methodology. Water harvesting is based upon the fact that there is a huge amount of monsoon water flow, which remains uncaptured and eventually ends up in natural sinks Considering the runoff potential of sub-watershed, WH structures such as Nala bunds (17), Check Dams (12), Inverted/Recharge Wells (18), Desilting Tanks (2), Recharge Pit (1), Storage Tanks (38) etc. were suggested on identified WH sites.

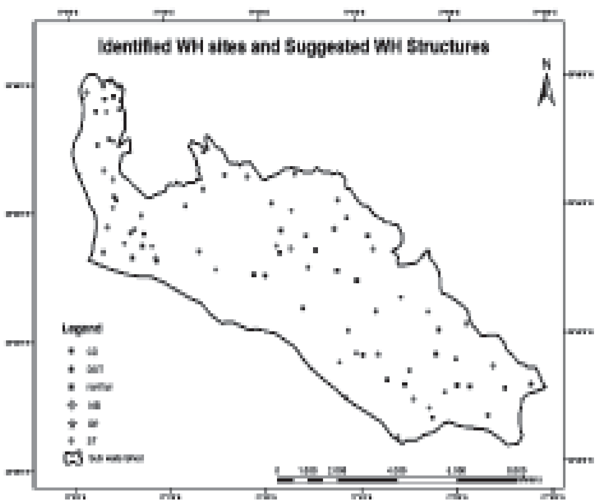


Fig. 5

After suggesting potential WH structures for the study area, catchment area for each structure was calculated by overlying several maps as shown in Fig. 6. It was found that about 1528 ha of area contribute direct runoff towards suggested WH structures. Out of this catchment area contributing water towards Nala Bunds, Check Dams, Inverted/Recharge Wells, Desilting Tanks, Recharge Pit, Storage Tanks is 11.02%, 0.35%, 15.51%, 72.99%, 0.05% and 0.08%, respectively.

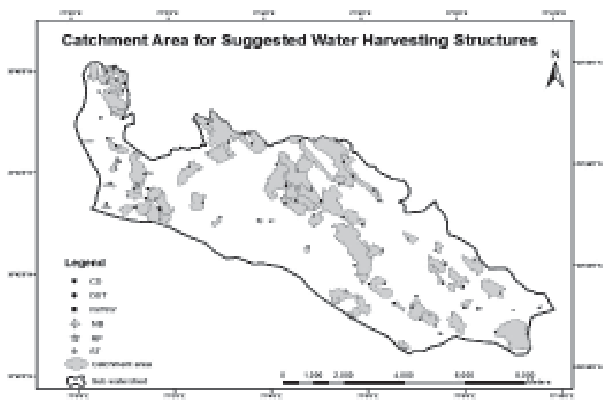


Fig. 6

CONCLUSION

From the obtained results it was concluded that the baseline information generated on land use/land cover of the area is immensely helpful in formulation of policies and programmes requires for the developmental planning of the area. Successful application of remote sensing and GIS with multilayer integration viz. geomorphology, geology, drainage network, DEM, contour, slope, stream order, groundwater quality etc. provided useful information for site selection for WH structures and demarcation of catchment area in minimum time and efforts compared to the traditional methods.

Acknowlegement

I am very much thankful to the Department of Science and Technology, GOI, which has financially supported this project under Women Scientist Scholarship, WOS-B, Internship mode. I express my deep sense of indebtedness and gratitude to HARSAC (Haryana space Applications Centre) staff, who helped me directly or indirectly during this research.

REFERENCES

1. Agarwal A K & Mishra D. (1992) Evaluation of Groundwater Potential in the Environs of Jhansi City, Uttar Pradesh through Hydro Geological Assessment by Satellite Remote Sensing Technique. Journal of the Indian Society of Remote Sensing, 20(3), pp. 121-128.
2. Jenson, S.K. & Domingue, J.O. (1988) Extracting Topographic Structure from Digital Elevation Data for Geographic Information System Analysis, *Photogrammetric Engineering & Remote Sensing*. 54(11):1593–1600.
3. Kang-Tsung Chang. (2008). Introduction to Geographic Information Systems. Fourth edition. McGraw-Hill International Edition.
4. Rao S. N., Chakradar G.K.J. & Srinivas V. (2001). Identification of Groundwater Potential Zones Using Remote Sensing Techniques in Around Guntur Town, Andhra Pardesh, India, Journal of Indian Society of Remote Sensing. 29(12), pp. 69-78.
5. Suresh, R. (1993). A text book on Soil & Water Conservation Engineering. First Edition, pp. 180-181.
6. Tarboton, D.G. (1997). A New Method for the Determination of Flow Directions and Upslope Areas in Grid Digital Elevation Models, *Water Resources Research*. 33(2) : 309–319.
7. William, N. (2000). Agricultural and Small Watershed Hydrology: Watershed Characteristic. College of Engineering, Michigan State University *http://www.egr.msu.edu/~northco2/BE481/WshedChar.*

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INTEGRATED GEOSPATIAL APPROACH FOR MONITORING AND MANAGEMENT OF FOREST COVER DYNAMICS – A STUDY IN NAYAGRAM BLOCK OF WEST MEDINIPUR DISTRICT, WEST BENGAL

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ABSTRACT

Forest is one of the basic natural resource which has been fulfilling various demands of human being from pre civilization to modern era. Due to increasing human activity and over exploitation, the forest cover scenario is changing very rapidly all over the world including India. Being the second most densely populated (1028 population per Km ^{2}) state of the country, different forests of West Bengal is also facing this problem most severely. For the present study Nayagram block is selected which is located in the south western part of West Medinipur district, West Bengal. The area comes under the famous Jangal Mahal territory with 28.48 % of its area covered with semi deciduous forest mainly dominated by the sal species. The advent of remote sensing (RS) and geographical information system (GIS) technique gives a new dimension to monitoring of forest cover dynamics. However, multispectral indices based forest monitoring system could only help to separately enhance the vegetation internal characteristics like health, height, vigor, etc. but fails to represent forest cover as a single feature. A study on monitoring of forest cover dynamics was conducted to reveal the actual situation based on LANDSAT imagery of the year 2001 and 2010 respectively. To monitor the forest cover as a single entity, a multi criteria assessment (MCA) based overlay analysis was conducted with the help of three distinct vegetation indices, i.e. modified atmospheric and soil adjusted vegetation Index (MASAVI), bare surface index (BSI) and scaled shadow index (SSI). Management of the degraded forest cover is proclaimed on the basis of three 'S' factor, i.e. soil erosion factor, slope factor and social factor. The study attempts to use geospatial based integrated application of RS and GIS to detect the dynamics of forest cover in the study area. It also focused to management of responsible factors influencing such dynamics.

Keywords: *Forest Cover, RS and GIS Technique, Vegetation Index, Factor.*

INTRODUCTION

Conventionally exploration of available forest resource has been successfully done in remote sensing by satellite image processing (Choudhury, 1987; Dymond *et al.*, 1992; Anatoly *et al.*, 2002; Jing *et al.*, 2010). In terms of modern research trend in this field, the methods roughly include two broad groups, namely qualitative image analysis using sample training areas and object oriented spectral band combination using algebraic operations (Dwivedi et al., 1999; Tammervik *et al.*, 2003). However certain disadvantages are associated with training area based vegetation cover analysis. Either low contrast of image due to atmospheric and environmental condition or limited spectral discrimination power of human eye, sometime both the cause influence the accuracy of the obtained result. Beside it requires ample time and money for the establishment of selected training area by field data collection. Whereas using of spectral band combination not only helps in the enhancement of targeted vegetation spectral from the associated feature but also provides ample scope to remove the atmospheric noise as well as surface influxes. Application of such operation to digital image improves the visual appearances for better interpretability and subsequent digital analysis (Lilliesand and Kiefer, 1999).

It seems that different vegetation cover enhancement algorithm or vegetation indices are indeed very much fruitful in defining vegetation class from various aspects. More than 40 types of vegetation indices have currently been defined *e.g.* normalized differential vegetation index (NDVI), perpendicular vegetation index (PVI), soil-adjusted vegetation index (SAVI), all have found wide application in areas like environment, ecology and agriculture (Dunean *et al.*, 1993; Li et al., 2010). Estimation of forest cover in terms of analyzing single or multiple indexes separately can only explore the single feature of vegetative pixel at a time, like growth, height, density, shadow etc. A new methodology, multi criteria assessment (MCA) based forest cover mapping on the basis of three new parameters, i.e. modified atmospheric and soil adjusted vegetation index (MASAVI), bare surface index (BSI) and scaled shadow index (SSI) has been developed to

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purposefully cluster the spectral information conveyed by selected parameters.

Forests account for 75% of the gross primary productivity of the earth's biosphere and contain 80% of the earth's plant biomass (Yude et al., 2013). It also plays an important role in energy exchange, recycling carbon dioxide, purify water and managing natural hazards. Much of our increasing concern semi deciduous forests of West Bengal are declining at an alarming rate which pose a serious threat of being thoroughly degraded in near future. According to Wastelands Atlas of India 2011 (State Forest Report, West Bengal, 2011) out of total degraded forest in the state 91.01% was of semi deciduous type. However, the rate and causes of such changes are not fully known. In order to monitor the forest cover dynamics of such forests a geospatial periodic forest inventory has been conducted using MCA based forest cover maps for the year 2001 and 2010.

The basic idea of forest monitoring by geospatial approach is that by analyzing the changing pattern of different vegetation class in terms of degradation and their distribution, means of forest management also get direction to be also explored geospatially, provided that monitoring is proven to be well integrated with management. Over the year forest management has changed considerably transforming into a practice called sustainable forest management. In which focus is set to manage both ecological factors like soil erosion and slope pattern as well as social factor simultaneously in consultation with local community.

STUDY AREA

Nayagram, a community development block located in south western part of West Midnapur district, West Bengal has been consulted in present study. It is bounded by $22^{\circ} 44'$N to $22^{\circ} 74'$ N latitude and $88^{\circ} 08'$E to $88^{\circ} 13'$ E longitude covering an area of about 501.44Km^2. Elevation of the area varies between a maximum of 110 m. in central north to a minimum of 10 m. in south east (from MSL). The Study area possesses an undulating topography having a gentle to moderate slope from north west to south east direction. As the place lying in the eastern fringe of Chotanagpur plateau, abundance of primary and secondary laterite profiles is very common.

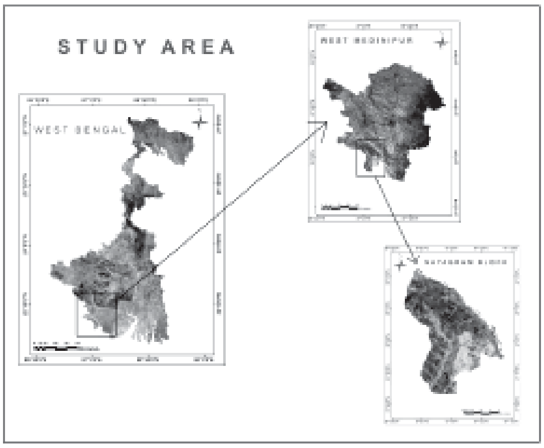

Fig. 1: Location of the Selected Area

The drainage of the area is controlled by Subarnarekha river which flows along the north eastern boundary of the block. One of the tributary of Subarnarekha River, Murli Nala, evolved in the heart of the area and flows from north east to south west direction. Prevalent climate of the area is tropical monsoon climate. Mean minimum temperature of coolest and mean maximum temperature of warmest months is 13°C and 35°C respectively with an annual rainfall around 1615 mm. Presence of forest and greeneries in the area reciting its historical connection with Jangal Mahal territory. About 28.48% of its geographical area is presently covered with semi deciduous forest mainly dominated by the sal species.

MATERIALS AND METHODS

In this present study Landsat ETM and TM digital data (P/R – 139/45) of 27th January 2010 and 13th February 2010 having resolution 30 m has been used and processed under TNT Mips Pro and ARC GIS environment.

In an image, pixel having chlorophyll influence will reflect greater in Near infra-red (NIR) band than Red band. Using this properties a generic normalized differentiate vegetation index (NDVI) has been developed to assesses the vegetation cover (Rouse et al., 1974). Although NDVI is very useful in estimating vegetation properties many external and internal influences restricts it global utility (Jensen, 2009). Drawbacks like atmospheric aerosol scattering and soil background factors has been dealt in this study to form a new vegetation index, i.e. modified atmospheric and soil adjusted vegetation index (MASAVI). In it blue band have been used in correction of atmospheric aerosol scattering reduction in red band (Huete et al., 1997). The soil background factor has been adjusted by using the soil line concept which is a linear correlation of NIR band against red band. On the basis of this consideration MASAVI can be calculated as:

$$MASAVI = [(pNIR - pRED) / \{pNIR + (pRED - pBLUE) + L\}] \quad (1)$$

(Where, *pRED*, *pNIR*, *pBLUE* = Reflectance value of Red, Near-infrared and Blue bands respectively of TM5 Sen-sor, L= Coefficient, varies with the trend line value of NIR and Red band correlation)

Vegetation index are not so reliable in situations where the vegetation cover exist in less than half of the area (Rikimaru et al., 2002). The value of vegetation index does not always extract the actual vegetation status correctly. For more reliable estimation, the information of Middle infra-red (MIR) band and Green bands can be included to form a bare surface index (BSI). The underlying logic of this approach is based on the high reciprocity between bare surface and vegetation. It is a normalized differenced index of the sum of two separate band clusters having the most contrastive value in terms of bareness and vegetation. Correlation value of MIR and NIR band have been used as an adjustment factor for soil background correction. BSI can be calculated as:

$$BSI = [\{(pMIR + pRED) - (pNIR + pGREEN)\} / [\{(pMIR + pRED) + (pNIR + pGREEN)\} * 1/L \quad (2)$$

(Where, *pRED, pGREEN, pNIR, pMIR* = Reflectance value of Red, Green, Near-infrared and Middle infra-red bands respectively of TM5 Sen-sor, L= Coefficient, varies with the correlation of MIR and NIR band.)

The arrangement of forest canopy develops marked variations in shadow pattern. By utilizing the spectral information of the forest shadow and the thermal information on the forest influenced by shadow, a scaled shadow Index (SSI) has been formulated. The index used the spectral value of three visible bands, Blue, Green and Red respectively. SSI has been calculated as:

$$SSI = [3'' \{256 - ((pBLUE + pGREEN + pRED) / 3)\} / 10] \quad (3)$$

(Where, *pBLUE, pGREEN, pRED* = Reflectance value of Blue, Green and Near-infrared bands respectively of TM5 Sensor.)

In the present study three parameters MASAVI, BSI and SSI were used as multi-parametric dataset in order to delineate forest cover map of the area. For the qualitative evaluation of the input dataset they were classified into five distinct categories on the basis of quantile method. A pairwise comparison matrix under multi-criteria decision making approach has been constructed for determine the individual weight of parameters (Satty, 1980) as per table 1. Sub weights of the individual parameter class have been set between values - 3 to 6 by giving maximum weightage to vegetative class. Finally a weighted linear combination (WLC) was performed to generate overall attribute as:

$$S = Wi * Xi \quad (4)$$

(Where, Wi = weight assign to each parameter and Xi = sub weight of each parameter.)

Table 1
Pair-wise Comparison Matrix

	MASAVI	BSI	SSI
MASAVI	1	5	3
BSI	1/5	1	½
SSI	1/3	2	1

The methods of forest cover mapping have been applied both for the images of year 2001 and 2010. The first two class of both forest cover map were identified as forest class and the rest classes were merged to represent non forest class. A combination function has been used between the forest cover raster of the respective years to get the changing status of different forest classes, i.e., deforested, no change and afforested area from the year 2001 to 2010. In order to generalize the obtained raster deforested, no change and afforested area were merged for monitoring the forest cover dynamics.

In the second phase forest cover dynamics have been re-explored by integrating it with the geospatially derived result of different concerning dimensions, i.e. S factors, slope, soil erosion and social factor for a meaningful forest management policy. A slope map after Wentworth has been prepared from Digital elevation model (DEM), soil erosion map generated from Revised universal soil loss equation (RUSLE) (Engel, 2003) and population density map as per census 2011 has been considered to represent the S factor. All the factors were classified into three groups representing high, moderate and low classes. By using combination function between classified S factors and forest cover dynamics three different new thematic layers have been generated. Finally the individual class wise forest cover dynamics under different S factor helps in identifying the vulnerable classes.

RESULT AND DISCUSSION

In order to delineate multi criteria based forest cover mapping, it was very essential to accurately estimate the different parameters along with their individual classes. From the MASAVI, BSI AND SSI outputs (Fig. 2, 3, 4) derived by using equations 1, 2 and 3 for the year 2001 and 2010 have shown the changing dynamics of forest cover. Broadly deterioration status was observed in very high and high vegetative class while up gradation experienced in moderate to low vegetative class.

From the pair wise comparison matrix individual weight of parameters was constructed. By following Satty's Analytical hierarchical process (AHP) process normalized weight for MASAVI, BSI and SSI have been generated as 62.5 %, 23.8 % and 13.7 %

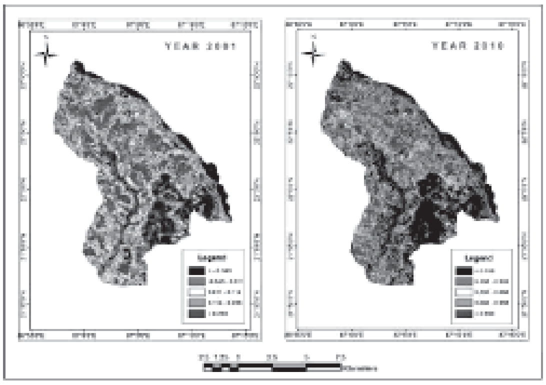

Fig. 2: MASAVI of the Area

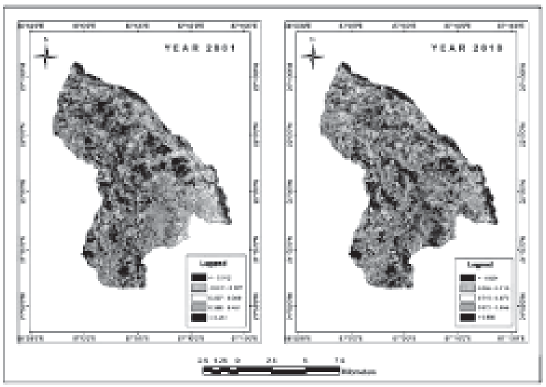

Fig. 3: BSI of the Area

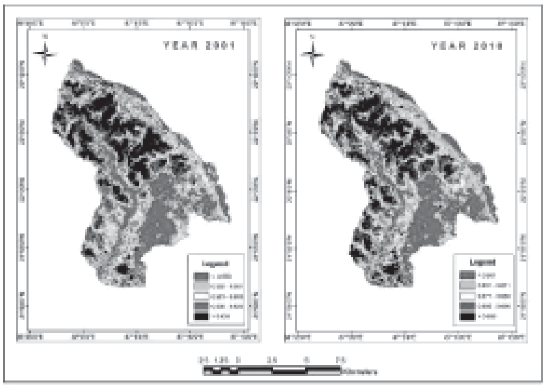

Fig. 4: SSI of the Area

respectively. Finally a consistency ratio has been calculated for the judgment with an acceptable result of 0.019.

From the forest cover map (Fig. 5) of 2001 and 2010, it is found that dense forest class has been deteriorated by 19.521 % of its previous area. Although interestingly open to dense forest class have been upgraded by 58.313 % of its earlier dimension. This fact suggests that overall forest area have increased significantly due to afforestation but the permanent loss of dense forest area is a matter of serious concern.

The class wise forest change map (Fig. 6) shows high deforestation and low afforestation, i.e. 9.43 % and 5.56 % respectively of total study area in dense forest

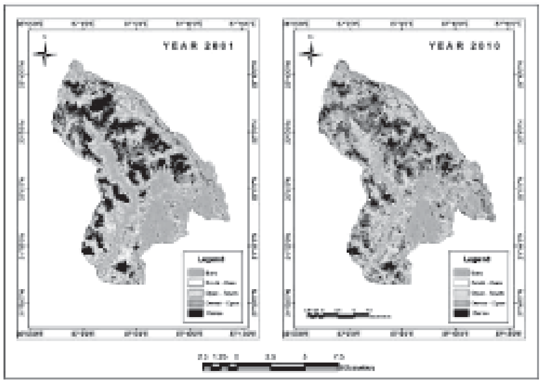

Fig. 5: MCA based Forest Cover Map

class and the reverse trend is found in dense to open forest class. As per category wise forest cover dynamics map, out of total forest area 31 % forest area were found deforested in nature and 27 % were afforested or newly developed. This result indicates that afforestation has been taken place at a large scale in the area yet during the study span but it failed to make up the loss due to deforestation.

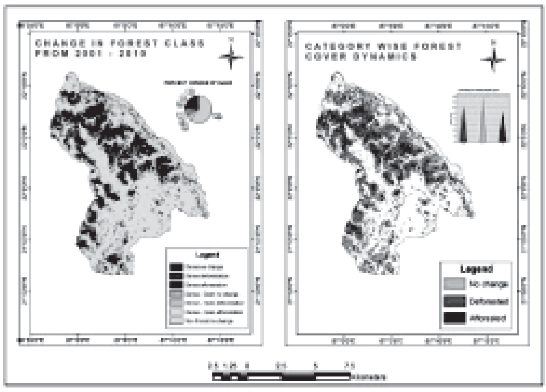

Fig. 6: Forest Dynamics of the Area

The area under investigation is in general suffering from land degradation, high soil loss and anthropogenic impacts. Influence of selected S factors on the forest cover dynamics give precise direction for the management of such vulnerable resource. The slope map as shown in map 7 represents the average slope of the area which varies from 0^{o} - 34^{o}. Identified classes of slope are low (< 5^{o}), moderate (5^{o}-10^{o}), high (>10^{o}). Most of the study area falls under the category of very gentle or low slope category (345.65 Km^{2}). As per forest cover dynamics in different slope category (Fig. 6) the high slope zone was found more prone to forest degradation having an overall degradation value of 5.93% while in low slope zone the value was only 1.47 %. It indicates that the success of afforestation by government and NGO intervention is only limited in low slope areas.

By using RUSLE the average soil erosion map of the area was prepared. The mean soil erosion of the area was found 0.060 ton per hectare per annum. Classified

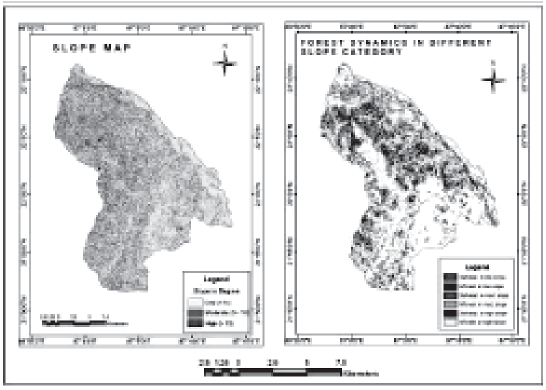

Fig. 7: Slope wise Forest Dynamics

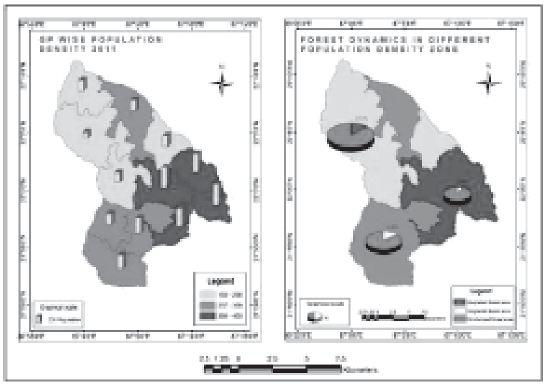

Fig. 9: Pop Density Wise Forest Dynamics

soil erosion map shows three distinctive soil erosion zones, i.e. low, moderate and high. The high eroded zone with a value of > 0.100 ton per hectare per annum extends over 112.60 Km^2 areas. Forest cover dynamics in different soil erosion class map (Fig. 8) shows decaying of forest cover with the increase in soil erosion intensity. The degradation of forest cover was found highest (12.559 %) in high soil erosion zone. It was found lowest in low soil erosion zone with a minimum value of 11.005 %.

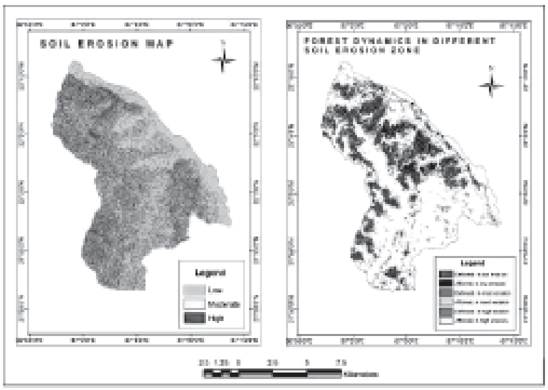

Fig. 8: Soil Erosion Wise Forest Dynamics

On the basis of population density 12 gram panchayats of the study area were classified into three groups having equal no. of representation. The result of forest dynamics in different population density zone (Fig. 9) shows that rate of deforestation was higher than afforestation in low population density zone resulting into a mass degradation of 15.771 %. On the contrary afforestation was found higher than deforestation in both moderate and high population density zone although in high population density zone the impact of afforestation was minimized due to extra amount of deforestation caused by high pressure of population.

It is suggested that the area having high slope and high soil erosion zone are found most vulnerable in terms of negative forest dynamics and must be given special priority during the implementation of afforestation program. Simultaneously removal of forest cover in this area must be restricted for better ecological balance. In consultation with the local people it was identified that under development, inaccessibility, illegal forest cutting and awareness were root cause behind the degradation of forest cover in the area. All these causes are much active in the area having low population density. Planning must be implemented for eradication of this root cause in order to save the forest.

CONCLUSION

From the above study it can be concluded that integrated geospatial approach of forest cover monitoring provides a new dimension for planning of management policy. Although government initiative for management of forest resource in the study area is found quite satisfactory yet most of the efforts are found in contrastive with ecological need. People awareness is also a matter of great concern in this regard. Nevertheless the study will surely help in the formation of forest resource management by which future flow of such valuable resource smoothens.

REFERENCE

1. Anatoly, A.G., Kaufman, Y.J. Stark, R., Rundquis, D. (2002). Novel Algorithms for Remote Estimation of Vegetation Fraction. Remote Sensing of Environment. 80 (l): 76-87.
2. Choudhury, B.J. (1987). Relationships between Vegetation Indices, Radiation Absorption and Net Photosynthesis Evaluated by a Sensitivity Analysis. Remote Sensing of Environment 22 (2): 209-233.
3. Dunean, J., Stow, D., Franklin, J., Hope, A. (1993). Assessing the Relationship between Spectral Vegetation Indices and Shrub Cover in the Jornada Basin. New Mexico. International Journal of Remote Sensing 14 (18): 3395-3416.
4. Dymond, J. R., Stephens, P. R. Newsome, P. F. (1992). Percent Vegetation Covers of a Degrading Rangeland from SPOT, International Journal of

Remote Sensing. 13 (11): 1999-2007.

5. Dwivedi, R.S., Rao, B.R.M., Bhattacharya, S. (1999). Mapping Wetlands of the Sundarban Delta and Its en-virons using ERS-1 SAR data, International Journal of Remote Sensing 20: 2235- 2247.

6. Engel, B. (2003). Estimating Soil Erosion Using RUSLE (Revised Universal Soil Loss Equation) Using ArcView. Purdue University.

7. Huete *et al.* (1997). A Comparison of Vegetation Indices over a Global Set of TM Images for EOS – MODIS. pp. 59: 440-4561.

8. Jensen J. R. (2009). Remote Sensing of the Environment – An Earth Resource Perspective. pp. 385-390.

9. Jing, X., Yao, W., Wang, J., Song, X. (2010). A study on the Relationship between Dynamic Change of Vegetation Coverage and Precipitation in Beijing's Mountainous Areas during the Last 20 Years, Mathematical and Computer Modelling:1-7.

10. Lilliesand, T.M. and R.W.Kiefer. (1999). Remote Sensing and Image Interpretation, 4th Edition, Jhon Wiley and Sons. New York.

11. Li, Z., X. Li, D. Wei, X. Xu, H. Wang (2010). An Assessment of Correlation on MODIS-NDVI and EVI with Natural Vegetation Coverage in Northern Hebei Province. China. Procedia Environmental Science. 2: 964-969.

12. Rikimaru et al. (2002). Tropical Forest Cover Density Mapping, International Society for Tropical Ecology. 43(1): 39-47.

13. Rouse et al. (1974). Monitoring Vegetation Systems in the Great Plains with ERTS. Greenbelt. NASA SP – 351. 3010-3017.

14. Satty, T. L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation, McGraw-Hill, New York. p287.

15. Tammervik, H., Hogda, J.A., Solheim, I (2003). Monitoring Vegetation Changes in Pasvik (Norway) and Pechenga in Kola Peninsula (Russia) using Multitemporal Landsat MSS/TM Data, Remote Sensing of Environment. 85 (3): 370-388.

16. Yude, P., Richard B., Oliver P. (2013). The Structure Distribution and Biomass of the Worlds Forest, Annu Rev. Ecol. Evol. Syst. 44 : 562-593.

APPROPRIATENESS OF DIFFERENT SPATIAL INTERPOLATION TECHNIQUES TO UNDERSTAND VARIATIONS IN SOIL ORGANIC CARBON IN CHULLIYAR-IKSHUMATHI SUB-WATERSHED OF GAYATHRIPUZHA, KERALA

Powshi V.[1] and S. SREEKESH[2]

ABSTRACT

Soil is the largest carbon reservoir in many terrestrial ecosystems. Soil Organic Carbon (SOC) determines soil fertility and soil quality. The aim of the study is the spatial interpolation of SOC using deterministic and geostatistical interpolation methods in GIS environment and to identify the most optimal interpolation method for the study area/study. Interpolation is a standard method for estimating values at unsampled locations based on sampled data. A total of 153 samples were collected from 51 locations of Chulliyar-Ikshumathi sub-watershed of Gayathripuzha a tributary of Bharathapuzha river basin, Kerala. Three spatial interpolation methods, including Ordinary Kriging, Empirical Bayesian Kriging and Inverse Distance Weighting were used for the analysis. The SOC level varies from very low to medium. Higher level of SOC is not observed anywhere in the study area.

Keywords: *Soil Organic Carbon (SOC), Spatial Interpolation, Inverse Distance Weighting, Ordinary Kriging, Empirical Bayesian Kriging*

INTRODUCTION

Soil is composed of disintegrated rock, minerals, organic matter, water and air. The soil minerals provide physical support for the plants while the organic matter contains many of the nutrients essential for plant growth. Soil Organic Matter (SOM) is important because all life forms exist in this part of the soil. Moreover, SOM is the prominent indicator of soil quality. It influences physical and chemical properties of the soil. SOM is comprised of approximately 50% Organic Carbon (OC) (Overstreet and Huges, 2014) and the remaining 50% consists of Nitrogen (N), Phosphorous (P), and Sulphur (S). Physiography, rainfall, temperature, vegetation cover, and soil types are the determinants of Soil Organic Carbon (SOC). SOC varies under different vegetative cover, crop types, terrain conditions and also from region to region. It is imperative to understand the degree of SOC variations among these cover types and management conditions not only from the perspective of soil nutrient but also from the perspective of carbon sequestration potential especially under changing climate scenario. In tropical regions luxurious growth of vegetation, enabled by the hot and humid climate, is conducive for the systematic addition of organic matter to the soil. This transform the parent material to soil with high organic content enabling the carbon sequestration process in the soil. However, the SOC content and consequent sequestration potential vary with space and time which need to assessed using appropriate methods. Soil sampling and subsequent analysis of SOC is the most efficient way to assess it.

Soil scientists study the site specific characteristics of the soil based on the soil sampling. It is significant because soil properties seldom change abruptly. Further it is nearly impossible to characterize every bit of soil due to cost and time constraints. This necessitates the characterization of soil at selected locations and interpolate within the region of interest. Besides, while analyzing this site specific properties of soil, the spatial continuum has often been neglected by soil scientists. Spatial continuum (spatially continuous surfaces) plays a significant role in planning and decision making in environmental management (Li and Heap, 2008). Similarly, in soil science too knowledge on spatial variation of soil properties is important in several related disciplines, including agricultural field trial research and precision farming besides the soil resources management as such. The spatial interpolation of site specific soil properties is essential to understand this spatial continuum.

Spatial interpolation techniques are used to estimate the values for unknown locations based on values at sample locations. It enables us to estimate possible values based on the values of the nearest locations. Interpolation is necessary when finite number of spatially distributed observations are available in order to draw the possible values in the intervening locations. In this study SOC values are interpolated

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to understand spatial variations within a sub-watershed. SOC spatially varies because of the differences in organic matter addition to the soil, which is contingent upon the biomass cover of the area, and the soil's ability to assimilate it. The spatial variability is assessed through soil sampling, chemical characterization and subsequent interpolation in GIS domain choosing appropriate methods. In order to understand the spatial variability of soil characteristics the best method of spatial interpolation need to be identified (Aguilar, et al., 2005). The appropriateness of the interpolation technique depends upon the shape of the area under consideration and the distribution of the sampling locations within that. There is no single preferred method for data interpolation in GIS environment (Zandi, et.al., 2011). The basic law behind interpolation technique, as Tobler (1970) pointed out, is that 'everything is related to everything else, but near things are more related than distant things'' Choice of the method is contingent upon number of data points, their spatial distribution and statistical parameters of data used for interpolation. Literature indicates that a variety of interpolation techniques are used in soil studies (Schloeder, et.al, 2001). All interpolation methods have been developed based on the assumption that nearby points have more correlations and similarities than distant observations (Zandi, et.al., 2011).

The spatial interpolation technique is broadly categorized into deterministic and geostatistical methods. The former attempt to interpolate surfaces based on the degree of similarity between measured points while the latter considers the statistical properties of the point information. The study examines Inverse Distance Weighting (IDW), a deterministic method and Ordinary Kriging (OK), and Empirical Bayesian Kriging (EBK) two geostatistical spatial interpolation techniques, to assess the spatial variation of SOC. Among the various deterministic methods, the study adopted IDW method for the analysis as it shows better results (Gotway, et.al., 1996) for the prediction of SOM.

Geostatistics use both mathematical and statistical methods to predict values at all locations within region of interest and to provide probabilistic estimates of the quality of the interpolation based on the spatial autocorrelation among data points. It quantifies the spatial autocorrelation among measured points and account for the spatial configuration of the sample points around the prediction location (Esri, 2008). Kriging is a widely used interpolation procedure in many disciplines (Oliver and Webster, 1990; Robinson, et.al., 2003). It is most appropriate when you know there is a spatially correlated distance or directional bias in the data. It is often used in soil science and geology (ESRI, 2008). Bhunia, et.al., (2016) compared the spatial distribution of SOC using IDW, local polynomial interpolation (LPI), radial basis function (RBF), OK and EBK methods. According to him OK interpolation method is superior than the other methods analyzed. In short, both IDW and Kriging estimate values at unsampled locations with certain weights attached to each of the measurements (Kravchenko and Bullock, 1999). Hence the study adopted a comparison between Inverse Distance Weighting (IDW), Ordinary Kriging (OK) and Empirical Bayesian Kriging (EBK) methods for spatial interpolation of SOC.

OBJECTIVE

The present study objectivizes to evaluate three common interpolation methods namely, IDW, OK and EBK to assess the spatial variation in SOC and also identify the most suitable method for assessing spatial variations in soil properties. The efficiency and accuracy of the methods are also examined based on correlation of observed and estimated values. Contingent upon these values most appropriate technique to represent the spatial distribution of SOC in the study area is identified.

DATA BASE AND METHODOLOGY

The study has been conducted in the Chulliyar-Ikshumathi sub-watershed of Gayathripuzha, a tributary of Bharathapuzha, in Kerala (Fig. 1). The soil samples were collected from 51 locations spread across the sub-watershed (Fig. 1), covering different crop cover and physiographic conditions. Since the distribution of soil nutrients vary with soil and crop types, the study adopted purposive sampling method in order to cover all crop types in the study area under different topographic conditions.

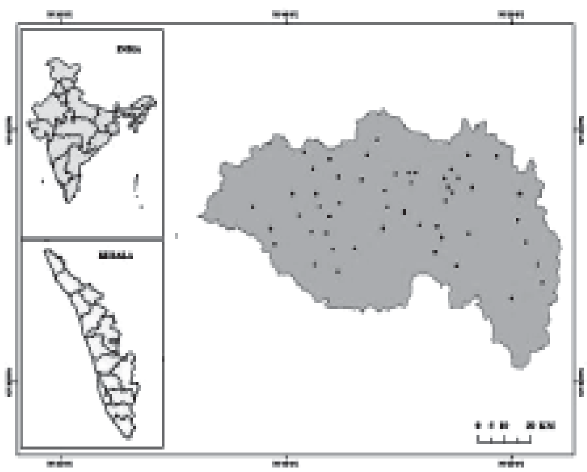

Fig. 1: Study Area and Sampling Locations in Chulliyar-Ikshumathi Sub-watershed of Gayathripuzha.

Top soil samples were collected from 51 locations during May 2015. At each site, sample was collected for the top layer, that is within 10 cm depth after removing the litter, grasses and crop residues. Soil samples are collected from 4 or more different locations within the same field of a crop type. These soil samples are thoroughly mixed before collecting 500 g sample for further soil organic content analysis. The soil samples were air dried for 72 hours and had subjected to through standard preprocessing to prepare the soils for chemical analysis. Available SOC content was determined by using wet combustion method of Walkely and Black (1934). The geographic coordinates of the samples sites were collected using GPS. These points are transferred to GIS environment and SOC values are added as attributes for interpolation. The summary statistics were analyzed to understand soil organic carbon variability. The statistical analyses carried out are mean, standard deviation, skewness, kurtosis, minimum, and maximum. The study also attempted to analysis the spatial trend in SOC distribution within the study area. The sample points are plotted on the XY plain. Above each sample point the SOC level is represented by the height of a bar in the Z dimension. The values are plotted onto the XZ plain and YZ plain as scatterplots. Then the polynomials are fitted through the scatterplots on the projected plains to represent the spatial trend.

The Chulliyar-Ikshumathi sub-watershed of Gayathripuzha. is located in a humid tropical region. Its climate, soil, and vegetation is unique since it is a part of Palghat Gap in Western Ghats. Location, physiography, climate, soil type, vegetation cover, and agricultural practices are the major factors which determine the organic carbon in a soil. Hence SOC content varies from region to region along with variation in the above mentioned factors. The Department of Agriculture, Government of Kerala (Venugopal, et. al, 2013) suggested a scheme to classify the SOC into high (> 1.5% SOC), moderate (0.76 to 1.5 %) and low (d"0,75%) for the soils of Kerala by considering the soil, plant and water relationship among different soil types of Kerala. It has been observed that the SOC level in the study area varies from 0.35 to 1.38 per cent. For the better understanding of the nature of variability among the 'low' SOC class, the present study classified the low SOC class further into three classes (Table 1) in order to capture the minor variations in SOC. Accordingly, if the SOC content varies from 0.51 to 0.75 per cent, it is classified as moderately low, 0.26 to 0.5 per cent is designated as very low and <0.25 per cent is categorized as critically low. Thus, the scheme of classification suggested by Venugopal, et. al., (2013) has been suitably modified to have two additional classes.

Table: 1
Classification scheme* for SOC content in soils

SOC Class in %	*SOC Status*
< 0.25	Critically low
0.26 to 0.5	Very low
0.51 to 0.75	Moderately Low
0.76 to 1.5	Medium
>1.5	High

*Modified after Venugopal, et al, (2013).

Spatial Interpolation Techniques Adopted

The SOC values are interpolated using IDW, OK and EBK methods to estimate the values for the areas for which there is no observation. The outcome of interpolation is influenced by the nearness of input data. It is also determined by the shape of the neighbourhood input data locations. There is no directional influence in the present data. Therefore, the present study adopted standard neighbourhood type with maximum 15 and minimum 3 neighbours since the number of the closest neighbouring samples is an important factor affecting the precision of IDW. The 4 sectors with 45^0 offset to each sector is opted within the neighbourhood. Root Mean Square Error (RMSE) and Average Standard Error (ASE) is calculated for cross-validation. ASE is not available for IDW. RMSE quantifies the error of the prediction surface with reference to the observed SOC values.

IDW

The IDW is one of the mostly applied deterministic interpolation techniques in the field of soil science. IDW estimates were made based on nearby known locations (Bhunia, et.al., 2016). It is a distance based interpolation method. It uses mathematical functions to calculate the values at unknown locations based on the degree of similarity. In IDW method, it is assumed that the rate of correlations and similarities between neighbours is proportional to the distance between them (Almasi, 2014). The number of the closest neighbouring sample sites is an important factor that affect the precision of IDW (Yao, et. al., 2013). IDW can produce "bull eyes" around data locations (ESRI, 2008; ESRI, 2014). This results in less error in estimated values through interpolation. In IDW method, a weight is attributed to the point to be measured. The amount of this weight is dependent upon the distance of the point to another unknown point. These weights are controlled on the basis of power of ten. Often with increase of power, the effect of the points that are farther diminishes (Poshtmasari, et.al., 2012). This method estimates values at unobserved locations by equation (1) (Yao, et. al., 2013; Gunarathna 2016)

$$Z_j = \frac{\sum_i \frac{Z_i}{d_{ij}^n}}{\sum_i \frac{1}{d_{ij}^n}} \qquad \text{Equation (1)}$$

Where Zj- estimated value for the unknown point at location j, d_{ij}- distance between known point i and unknown point j, Zi- value at known point I, and n - user-defined exponent for weighting

Ordinary Kriging (OK)

Kriging is a statistical method that makes use of a variograms to calculate the spatial autocorrelation between points at graduated distances (ESRI, 2008, 2014). The assumption behind this geostatistical method is spatial autocorrelation, which indicates the distance and direction between sample points are the major factors governing the estimated values at unknown points. In OK method the values at unobserved areas are estimated by equation (2) (Karydas, 2009; Gunarathna, 2016).

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i) \qquad \text{Equation (2)}$$

$Z(s_i)$ - measured value at the ith location, λ_i - unknown weight for the measured value at the ith location

$Z(s_0)$ - prediction location, and N - Number of measured values

Empirical Bayesian Kriging

According to Krivoruchko (2012) EBK model can be used to interpolate non-stationary data for large areas and the data can be transformed locally to a Gaussian distribution. In the case of large datasets, the input data is first divided into subsets of a specified size that may or may not overlap. In each subset, distributions of the semivariograms are produced. Then, for each location, a prediction is generated using a semivariogram distribution from one or more subsets. Each data subset uses models defined by nearby values, rather than being influenced by very distant factors. EBK supports power (Equation 3), linear (Equation 4), and thin plate spline (Equation 5) semivariogram models (Gunarathna 2016)

Power $y(h) = \text{Nugget} + b|h|^{á}$ Equation (3)

Linear $y(h) = \text{Nugget} + b|h|$ Equation (4)

Thin Plate Spline $y(h) = \text{Nugget} + b|h^2|*\ln(|h|)$ Equation (5)

Where h = distance, b= slope, and a power must be between 0.25 and 1.75

The interpolated values obtained through above methods are compared based on the statistical outcomes of the estimated values to determine the appropriateness of different methods used in this study.

ANALYSIS AND DISCUSSION

Distribution of SOC

The basic statistical analysis (table 2) was carried out to understand pattern of distribution of SOC in the soil. The SOC content in the Chulliyar-Ikshumathi sub-watershed of Gayathripuzha is medium to very low. High level of SOC is not observed in the study area. The mean SOC in the Chulliyar-Ikshumathi sub-watershed is only 0.76 per cent which is mainly because of the absence of high SOC class in the area and majority of the observations are in the low SOC class (table 3). The observed minimum SOC is 0.38 per cent while the maximum is 1.38 percent and the variability is confined to 0.28 per cent since 80 per cent of the observations are in the range of 0.51 and 1.5 per cent. About 55 per cent of the sample sites have low level of SOC (table 3) while the rest are in medium class. About 35 per cent of the sample sites are in low level subclass of 0.51 to 0.75 per cent. The distribution is more or less near to normal distribution with slight positive skewness. The SOC in this watershed is in general lower than other areas in Western Ghats.

Table 2
SOC Summary Statistics in the Study Area

Statistical Parameters	*SOC in %*
Mean	0.76
Standard deviation	0.28
Skewness	0.32
Kurtosis	2.07
Min	0.35
Max	1.38

Table 3
The Percentage Distribution Pattern of SOC in Different Classes in the Study Area

SOC Class in %	*SOC Status*	*SOC in %*
dd0.25	Critically low	nil
0.26-0.50	Very low	19.61
0.51-0.75	Low	35.29
0.76-1.50	Medium	45.09
>1.50	High	nil

The fig. 2 shows the spatial trend of SOC over the study area. The three dimensional trend analysis is carried out in the GIS environment. A curve shape/ convex shape trend line is observed from west to east of the study area with the maximum concentration of SOC (height) in the middle part of the watershed. From north to south a declining spatial trend of the SOC is observed. In the north-central part, paddy and vegetables (tillage crops) are dominated while in the southern part mango, coconut and arecanut plantations (non-tillage crops) are dominated. The SOC concentration in these plantations is lesser than paddy and vegetables. It is to be noted that probability of churning biomass is more in the paddy and vegetable fields in comparison to plantation crops where there is no tillage. Tillage in the paddy and vegetable fields may help in effective churning of biomass at least two times in a year which might have resulted in higher SOC.

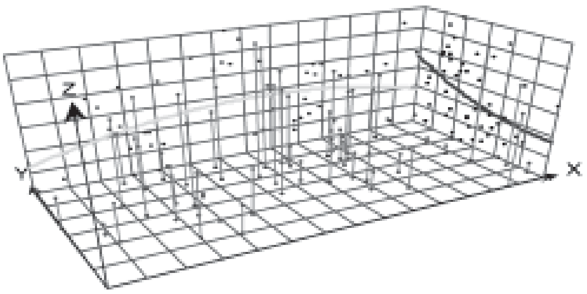

Fig. 2 : Spatial Trend of SOC in the East-West and North-South Direction in the Study Area

Interpolation of SOC

As discussed in the methodology, the present study made use of IDW, OK and EBK methods to assess the variation in SOC in the top soil of Chulliyar-Ikshumathi sub-watershed.

IDW

In IDW the weight decreases when the distances between observed locations increases. The rate at which the weight decrease depends on the power (p) value. If p is 0, there is no decrease of weight with distance. As p value increases the weight for distant points decrease rapidly. If the p value is very high, only the immediate surrounding points will influence the prediction. When p=2, the method is known as inverse distance squared weighted interpolation. An optimal power value can be determined by minimizing the RMSE (ESRI 2014). Therefore, the present study compared power 1, power 2, and power 3 models of IDW (Table 4). The results showed that the variation in RMSE is negligible and the RMSE was least when power 1 model is used for IDW interpolation. As per Fig. 3 higher SOC is found in northern and east-south-eastern part of the watershed while the western, southern, and central eastern part of the basin is dominated by low SOC (Fig. 3). Very low SOC content are found in few pockets in the western and norther eastern part of the sub-watershed.

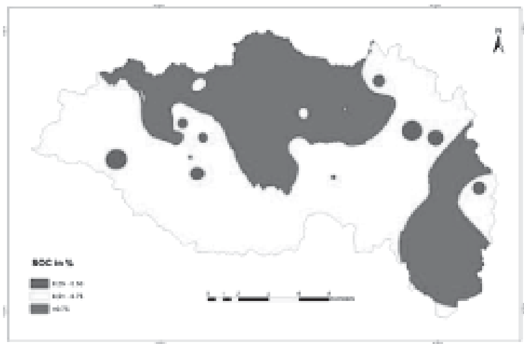

Fig. 3: Spatial Variation of SOC Using IDW

Ordinary Kriging

The spatial distribution, as evident from output of OK (Fig. 4), is similar to that of IDW except that very low SOC class areas absent while we use this interpolation technique. In the semivariogram model of OK, exponential, circular, Gaussian and stable models are compared in the present study. While comparing the RMSE of various interpolation models of OK, exponential model is only marginally better for the present study area (Table 4). The difference in RMSE is only 0.0048 among different models which is negligible. Thus, considering the very low RMSE, it is possible to conclude that the spatial variation in interpolation outputs more or less remains the same while we are using different semivariogram outputs experimented in this study.

Fig 4: Spatial Variation of SOC Using OK

Empirical Bayesian Kriging

The advantage of EBK is that it accounts for the uncertainty in semivariogram estimation by simulating many semivariograms from the input data. The overlap factor specifies the degree of overlap between subsets. Each input point can fall into several subsets. A high value of overlap factor makes the output smoother. The overlap factor selected for the present analysis is 1. The spatial pattern of distribution of SOC is comparable to that of OK and not IDW since very low SOC class is absent in this interpolation too (Fig. 5). However, this interpolation generated more generalized output. Thin plate spline, power and linear models are compared in the present study. Power and linear models are showing less RMSE as well as ASE while thin plate spline produced higher errors (Table 4). The RMSE are same when the analysis is done with power and linear. The thin plate spline model showed higher error among all the models analyzed for the present study.

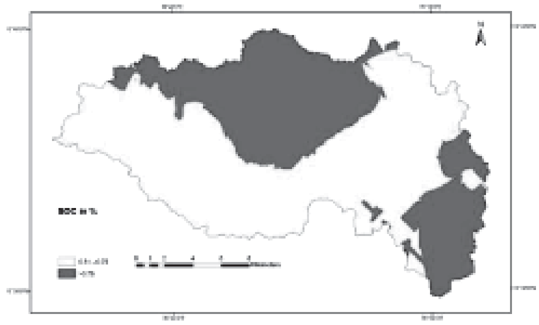

Fig. 5: Spatial Variation of SOC Using EBK

Table 4
Statistical Reliability of Interpolation Methods

Inter-polation type	*Inter-polation method*	*Model*	*RMSE*	*ASE*
Deterministic	IDW	Power 1	0.2729	nil
		Power 2	0.2783	nil
		Power 3	0.2895	nil
Geostatistical	OK	Exponential	0.2664	0.2533
		Circular	0.2696	0.2524
		Gaussian	0.2712	0.2519
		Stable	0.2712	0.2519
	EBK	Thin plate spline	0.3089	0.2952
		Power	0.2659	0.2634
		Linear	0.2658	0.2646

Comparison of Interpolations Methods

The suitability of different interpolation methods has been assessed based on the error statistics of interpolation techniques. The Fig. 3, 4 and 5 showed the spatial variation of SOC in Chulliyar-Ikshumathi sub-watershed of Gayathripuzha using IDW, OK and EBK models. Only IDW method represents very low SOC class in the interpolated map. The other two methods failed to represent 'very low' class of SOC level even though the observed values range from 0.35 to 1.38.

The table 4 shows the cross validation performance of prediction maps generated by IDW, OK and EBK methods. The RMSE among the models analyzed show only marginal variation. It varies from 0.265 to 0.308 with a difference of 0.043 (table 4). This range is because of the variability of RMSE of EBK resulting in lowest and highest errors among all the methods analyzed. When thin plate spline is excluded, the RMSE is very narrow (0.023). Considering the representation of the entire range of data as well as the RMSE, it can be safely concluded that the IDW with power 1 model is best suited to represent SOC in the study area.

CONCLUSION

Characterisation of soil properties by collecting ollection of soil samples from each plot under different land use of the study area is impossible for large areas. It is imperative to attempt sampling of soils following by spatial interpolation to assess the soil quality variation. Spatial interpolation in one of the way to asess the variability for the regions/ watershed for which sufficient number of observations are not available. The present study evaluated different interpolation techniques in GIS envrionment along with analysis of summary statistics of SOC variability under different crop cover. In spite of being located in the tropical region, high level of SOC is not observed anywhere in the study area. The oberved SOC range from 0.35 to 1.38 in the study area. As per suggested method of classification of SOC the entire sub-watershed falls under medium to very low SOC whereas high and critically low categories are absent. Statistical analysis reveals, only 19.61 per cent of the samples analysed have very low (0.25-0.50 per cent) level of SOC. Among the interpolation method used in the present study, only IDW represents the very low SOC class while other two methods failed to respresent very low SOC class. EBK with linear model has the lowest RMSE while interpolating the observed values. Considering the spatial representation of all classes and least RMSE, the analysis identified IDW method with power 1 model is better interpolation method for the study area.

REFERENCES

1. Almasi, A., et.al. 2014. *Using OK and IDW Methods for Prediction the Spatial Variability of A Horizon Depth and OM in Soils of Sharekord, Iran*. Journal of Environment and Earth Science. 4(15) 17-27

2. Bhunia, G. S., et.al. 2016. *Comparison of GIS-based Interpolation Methods for Spatial Distribution of Soil Organic Carbon (SOC)*, Journal of Saudi Society of Agricultural Sciences. http://dx.doi.org/10.1016/ J. jssas.2016.02.001

3. ESRI. 2008. Arc GIS Desktop release 9.3, Redlands, CA, Environmental Systems Research Institute.

4. ESRI. 2014. Arc GIS Desktop release 10.2.2, Redlands, CA, Environmental Systems Research Institute.

5. Gotway, C.A., et.al. 1996. *Comparison of Kriging and Inverse-distance Methods for Mapping Soil Parameters*. Am. J. Soil Sci. 60: 1237–1247

6. Gunarathna, M.H.J.P., et.al. 2016. *Evaluation of Interpolation Methods for Mapping pH of Groundwater*. International Journal of Latest Technology in Engineering, Management and Applied Science. 5(3) 1-5

7. Karydas, C. G., et.al. 2009. *Evaluation of Spatial Interpolation Techniques for Mapping Agricultural Topsoil Properties in Crete*. EARSeL eProceedings. 26-39

8. Kravchenko, A. N. and D.G. Bullock.1999. *A Comparative Study of Interpolation Methods for Mapping Soil Properties*. Agronomy Journal 91: 393-400

9. Krivoruchko, K. 2012. *Empirical Bayesian Kriging*. Esri, Redlands, CA, USA. < http://www.esri.com/news/arcuser/ 1012/empirical-byesian-kriging.html>

10. Overstreet L.F. and J.D. Huges.2014. *The Importance of Soil Organic Matter in Cropping Systems of the Northern Great Plains*, University of Minnesota–Extension. http://www.extension.umn.edu/agriculture/ tillage/importance-of-soil-organic-matter/#effect

11. Li, J. and A. D. Heap. 2008. *A Review of Spatial Interpolation Methods for Environmental Scientists*. Geoscience Australia. Record 2008/23:137

12. Poshtmasari, H. K., et. al. 2012. *Comparison of Interpolation Methods for Estimating pH and EC in Agricultural Fields of Golestan Province*. Int. J. Agric. Crop Sci. 4 (4): 157–167

13. Robinson, T.P. and G. Metternicht. 2003. *A Comparison of Inverse Distance Weighting and Ordinary Kriging for Characterizing Within-paddock Spatial Variability of Soil Properties in Western Australia*. Cartography 32(1):11-24

14. Tobler, W.R. 1970. *A Computer Movie Simulating Urban Growth in the Detroit Region*. Economic Geography 46: 234–40

15. Venugopal, V.K., et.al. (Ed.) 2013. *Manual on Soil, Plant and Water Analysis*. Department of Agriculture, Government of Kerala

16. Walkley, A. and I. A. Black, 1934. *An Examination of the Digtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method*. Soil Science 37: 29-38

17. Yao, X., et al. 2013. *Comparison of Four Spatial Interpolation Methods for Estimating Soil Moisture in a Complex Terrain Catchment*. PLoS ONE 8(1)

18. Zandi, S. et.al. 2011. *Evaluation of Spatial Interpolation Techniques for Mapping Soil pH*, 19th International Congress on Modelling and Simulation, Perth, Australia. http://mssanz.org.au/modsim2011. 1153-1159.

VILLAGE –LEVEL FLOOD RISK ASSESSMENT: A CASE STUDY IN MURSHIDABAD DISTRICT OF WEST BENGAL

Swati MOLLAH[1]

ABSTRACT

Sensitivity to flood hazard is expressed as a function of the variability of annual rainfall and the degree of socio-economic tolerance. Kandi block of Murshidabad district of West Bengal is situated in the Mayurakshi-Dwarka Plain in the western part of the district. The Hijal Beel covers a good part of the block. The percentage of area likely to be flooded and the flood-prone population of the block are as high as 75.6 and 92.43 respectively (IWD-GoWB, 2009). The average frequency of the occurrence of flood in last decade is 6. The area needs in depth study regarding flood risk which will help regional planning for management of flood. This study aims at preparing a flood risk map of Kandi block at village level combining physical, social and economic factors. The study is based on secondary sources of data and uses composite indices for calculation of risk. Village-wise spatial pattern of flood risk has been shown with the help of GIS. It is found that degree of flood risk is not only determined by the physical exposure to flood but also the degree of socio-economic development of the different villages. The study reveals that the central part of the block i.e. Hijal Beel and its surrounding villages and the villages along the river Dwarka have higher flood risk.

Keywords: *Flood Risk, Human Vulnerability, Composite Risk Index, Flood Hazard*

INTRODUCTION

The Gangetic Plain is one of the largest flood plains with highly dense population. Almost every year floods hit the plain. Each time losses get increased instead of decreasing. Earlier farmers used to welcome low-intensity flood and learnt to live with flood in this fertile plain. But with developmental activities like construction of railways and highways in an inappropriate geographical setting the intensity of flood aggravates. It is more challenging in the Gangatic plain where mainly agriculture has remained the major economic activity. Utilisation of resources and implementation of polices have never occurred at a gainful level. Like other programs, existing flood management measures have been unsustainable, as they adversely affect the river ecology. Frequent incidence of destructive floods poses challenge to economic development. We have failed to draw an integrated plan to minimise losses. The alternative plan requires a proper integration of hydrological data with socio-cultural and economic data. Although Irrigation and Waterways Department, Govt. of West Bengal has broadly identiûed ûood prone areas of the state, there have been no attempts to assess the vulnerability by coordinating the hydrological facts with socioeconomic or infrastructural data of the flood prone areas in Murshidabad district.

Vulnerability has two sides. One is external risks, shocks to which an individual or household is subject to climate change and internal which is defenselessness, meaning a lack of means to cope with disaster (Chamber 1983). Vulnerability is linked with the capacity to anticipate, cope with, resist and recover from the impacts of natural hazards and can be viewed along a continuum from resilience to susceptibility (Blaikie *et al.* 1994). Vulnerability is generally perceived to be a function of two components. The effect that an event may have on humans, referred to as capacity or social vulnerability and the risk that such an event may occur often referred to as exposure (Adger 1999). Vulnerability not only depends on a system's sensitivity but also on its ability to adapt to new climatic conditions (Watson *et al.* 1996). Vulnerability means the degree to which an exposure unit is susceptible to harm due to exposure to a perturbation or stress and the lack of the exposure unit to cope, recover or fundamentally adapt to become a new system or to become extinct (Kasperson *et al.* 2005).

There is a close relationship between vulnerability and economic well being which defines the resilience of populations to environmental shocks, the structure and health of the population may play a key role in determining vulnerability (O'brien and Mileti 1992). Age is an important consideration as the elderly and young persons are tends to be inherently more susceptible to environmental risk and hazard exposure. Generally populations with low dependency ratio and in good health are likely to have the widest coping ranges and thus be least vulnerable in the face of hazard exposure.

The factors like institutional stability and strength of public infrastructure are crucial importance in determining the vulnerability to climate change (Handmer *et al.* 1999). A well connected population with appropriate public infrastructure will be able to deal with a hazard effectively and reduce the

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vulnerability. Such a society could be said to have low social vulnerability. If there is an absence of institutional capacity in terms of knowledge about the event and ability to deal with it, then such high vulnerability is likely to ensure that biophysical risk turns into an impact on the human population.

OBJECTIVES

The study has the following objectives:

- To find out the main causes of flood in the Mayurakshi-Dwarka Plain of Murshidabad district of West Bengal.
- To assess the village-wise vulnerability to flood hazard of Kandi block of Murshidabad district.

STUDY AREA

The part of Murshidabad district situated in the Mayurakshi-Dwarka Plain lying to the west of the Bhagirathi get flooded by a host of the scouring rivers which rise from the Chhotonagpur Plateau. Earlier these rivers used to traverse over a series of basins replete with *beels* and low lands to detain the courses of the rivers and they acted as flood cushions; they would release stream-flows considerably late, when the flood-flow in the Bhagirathi receded. The rivers over this region would follow the natural sequence of flooding that prevailed- the Pagla, the Bansloi and the Ajay brought flood-flow first to be followed by the Mayurakshi-Babla system and the Brahmani-Dwarka came last of all. Now, the British ruler Lord Cornwalis vested native landlords with power to rule their subjects locally through the historic 'Permanent Settlement'. Obviously the native zamindars wanted their tenants to cultivate more lands and thereby the revenue to be pushed up. Hence followed reclaimation of lands, embankments and encroachments intensified the direct flow down the channels across the Rarh region.

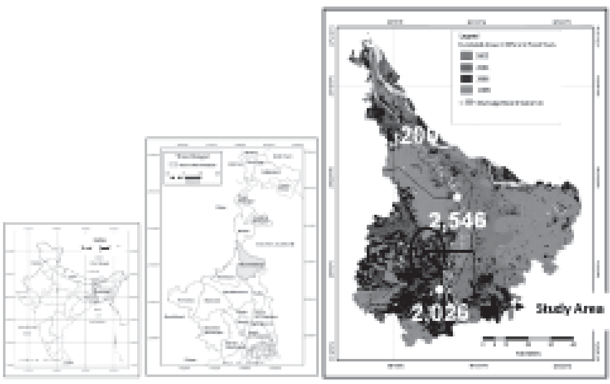


Fig. 1: Location of the Study Area

The vast areas of land, which used to absorb the floods of these flashy rivers, got segmented with unscientifically aligned and designed circuit embankments. There was post-Independence population influx into this border district in addition to natural growth. To provide for accommodation to this increased population, a drastic human encroachment on the detention basins and rivers across the area followed which evidently put the district's riverine eco-system to an unprecedented stress. This upset the flood-dynamics altogether over the district. For the village level flood risk assessment Kandi block- one of the most flood affected blocks of Murshidabad district has been taken in the study. The study area is situated on the western part of Murshidabad district and lies in the Mayurakshi-Dwarka river basin. Fig. 1 shows the location of the study area. High floods in 1956, 1959, 1971, 1978, 1995, 1999 and 2000 inundated some 1000 km^2 of this region. The areas are subject to sustained submergence almost annually and the severity of flood in the Kandi area has been shown in Plate 1.

Occurrence of Flood in the Study Area

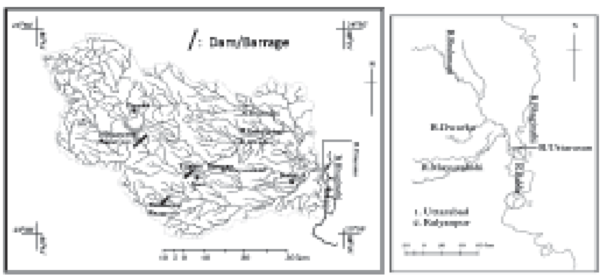
This plain is drained by the Dwarka and the Mayurakshi along with their tributaries – all flowing down in the south-east direction. Both the rivers meet near the Hijal and the confluent flows towards the south. There are several prominent and permanently marshy depressions of various shapes and sizes. Some of them, such as Hijal, Patan, Belun, Langolhata, Karul etc, are mostly abandoned beds of the rivers. The Hijal, a saucer-shaped depression, near the confluence of the Mayurakshi and the Dwarka, covering about 130 km^2, presents a very different topographic aspect. Recently, the Mayurakshi and Hijal Beel have lost their carrying capacity and storage capacity. Estimated volume of sand deposition of the river Mayurakshi is about 0.786×10 m^3 over the last 54 years. Ability to carry discharges of all the rivers collectively has descended to about 0.786×10^6 m^3. Storage capacity of the Hijal Beel area has got reduced to about 1.90×10^6 to 1.56×10^6 m^3 over the last five decades (Mukhopadhyay and Pal 2011). An outflow of such a huge volume of extra water from Hijal Beel and loss of carrying capacity of the rivers are only too responsible for flood severity in the Kandi block, in particular.

The Kandi area is traversed by the rivers Mayurakshi, the Kuye (combined flow of the river Kopai & Bakreswar), the Dwarka, the Brahmani and the spill channels viz. the Manikarnika, the Kana Mor and the Gambhira. The Mayurakshi meets with its major tributaries namely, the Dwarka- Brahmani system and the Kopai- Bakreswar system in Hijal Beel, wherefrom the river Babla takes off to ultimately outfall into the Bhagirathi, through two-outfall channels viz. the Babla and the Uttarasan (Fig. 2). For the sake of better understanding of the nature of problem, the Mayurakshi-Babla basin should be segmented into two zones (Fig.3). The areas with steeper slope having the level of grounds fairly above the flood-level of the Bhagirathi are to be considered in the 1st zone, while the areas having low-lying *beels* and swamps with relatively flat grounds below the high flood-level of the Bhagirathi around the countryside can taken in the 2nd zone.

ZONE- I

Fig 3 shows the different rivers comprising the Mayurakshi River Basin. The Zone- I comprises broadly areas below the Tilpara barrage on the Mayurakshi and other barrages on the tributaries extending up to Badsahi road. The flood problem in this area is mainly due to deteriorated condition of the river channel, being shallow, starts spilling over their banks even at low flood stages. The Mayurakshi river below the Tilpara Barrage, however, been mostly embanked on either side in the zamindari period. These embankments appear to have been constructed arbitrarily quite close to the river channel in certain reaches without much technical planning, consequent to which the channel capacities are greatly reduced at many places.

Due to population pressure the local beneficiaries tried to save the Hijal Beel area from flood for Kharif



Source: Prepared from SRTM data, 2010 and IRS-P6 LISS-3 image, 01.10.2010

Fig. 2: The River Systems of Mayurakshi Basin and Babla and Uttarasan Outfalls

cultivation by compartmentalisation of some areas by construction of several *Gher Bundhs* called as ex-zamindari embankment. The embankments on account of their unplanned and faulty alignment encroach upon the spill areas considerably so much so that they quite often get breached during high floods. Further, as the general slope of the country is not always towards the river, some portion of the spill waters do not return back to the river but flows across the countryside along depressions and ultimately collects into Hijal Beel area. The rivers Manikarnika and Kana Mor are two such important spill channels which, although remain practically dry during low floods, carry large volume of spill waters during high floods, creating additional problems on the left bank of Mayurakshi by flooding large areas all along. In fact, the whole area surrounded by the river Manikarnika, Kana Mor and Mayurakshi gets flooded. Quite often, the Mayurakshi flood spills enter into the Manikarnika from above the Burdwan-Murarai railway line through gaps in the existing embankment on its left bank.

The rivers Dwarka and Brahmani before their confluence near Sankoghat get absorbed in the Jhilli Beel area measuring 36 km^2. After confluence the river is called Dwarka and again the flood volume is absorbed in the Basia Beel area with a surface area of 101 km^2. After Basia Beel there is a constriction on the river Dwarka at Gantlaghat which acts as a natural regulator of the flow of the river Dwarka and desynchronise and moderate the flood volume. The spills of river Dwarka, though moderate below the railway line, increase substantially from near Sankoghat. From Sankoghat downstream; the terrain becomes flat and low-lying. On the right side of Mayurakshi, the problem is, more or less, concentrated near Langolhata Beel and Panchthupi Beel due to spilling of Mayurakshi and floods in Kuye River.

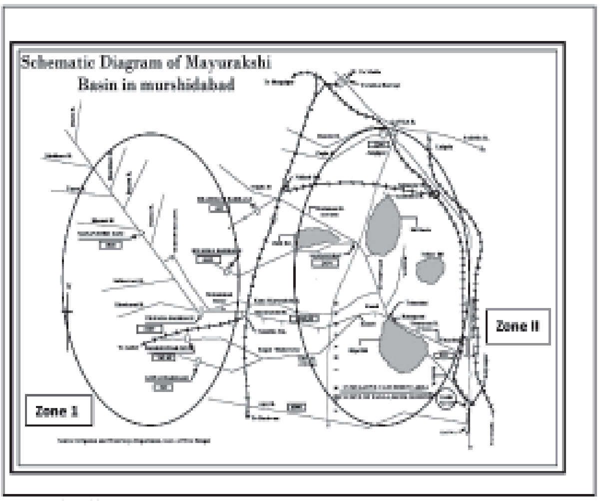
Though the flooding period is not very prolonged, it causes acute drainage congestion, as the drainage from these *beels* is rather slow. The problem of this zone can now be summarised as follows:

- Flooding in the left bank of the Mayurakshi across this zone owing to spill over out of the three channels- the Mayurakshi, the Manikarnika and the Kana Mor.
- Inundation of the areas in the right bank of the Mayurakshi and the drainage congestion in Langalhata and Panchthupi areas due to the spate in the Mayurakshi and the Kuye.
- Floods in the Dwarka and the Brahmani subscribing to the moderate spilling over the both banks of the rivers.
- Unscientific alignment of the embankments and constringed river-channels across the zone.

Mayurakshi river system, the upper catchment lying in Jharhkhand state is free from flood menace. Actual flood problem starts in the state of West Bengal from downstream of Tilpara Barrage. The core problem area is the Kandi area comprising broadly 2,764 km^2 of low or flat lands bounded by Sahibganj loop railway line on the west, Nalhati- Azimgunge railway line on the north, Katwa- Azimgang railway line on the east and Ahmedpur- Katwa railway line on the south.

Source: Field Survey, 2010.

Plate 1:Living with flood; (*Clockwise from upper left*) •Depth of flood water at Hijal; •Damages to schoolin Kandi •Damages to cropsin Hijal area; •Daily life during floodat Kandi Bharatpur road; •Daily life during floodin Nirmal Char village; •Daily life during floodat Sujapur village;



***Source*: Adapted from IWD- GoWB, 2000.**

Fig. 3: Schematic diagram of part of Mayurakshi Basin in Murshidabad.

DATABASE AND METHODOLOGY

The data used in the study for capturing the risk to flood hazard at village level in Murshidabad district are from various reports of Census of India (Govt. of India 2011) and Irrigation and Waterways Department (Govt. of West Bengal 2009)

Composite index is the aggregation of individual indicators into a single index or bottom line using a certain weighting scheme (Sharpe and Smith 2005). PCA and Factor Analysis (FA) are of the most often used multivariate statistical techniques to weight composite indices (Booysen 2002). The weights derived from the PCA are determined by the factor loadings on the components and are fixed across all groups. Therefore, an instrument is derived which compares the quality of life of different groups.

PCA objectively weights the dimensions included in the composite index, therefore limiting a priori information needed on the weighting. It is a basic method to determine the weights and it contributes to the selection of a limited number of indicator variables which represent the data.

PCA aims to extract the maximum variance from a data set with each component (Tabachnick and Fidell 2007).

In mathematical terms, PCA can be explained as follows:

From a set of variables X_1, X_2 to X_m, the principal components PC_1 to PC_m are extracted:

$$PC_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. a_{1n}X_n$$

$$.$$

$$.$$

$$PC_m = a_{m1}X_1 + a_{m2}X_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots . a_{mn}X_n$$

Where, a_{mn} represents the weight for the m[th] principal component and the *n* th variable. The weights of each principal component are given by the eigenvectors of the correlation matrix or the co-variance matrix. The variance (›) for each principal component is given by the eigenvalue of the corresponding eigenvector. The analysis conducted for this paper relied on the eigenvalues and their corresponding eigenvectors, as they summarise the variance in a correlation or covariance matrix.

DISCUSSIONS AND ANALYSIS

From the Fig. 4 it is clear that the occurrence of flood in the Kandi block is immencely governed by the elevation pattern of the block. Thus the study finds that occurrence of flood in the block is almost inevitable. From this point of view it needs the assessment of the socio-economic vulnerability of the society as well as the physical vulnerability of the villages so the proper flood management programmes can be taken.

To calculate the composite index for vulnerability total 14 indicators have been selected. Though these indicators do not explain the vulnerability in total but unavailability of authentic data compels to do the analysis with these data. General literacy, female literacy, dependent population, population below 6 years age and distance of the villages from the main centre of the region have been considered to express the degree of social status of the villages. Social development is one of the important indicators of vulnerability. Socially under developed community are more sensitive to any extreme condition in their environment as compare to socially developed

Table 1
Results of PCA Analysis of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.786
Bartlett's Test of Sphericity	Approx. Chi-Square	1.185E3
	Df	78
	Sig.	.000

Indicators	Component 1	Component 2	Component 3	Component 4	Square Loadings			
Frequency	-0.184	0.907	-0.038	-0.138	0.008	0.196	0.001	0.017
Duration	-0.234	0.891	-0.057	-0.13	0.013	0.189	0.003	0.015
Depth	-0.102	0.953	0.001	-0.038	0.002	0.216	0.000	0.001
% area flood	-0.083	0.896	-0.007	0.117	0.002	0.191	0.000	0.012
% pop flood	0.251	0.852	0.188	0.093	0.015	0.173	0.030	0.008
Density of pop	0.225	-0.013	0.909	-0.026	0.012	0.000	0.693	0.001
% minority pop	0.256	-0.231	-0.204	0.797	0.015	0.013	0.035	0.561
% Dependent pop	0.902	-0.067	0.263	0.033	0.188	0.001	0.058	0.001
% <6 yrs pop	0.927	-0.066	0.151	-0.135	0.199	0.001	0.019	0.016
Gen illiteracy	0.899	0	0.025	0.034	0.187	0.000	0.001	0.001
Female illiteracy	0.945	-0.091	0.183	0.115	0.207	0.002	0.028	0.012
% agri pop	0.37	-0.223	-0.273	-0.636	0.032	0.012	0.063	0.357
Distance from town	0.722	-0.177	-0.29	0.33	0.121	0.007	0.071	0.097
Total Variance	4.317	4.204	1.192	1.133				
	Social Backwardness	Exposure	Pop Density	Economic Backwardness				

community. Literate population can collect information regarding the early warning and probabilities of occurrence of flood provided by different media and prioritize adaptation efforts to address the most threatening impacts and events. They also can take measures accordingly. Illiterate communities do not have idea of level of impact of different climate events on household and community. They have lack of skill in identifying current and possible uses of climate information also.

In the present state of economic system in the study area agriculture does not bring high income. High dependence on agriculture results less earning and consequently lack of money to cope with the extreme situation. Dependence on natural resources again accelerates the sensitivity to flood hazard. Flood conditions severely affect the production system too. Thus this pattern of livelihoods is highly sensitive to flood hazard. Pressure of dependent population in terms of workforce and population below 6 years determine demographic vulnerability of the region. The minor population and old population need much assistance during evacuation process and thus more vulnerable. Accessibility reduces the vulnerability. Highly accessible areas have advantages to rapid evacuation process.

The result of Factor Analysis has been shown in the Table 1. The KMO measure of sampling adequacy was 0.786, which indicated a high sampling adequacy for Factor Analysis.

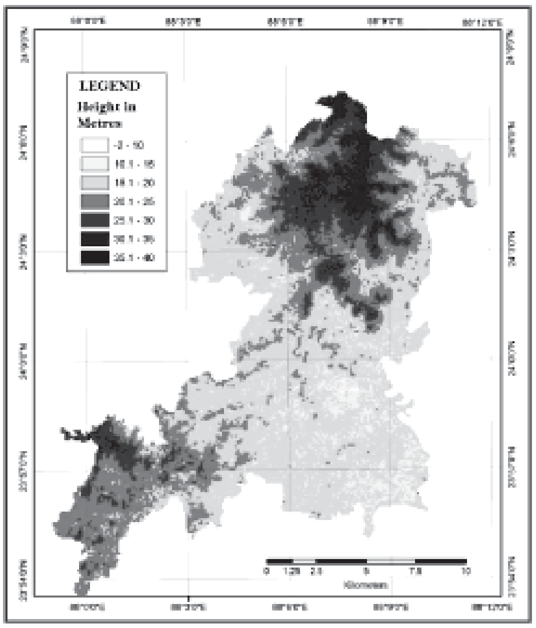
The Bartlett test of sphericity associated probability was less than 0.05, which was small enough to reject the null hypothesis of no correlation in the data set. Therefore both these tests indicated that there was sufficient correlation in the selected variables to perform Principal Component Analysis for calculation of composite index.

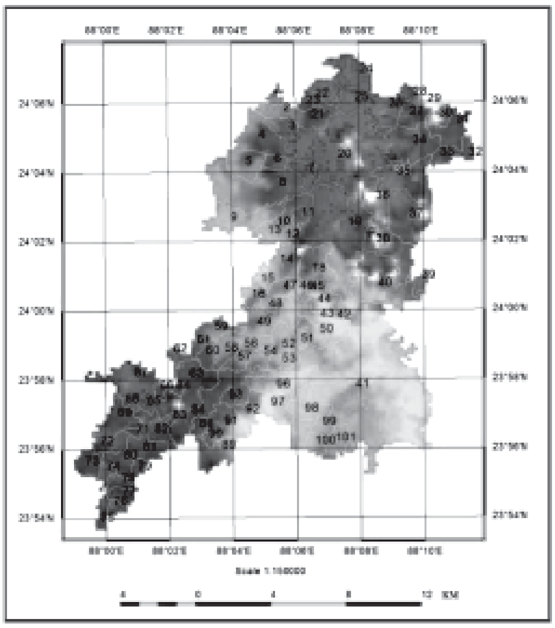
Table 1 shows that percentage of dependent population (0.902), percentage of below 6 years age population (0.927), general literacy rate (0.899), female literacy rate (0.945) and distance from main town (0.722) have the highest factor loadings on the first component. This component was labeled **'social backwardness'**. This dimension explains the most variance in the data set, 33%.

In the second component, flood frequency (0.907), duration of flood (0.891), depth of flood in metre (0.953), percentage of flood prone area (0.896) and percentage of flood prone area in hectare (0.852) loaded the highest on the component and this component was labeled as **'exposure to flood'**.

This dimension explained the second most variance in the data set (32%), and these indicator variables therefore also showed considerable variance between the indicators. The third and the fourth components- **'population density'** and **'economic backwardness'** explain about 17% of the dataset. These two components are less significant in terms of variance explained and thus they have not been discussed much in the analysis.

The study finds that the villages with highest indices of physical exposure i.e. 'exposure to flood' component are not the same in terms of their relative

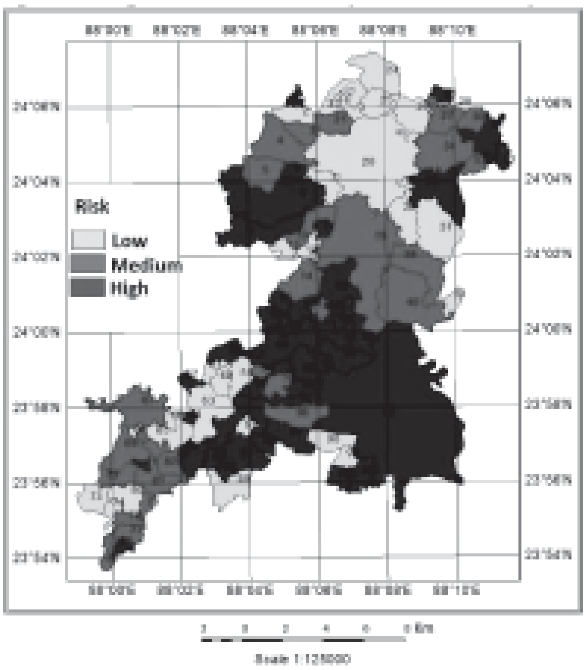




position as well as in terms of their absolute values with respect to their composite vulnerability indices combining the physical and socio-economic features.

Regarding the degree of physical exposure to flood risk H.T. Chak, Hijal, Jayarampore, Udaychandpur, Baze Gopalnagar, Durgapur, Gopalnagar, Belun, Benipur and Lakshmi-kantapur villages are highly vulnerable. The socio-economic index reveals that

Ranipur, Bhabanandapur, Nabagram, D. Lakshminarayanpur, Munigram, Patenda, Gobarhati, Madarhati, Asua and Kumar Sanda are exceedingly backward villages showing least adaptive capacity to cope with the flood risk.



Source: Prepared by the Author

Fig. 5: Village-wise Flood Vulnerability to Flood in the Study Area

With respect to overall vulnerability to flood risk the awfully vulnerable villages are Kalyanpur, Sashpara, Bajedohalia, Parbbatipur, Udaychandpur, Ranipur, Bundai, Durgapur and Solepara (Fig. 5). Risk of any hazard cannot be determined by only physical characteristics but it also influenced by socio-economic structure of the area. The socio-economic structure of a community determines its adaptive capacity which reduces the risk of any hazard. From the risk map the 10 villages having highest flood risk are Kalyanpur, Sashpara, Bazedohalia, Parbbatipur, Udaychandpur, Chandra Prasadpur, Ranipur, Bundai, Durgapur, Solepara.

In Murshidabad district with a view to controlling floods a great deal of efforts has been directed to construction of embankment. People all over the district, however, have heavily encroached upon these public structures quite regardless of the fatal consequences that could befall them ignorant. As regards the proportion of the measure around, in the Mayurakshi basin alone the rivers have been caught in snares of embankments 377 km long. The efforts in this direction have obnoxiously interfered with the natural course of drainage across the region. At some places, the Irrigation and Waterways Department have undertaken construction of drainage channels to relieve certain areas from drainage congestion and waterlogging. The efforts have been proved contravening the nature's regime of hydraulics and results reverse effect exacerbating the flood condition.

CONCLUSION

Physiographic features of the study area favour natural generation of flood. By comparing the elevation pattern of the study area with that of inundation pattern of 2000 flood, recorded as one of the biggest flood events ever hit the block, it is found that topography plays the most important role in inundation. Outflows of a huge volume of extra water from Hijal Beel during rain and the loss of carrying capacity of the Mayurakshi River are too responsible for flood severity in the Kandi block, in particular. So it is quiet impossible to control the occurrence of flood in the region. We must think about preparedness driven approach relating to live with flood and vulnerability analysis, improving the community's adaptive capacity etc. are much more significant management options. In our state as well district all the flood controlling measures are structure oriented in examining only the physical exposure. The socio-economic structure of that area is overlooked during formulation of any flood management plan in district level. It is quite evident from the existing structures meant for controlling floods in Murshidabad, that people including those in political power and public administration conceived building up structures like embankment, barrage, canals or like as the sole measure towards managing the noxious events of floods. Non-structural approaches remained obscure all the time. We must look forward for proper flood management plans which will consider the social aspect along with biophysical aspect.

REFERENCES

1. Adger, W.N (1999). Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. World Development,.Vol 27(2): pp 249–69.
2. Booysen, F (2002). An Overview and Evaluation of Composite Indices of Development. Social Indicators Research. Vol 59: pp 115-151.
3. Blaikie, P., Cannon, T., Davis I. and Wisner, B. (1994). At Risk: Natural Hazards, People's Vulnerability and Disasters. New York. Routledge
4. Chamber, R. (1983). Rural Development: Putting the Last First, Essex: Longman
5. DCO: Directorate of Census Operations (2011): District Census Handbook, Series-26, Part- XII-A, New Delhi: Government of India.
6. Handmer, J.W., S. Dovers and T.E. Downing. (1999). Societal Vulnerability to Climate Change and

Variability. Mitigation and Adaptation Strategies for Global Change, Vol 4: pp 267-281.

7. IWD: Irrigation and Waterways Department (2009). Flood Preparedness and Management plan. Disaster Risk Management Section. Kolkata: Govt. of West Bengal.

8. Kasperson, J., R. Kasperson, B. L. Turner, W. Hsiehand A. Schiller. (2005).Vulnerability to Global Environmental Change: In The Social Contours of Risk. Volume II: Risk Analysis, Corporations & the Globalization of Risk (eds. Kasperson, J. and Kasperson, R.). London: Earth scan.

9. Mukhopadhyay, S and Pal, S (2011). Trend of flood at Riverine Bengal Basin of Kandi block of Murshidabad District: a Hydrogeomorphological Overview. Indian Journal of Geography and Environment. Vol. 12: pp. 9-18.

10. O'brien, P and D. Mileti (1992). Citizen Participation in Emergency Response Following the Loma Prieta Earthquake. International Journal of Mass Emergencies and Disasters. Vol. 10: pp. 71-89.

11. Sharpe, A. & Smith, J. (2005). Measuring the Impact of Research on Wellbeing. Ottawa: Centre for the Study of Learning Standards.

12. Tabachnick, B. G. & Fidell, L.S. (2007). Using multivariate statistics, Boston: Pearson Education.

13. Watson, R.T., M.C. Zinyowera and R.H. Moss. (1996). Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses, Cambridge: Cambridge University Press.

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Rural Planning and Decentralisation

GEOGRAPHICAL APPRAISAL OF AGRICULTURAL SITUATION IN RAJPUTANA STATE

Balak RAM[1] And J.S.CHAUHAN[2]

ABSTRACT

The peasantry condition in India was not bad up to 14th century but during sixteen and seventeenth century it had considerably deteriorated. During Mughal period agriculture in Rajputana was ruined due to the agrarian crisis, long-drawn wars, jagirdari crisis, recurring famines etc. Britain also changed the old revenue system to the disadvantage of the farmers. Under feudal system in Rajputana, the situation was more precarious. There were no tenancy rights and farmers were overburdened with many taxes, cess and 'begars'. The present study is an attempt to assess the agricultural situation and socio-economic condition of peasants in Rajputana. Princely state wise historical data on theland system, agriculture, and population for the years 1900-01, 1930-31 and 1950-51 are analysed and status and trend of various parameters viz. land tenure and land revenue, land use, irrigation, cropping pattern and demographic aspects are worked out. Historical maps are interpreted and with the help of recent maps, various thematic maps showing above aspects are prepared.

Keywords: *Rajputana, Princely States, Khalsa, Jagir, Agriculture*

INTRODUCTION

From centuries, agriculture in our country remained lifeline of more than 70% inhabitants. In earlier days there was no problem of land tenure and revenue but fall of Gupta Empire in thesixth century created political unrest and agriculture and peasantry conditions getting gradually worsened. During *Mughal* period the situation became more critical due to the agrarian crisis, long-drawn wars, jagirdari crisis, recurring famines etc. Britain also changed the old revenue system to the disadvantage of the farmers. Under feudal system in Rajputana, the situation was more precarious. There were no tenancy rights and farmers were overburdened with many taxes, cess and '*begars*'. The present study is an attempt to assess the agricultural situation and socio-economic condition of peasants in Rajputana. Princely state wise historical data on the land system, agriculture, and population for the years 1900-01, 1930-31 and 1950-51 are analysed and status and trend of various parameters viz. land tenure and land revenue, land use, irrigation, cropping pattern and demographic aspects are worked out. Historical maps are interpreted and with the help of recent maps, various thematic maps showing above aspects are prepared. Rajputana, also called *Rajwar* form a group of 19 princely states and two chief ships together with the small British Province of Ajmer-Merwara, with an area of 3,43,328 km^2 (Anon.1908). Out of total area of Rajputana, the reporting area was 51.4%. Khalsa villages were occupying 39.4% area and 49.8% of the total villages. Jagir, sasan, muafi, bhum and dharmada were another important land tenure system. Major factors for the poor condition of agriculture and that of peasants were: feudal system and political diversity; anti-farmers land tenure and land revenue system; recurring famines; long driven wars; autocratic and self-willed rulers; very poor infrastructure and transport system, under utilisation of natural resources; and ill management of natural disasters. The problems were more human created rather than natural since Rajasthan witnessed remarkable agricultural development after independence with the same natural resources.

METHODOLOGY

Series of gazetteers on Rajputana (Touché 1870, Henry Frowse 1908, Erskine1908, Bartholomew 1909, Pyne 1952 and Tod 1978) were consulted to bring out related information on history, people, land tenure and agriculture. Similarly maps of Rajputana (1897, 1906, 1909, 1920 and 1931) publishedby various authorities (Pope, 1880; Johnston, 1897, 1906; Bartholomew, 1909; Deutsch, 1926; Gutenberg, 1931) as well as world million series maps are consulted and with the help of newly published administrative map of Rajasthan (Census of India, 2011) a final digital map of Rajputana has been prepared. Historical data on population, land use, agriculture, irrigation, cropping pattern, crop production and other related aspects are collected from statistical reports of 1900-01 to 1905-06 and 1951-52 and census reports of 1931 and 1941. After analysis of these data a series of thematic maps on population, culture, land

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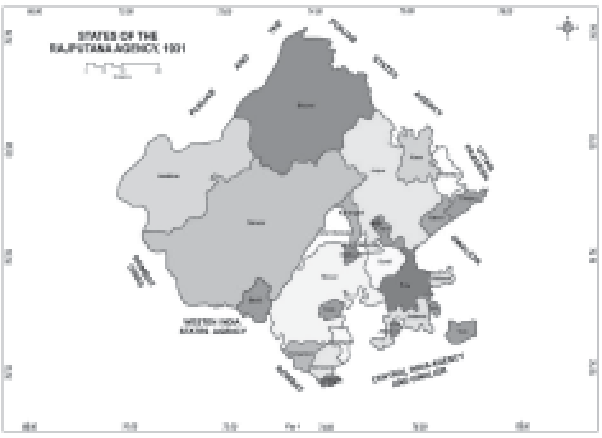
use and agriculture are prepared. A lot of literature has been studied to assess the situation of land tenure, land revenue, the condition of peasants and agriculture as well as post-independence developments.

RESULTS AND DISCUSSION

Location and Environment

Rajputana is the name of great territorial circle which includes 19 native states and two chief ships together with the small British Province of Ajmer-Merwara was located between 23^0 03¢ to 30^0 12¢ north latitudes and between 69^0 30¢ to 78^0 17¢ east longitudes (Fig. 1). With a total geographical area of 339071 km^2, Rajputana was bounded by the province of Sind on the west; in the north- west by the Punjab State of Bahabalpur; on the north and north-east by Punjab. Its eastern frontier marches first with the United Province of Agra and Oudh and next with Gwalior while in southern boundary run across the Central Region of India with a number of native states in Central India and Bombay Presidency (Anon.1908).

Rajputana, also called *Rajwar* form a group of princely states chiefly constituting what is now Rajasthan State north-west India with an area of 3,43,328 sq. km. The name means' land of The Rajputs'. George Thomas (Military memories) was first in 1800 AD to term this



region as Rajputana. Rajputana is mentioned for the first time as a compact land of the princes with territorial divisions, plains and mountain in an inscription of 1708. The region has two geographic divisions. The area north-west of Aravalli range is being mostly sandy and unproductive and including part of the 'Great Indian Desert' and the area south-east of the range is generally high and most fertile. The physiography of Rajputana is characterized by sandy arid plain and arid pediplain of *'thar'* desert in western part; transitional plain of *Luni* river basin; central highlands and Aravalli range of hills; eastern uplands of Mahi and *Banas* river system; Bundalekhand upland and pathar of Vindhyan system; and Malwa plateau primarily consists of Deccan trap and basaltic formations, formed by the alluvium laid by *Chambal* and its tributaries viz. *Parbati* and *Kalisindh*. The western sandy arid plain is dotted with sand dunes of various types ranging upto 110 m height and saline playas and salt lakes. The Aravalli hill ranges have a width ranging from 10-100 km, height between 300-900 m and length 560 km with a maximum altitude of 1722 meters at Mount Abu.

The climate of Rajasthan ranges from semi-arid to arid on the west of Aravalli and semi-arid to sub-humid on the east of Aravalli. The arid region is characterised by low, erratic and highly variable rainfall, frequent droughts, and high wind speed during summer and low humidity. The mean annual rainfall varies from less than 100 mm in the extreme western part of Jaisalmer to more than 920 mm in the eastern parts of Jhalawar and Banswara.The annual potential evapotranspiration (PET) vary from less than 1300 mm in the district of Banswara and Dungarpur in eastern Rajasthan to more than 2000 mm in Jaisalmer district in the extreme west. There is wide variation in temperature ranging from below freezing point in winter to as high as 47^o to $48\ ^oC$ in summer. Rajputana experienced many famines which caused great loss to human and animal life as well very poor agricultural and dairy production. Years of major famines recorded are 1746, 1755, 1783-85, 1903-4, 1812-13, 1833-34, 1837-38, 1848-49, 1868-69, 1891-92 and 1899 (Fisher, 2014).

The length of crop growing period varies from less than 45 days in extreme west to 150 days in Malwa Plateau. The soils of the sandy plains are deep, calcareous and sandy with severe wind erosion. Soils of aeofluvial plains of Luni are moderately shallow to very deep, calcareous and sandy to loam in texture. Soils of Aravalli landscape are shallow to moderately shallow, loamy to loamy-skeletal and severely eroded. Eastern Rajasthan upland is represented by moderately deep to deep, loamy soils with slight to severe erosion. Malwa plateau has moderately shallow to moderately deep, loamy skeletal to clayey soils (NBSS&LUP, 2000).About 16.78% area of Rajasthan is occupied by natural vegetation cover of which 4.71 % area is occupied by forest. Scrub and grasslands occupy 9.18 and 2.87% area. The major classes are dry deciduous forest, thorn forest, broad leaved hill forest, dark forest, teak mixed forest and riverine forest.

Historical Background

The history of human settlement in north Indian state of Rajasthan dates back to 5000 years ago. Part of Rajasthan may have been occupied by the Indus valley Civilisation (harappans). It was part of Mauryan Empire around 321-184 BCE. Gupta reigned in the 4th century. The decline of 300 year old Gupta Empire in the 6th century led to political unrest in north India and a number of large states emerged. The situation stabilised when Gurjara-Pratihara emerged around 700 CE. By the 11th century, the Chauhan has emerged as a major power in the eastern region. Rajputs started emerging on the political scene of Rajputana from the 7th century onward and gradually by the13th century, Rajputs created a network of states by both migration and invasion throughout present day Rajasthan (Vyas *et. al* 2007). In the following century, other clans such as Kachhwaha, Bhati, Rathore etc. succeeded in establishing an independent kingdom in the area. After the defeat of Prithviraj Chauhan in 1200 AD, a part of Rajasthan came under muslim rulers. The Mughal Empire prevailed from 1526 to 1857. Since early 1700 Maratha Empire extended into Rajasthan till British East India Company replaced Marathas as permanent rulers at the end of the last Anglo-Maratha war in 1818.British rule prevailed from 1817 till independence in 1947. On 1st Nov. 1956, after the merger of all princely states and other states, Rajasthan State came into existence.

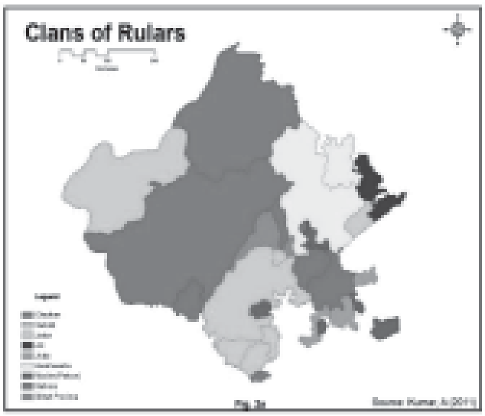
Administrative Setup

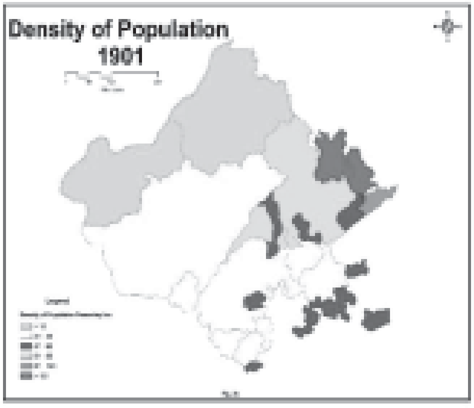
Rajputana was a political office of British Indian Empire under the political charge of an agent reporting directly to the Governor General of India and residing at Mount Abu. The total area of Rajputana was 3,30,330 km^{2}with19 states and tow chief ships or estates. Excepting Bharatpur and Dholpur states which were ruled by jat and Tonk by muslimpathan, all other states were controlled by rajputs. It was divided into 9 groups of states consisting 3 residencies and 6 agencies (Anon.1909)as per details are given in table 1.Formed in 1806, Tonk state was having six pockets of territory three of them (Tonk, Aligarh and Nimbahera) within Rajputana with an area of 2895 km^2 and three (Chhabra, Pirawa and Sironj) in Central India with an area of 3740 km^2. In 1631 the Phulia estate 'jagir" was renamed Shahpura.The State of Shahpura was formed in 1706 with an area of 1049 km^2, 90 villages and 54233 inhabitants in 1931.Kushalgarh chiefship with 2443 km^2 area was having 3 tehsils viz. Maiyad, Dangra and Patan covering 310 villages (104 khalsa and rest jagir and muafi).Founded in 1643, Lawa estate with an area of 49.38 km^2 located within Tonk state has only one town with its surroundings. Under the sway of Kachhwahas it became autonomous (British protectorate) in 1867.Ajmer–Merwara British Province with an area of 7046 km^2 was ceded to the British by Scindia by treaty in 1818. Its population was 460722 in 1881 which risen to 5836932 in 1941 (Anon.1879).

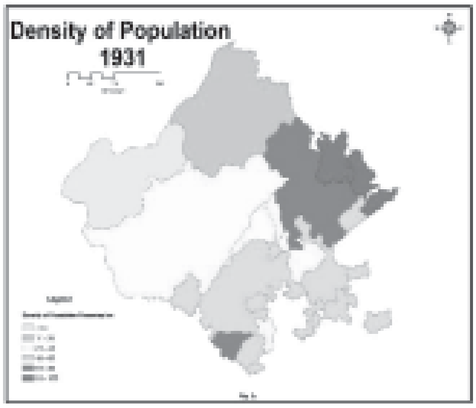
Population, Culture and Society

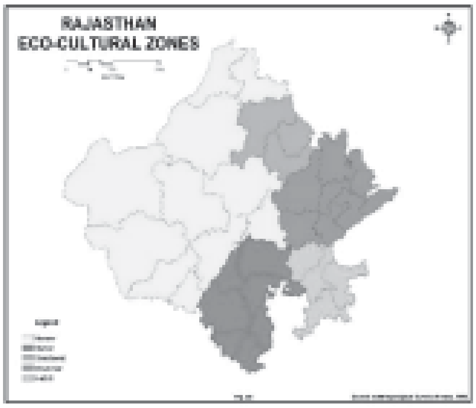
The population of Rajputana in 1881 was 10.1 million and in 1891 12.2 million. In 1901 the population came down to 0.97 million due to famine. There were128 towns and 29901 villages. The rural and urban population were 85.5 and 14.5 per cent respectively. Male population was 52%. The density of population varies from 36 in sandytract to 79 in fertilesouth eastern part and 165 in the eastern part. The density of population in 1901 is shown in fig. 2b and that of 1931 in fig.2c. Of total population brahmin community constitute 10.4%, jat 8.7%, mahajanand bania 7.8%, chamars 7.0%, rajput 6.4% and sheikh 6.87 per cent respectively. On the other hand,minas were 5%, gujar 4.7% and bhil 3.5%. State wise area, number of villages and towns and variation of population (1889-1901) are given in table 2.Out of total rajputs 20% were rathore, kachhwaha 16%, chauhan 14%, jadon 12%, sisodia 8%, panwar 7%, solanki 3% and parihar 2% respectively (Banerjee, 1945). Bundi, Kota and Sirohi states were ruled by Chauhan rajput; Banswara, Dungarpur, Udaipur, Pratabgarh and Shahpura by guhilot; Jaisalmer and Karauli by jadonrajput, Jhalawar by Jhala; Alwar, Jaipur and Lawa estate by kachhawaha; and Bikaner, Marwar and Kishangarh by rathorerajput (Gupta and Bakshi, 2008). Their distribution is shown in fig. 2a.Religion wise the hindus were 83%, muslim 9.5% jain 3.5% and animist 3.75%. There were six linguistic zones in Rajputana (Kumar, 2011). Marwari was prevalent in Jodhpur, Pali, Sirohi, Jalor (with gujarati influence), Nagaur with Sekhawati influence and Jaisalmer and Barmer with sindhi influence.

Bikaner and Ganganagar were influenced by bikaneri and Punjabi. Mewari language was spoken in Udaipur, Chittorgarh, Bhilwara and Ajmer. Bagri was spoken in Dungarpur and Banswara. Dhundhari was prevalent in Jaipur centre, Tonk, Bundi, Kota, part of Jhalawar, Sawai Madhopur and Dang. Mewati was the mainlanguage of Alwar, Bharatpur, Karauli and Dhaulpur (Kumar, 2011).Bagar, Sekhawati, Marwar, Dhundhar, Mewar, Matsaya, Haroti, Merwara and Vagor were major cultural zones in Rajputana (Fig. 2d). The distribution of major castes in these zones is shown in table 3. Upper caste population was dominant in Dhundhar, jat in Sekhawati, gujar in Matsaya, craftsman and service OBC in Haroti, Scheduled Caste in Bagar and Merwara, Scheduled Tribes in Vagor and muslim in Shekhawati region. Population of bhils in Mewar residency was 21% highest being 63% in Banswara, 34% in Dungarpur and 22% in Pratabgarh state. Regarding infrastructure, the length of rails was 1049 km in 1881 and 2536 km in 1906. The length of metalled roads was 1915 km and that of un-metalled roads 3797 km. In 1904 there were 178 hospital and dispensaries. There were altogether 647 schools which include 4 colleges, 86 secondary and 545 primary schools.









Feudal System

Tod concludes, four of the six incidents making the feudal system are in force in Rajputana, viz. relief, escheat, aids and warship (Ency. Britanica).In Rajputana administrative and the economic consequences contributed to the spread of feudalism more intensely. Internal struggle in the Rajput House made the political condition even bitter (Indianetzone, 2014). In the period of Rajput feudalism, service grants were associated with all the rights usually made to the grantees. Rajputs were divided into 36 races and 21 kingdoms). Mahajan (1972) observed that rajputs used to fight separately against the foreign invaders and each one of them defeated separately. They wasted all their time and energy in mutual bickering and jealousies and no wonder they accomplished nothing. According to Tod (1978), there was a resemblance of jamindars of Rajputana with the fief of Europe. The caste played a crucial role in the feudal system as it prevented lower classes being incorporated in the nobility. Almost all the rajput state vied each other for supremacy since there was no central authority to face any foreign invasion (Rudolf and Sussane, 1966). Major causes for the worst condition were political diversity, mutual distrust and acrimony, autocratic and self–willed rulers, feudal system, absence of border defence policy, old military setup and outdated strategy and a false sense of pride. Many of the rulers were insignificant men, who strutted. Their only contributions were internecine feuds and wars (Randhawa, 1980).

Land Tenure and Land Revenue system

The central feature of land tenure system in Rajputana was a hieratical system of ownership. There was two main type of and tenures. Khalsa or crown land under the direct control of central darbar and jagir estates of varying value and size controlled by the Maharaja's subordinate sardars (Saxena, 1952). The land tenure systems in Rajputana remain unchanged without any serious modificationduring a period of seven hundred years. *Muafi, bhum, sasan* and *dharmada* were other system of land tenures. In addition of jagirdari there was also zamindari and biswedari system which was prevalent in the non-rajput states of Bharatpur, Dholpur, over a great part of Alwar and the parganas of Kotkasim and Kotputli in Jaipur (Saxena, 1952) covering 4867 villages spread over eight districts of northern and east Rajasthan and that of Tibi tehsil of Ganganagar district (Kumar, 2001). Regular settlement have been made in Alwar (1899-1900), Bharatpur (1900), Bikaner (1894), Dholpur (1892), Jhalawar (1884), Kota (1877-86), Tonk (1890-92), Jodhpur (1894-960) and in Udaipur 1885-93. Jagirdari system prevailed in 16780 villages covering an area of 200409 sq km and khalsa system in 16838 villages (Anon.1950).State-wise number and area of khalsa and non-khalsa villages are shown in table 3.

There were three type of jagirs viz. scheduled jagir (govern by therule of primogenitors), listed jagirs (held by co-heirs but are indivisible) and bhumichara (divisible among the heirs). Jagirs of different type of tenures include 107 rajvis, 824 jagirs in lieu of services, 6963 jagir proper, 578 bhomichara, 66 istimrar and cheritable grants of all description 1343 (Saxena ,1952).There were 550 bhumichara villages in Marwar state (mainly in Mallani region). Istimrari estates were mostly dominant in Ajmer-Merwara. These include Tazimi 16, Non-Tazimi 3, Class I Jagir 10, Class II jagir 6, Class III Jagir 4, Misc. Jagirs 44 and Seth Castle 4, Bhumi Jagir villages estate 38, bhum village estates 63 and misc. estates 9 respectively (Saran, 1946). In bhumia or free hold tenure, grants were made in recognition of important contribution and services rendered to the Maharaja. In Ajmer-Merwara Istimrar system was prevalent in 691 km^2 area (Baden Powell, 1990). In muafi tenure system land is granted free of revenue while in istimrari system land is charged with a permanently fixed quit- rent (Anon.1907b). Jodhpur division was having highest area (72.5%) under jagirdari while Kota division had 80% area under khalsa land (Sharma, 1993). Details are given in table 4. In total, there were about 259025 jagirs of different sizes in Rajputana (Anon. 1966) which were resumed after abolition. Religious jagirs were 50931 and unsettled jagirs 318860.In *'tankedari'* the holder neither to perform services save on special occasion, nor to furnish horsemen and foot soldier. In khalsavillages the system of tenure is modified jamindari. The jamindars were a collector of revenue on 5% commission basis. They were considered as owner of the land cultivated by them and their tenents and also uncultivated land. Actual cultivators held on lease granted by jamindar. In Bharatpur state khalsa land constitute 87.6%, muafi 11.8% and istimrari 0.6%.In Alwar, there were 367 villages with revenue free holding. These were of two types viz.*'battihui'* or divided or *'pattidari'* and *'gol'* or undivided. In *'bhumia'* or freehold tenure the grants were made in recognition of important contribution and services rendered to maharaja (Anon. 1880).Types of the village include khlasa, jagir, mustarka (jointly held by Darbar and jagirdaran), sasan, bhomichara, and samlat (held jointly by two states). Besides share of produce the farmer has to pay numerous 'lags' or cesses. There were 64 kinds of *begars* (work without payment) were prevalent in Marwar (Adams, 1899). Jats were an important farming community. Among them, the important categories of peasants were: *Karsa* (resident cultivators), *Pohis* (non-resident cultivators) and *Basi* (subordinate peasants).

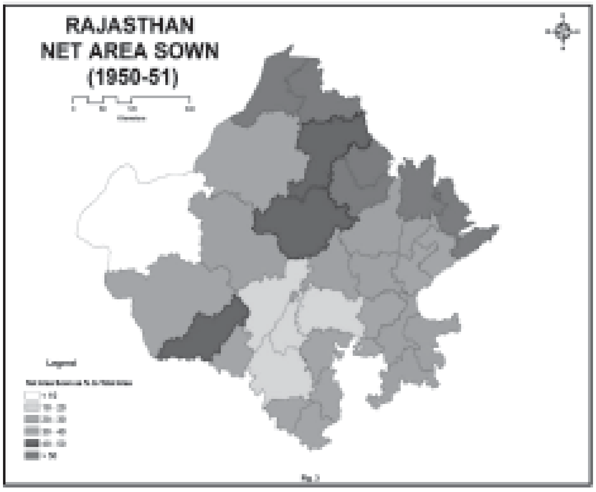
There was no uniform system of assessment of revenue. The prevailing systems were per *bigha* sum paid by cultivator, division of produce (*batai*), apportionment (*Kankut*) and lump assessment (*ijara).*The methods to assess the land revenue were very orthodox, oppressive and irrational (Tod, 1978a). Major source of revenue were khalsa or fiscal land, dooh or tax on smoke, angah (body tax on human and animal, property tax), town and transit duties, pusdeti or plough tax, malbah (original tax per plough used in agriculture, corn tax on one fourth of produce) and sayer or impost. The method for assessment of rent on jagir lands was in form of *Latai* (standing crops yield was estimated) and *Batai* (assessment of the share of jagirdar was made after the crop harvested and grain winnowed in the thrashing floor). The assessed share of jagirdar was delivered at his door which varies from 1/3 to 1/6 of produce. Misc. revenue derived from salt, opium, liquor, hemp drugs (*bhang, ganja* and *charas*) and stamps. Taxes from *afeem- ka- sauda* and *menhh-ka-sauda* collected from those who gambled about the price of opium and amount of rainfall.

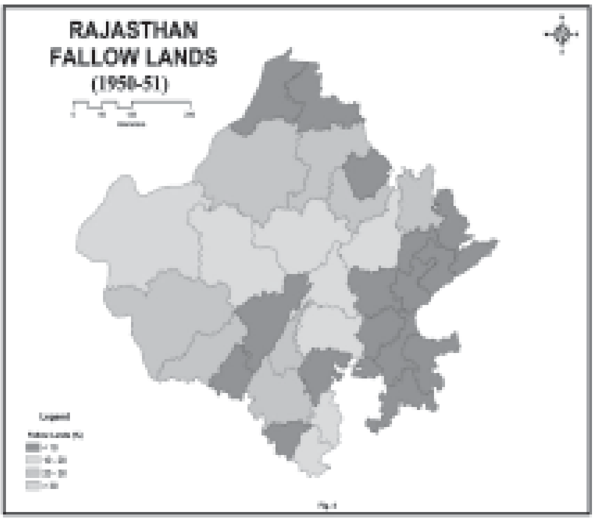
Condition of Peasants

With the introduction of highly centralised administrative and judicial machinery with the taking away entire revenue by the central authority and with the destruction of unity between agriculture and manufacture that characterised traditional Indian society, the village lost their autonomy and self-sufficiency. Various village and local institutions were rendered defunct with the introduction of extremely high land revenue, which often exceeded 50% of produce and appropriation by the state of all local resources, the Indian peasant was rendered to a state of almost deprivation (CPS, 2011). The cruel land revenue system left nothing except bare subsistence with the farmer. Under the British rule the condition of Indian peasants deteriorated steadily. They introduced different land revenue policies with aim to appropriate of maximum revenue from Indian jamindars and peasants. The growth of minimum of subsistence crop led to the deterioration and impoverishment of Indian agriculture and cultivators. The peasants were suppressed under triple burden of the government, landlord and money lender. His subsistence baswas completely ruined by the agrarian policies of British Govt. (Mamta Agarwal, 2015).The great depression of 1929 has a terrible impact on the Indian farmer. The values of agricultural produce came down to alarming rates. Therefore the farmers were compelled to sale of gold and silver ornaments in order to pay the land rent and other taxes (Rajiawani, 2012).

Land use and Agriculture

Agriculture begun in India by 9000 BCE as a result of early cultivation of plants and domestication of animals (Gupta, 2004). The indigenous agricultural technology largely escaped such direct assault in the 18th and 19th century; but during this period the indigenous agrarian social order was completely uprooted and transformed with the introduction of notion of private properly in land, Indian cultivators lost his earlier rights of land. Total area of Rajputana during 1903-04 was 230264 sq km. Area for which return exist was 68034 sq km or 30% comprising mainly khalsa land. Agricultural statistics are available for khalsa area only and that too for selected 9 princely states. State wise land use statistics for 1900-01 are shown in table 4 and cropping pattern in table 5. Out of the total reporting area, the area available for cultivation was 78%. Of this net cropped area constitute 39% and gross cropped area 41%. Irrigated area was 3862 sq km or 7.2% of area available for cultivation. Out of total irrigated area 75% comes from wells, 7% from tanks, 6% from canals and 12% from other sources. Out of total cropped area bajra constitute 22%, jowar 16%, wheat 8.8%, gram 7.3%, barley 6.6%, sesame 4.1%, cotton 3.8%, maize 2.1% and poppy 0.7 per cent respectively (Anon.1906). Table 6 shows district wise land use statistics in percent for the year 1950-51 (Anon.1952).





Jhunjhunun, Sikar, Alwar, Bharatpur and Ganganagar districts were having more than 55% net sown area while Bhilwara tops (38.3%) in irrigated area (Anon. 1952). The distribution pattern (%) of net sown area is shown in fig. 3 and fallow lands in fig.4.

Apart from agricultural land, 'oran' has been an important land use system in Rajputana. These lands with religious sanctity come under common property resources (CPR). There are about 1100 *orans* with an estimated area of 1,00,000 ha. Devas than beed grasslands and charnot are the only public land in Mewar region. Agricultural lands in Mewar State were classified into 3 category viz. *kachhadakhila,aslipakka (kham-asami)* and *bapi* (Chandna and Gujar, 2014). Residential land was classified into *kachha* and *pakka* and *padat* (wasteland) into *charnot* and *bedakhil*.

In agriculture Bagar and Shekhawati regions were more developed while Vagor, Merwara and Haroti were less developed. Thus the areas with major share of rural population were less developed. A major defect of British rule was the growing imbalance between population and resources. Up to 1921 India was exporting cereals (Gilbert, 2014). It is estimated that 25% if the national income of Britain was derived from India. Food was exported for purpose of profit during the period of famine. The rail, road, port, irrigation development was designed to serve British interests not India. Nothing was done for poor of the villages (Blackwell, 2004). The agricultural situation of states for which no statistics are available, is summarized below.

Dholpur State: Out of total 3111km^{2}about 949 km^2 or 30 % area is occupied by river and streams. Khalsa land constitutes 2334 km^2 or 75%. Of this cultivated area constitute 59.4%. Irrigated area was 400 km^2 or 38% of khalsa land. There were about 12667 irrigation wells(Henry Frowde, 1908a). Out of total cropped area during 1903-04 bajra constitute 43%, moth 10%, jowar 9%, cotton 12%, wheat and gram 5% each and barley 4% respectively.

Karauli State: Karauli State with 3226 km^2 area, was having 436 villages (204 khalsa and 232 muafi). Cultivated area was about 677 km^{2}or 21% of total area. Irrigated area was nearly 159 km^2 or 23% of total cultivated land. There were about 2813 wells and 379 tanks used for irrigation (Henry Frowde, 1908c). Out of total cultivated area bajra constitute 22.3%, gram 22.0%, moth 13.85, wheat 9.6%, barley 7.75, rice 6.9% and jowar 5.4% respectively. Besides, cotton poppy and sunhemp were also produced.

*Jaisalmer State:*Founded in 1156 AD, Jaisalmer State was having 427436 km area with 461 villages of which 229 were khalsa, 71 held by jagirdars, 32 sasan 11 under patta or title deed, 109 in bhumichara and 9 under services performed to state (Henry Frowde, 1908b). Due to high per arid climate and desertic terrain, cultivated area was very less. Only rainfed crops like bajra, jowar, moth and til were grown. Rabi crops like wheat and barley were taken in few *khadins*on the conserved moisture. There were nearly 377 *khadins*. Irrigation was almost unknown.

*SirohiState***:** The state was having 5104 km^2 area with 413 villages & towns and 1545443 inhabitants (1901). Cultivated area was 904.4 km^2 or 17.7% of total area. Total forest area (reserved and protected) was 1991 km^2 or 19.6%. Irrigated area was 208 km^2 or 23% of total cultivated land. There were 5157 irrigation wells and four tanks with irrigation capacity of 1902 ha. Persian wheel was important water lifting device. Important crops include maize, bajra, moong, kulath and tilduring kharif and barley, wheat, gram and mustard during rabi (Henry Frowde, 1908d)

*Udaipur or Mewar State:*Udaipur State with an area of43645 km^{2}and a population of 1018805 inhabitants (1901) was having 14 towns and 6030 villages. There were 11 zila,6 parganas and 25 estate or *thikana*. Nearly 56.5% population of state was depending on agriculture and pasture (Anon.1944). No reliable agricultural statistics was available even for khalsa land which was about 25% of total area. Forest area was about one third or 12111 km^2. Major crops of the region were maize, jowar, wheat, barley, gram, some rice, poppy (13760 ha to 22662 ha), kangani, kodra, kuri, sama, mung, moth, sugarcane and tobacco (Erskine, 1908). Irrigated area was roughly 520 km^2. There were more than 100 lakes and tanks used for irrigation.

Pratabgarh State: With an area of 51235 ha and 52025 inhabitants (1901), the state has five districts viz. Pratabgarh, Kanora, Bajrangarh,Sagthali and Magra. There were 497 jagir, 54 muafi or dharmada and 308 khalsa villages. Information on agriculture is available only for 114 surveyed khalsa villages. Total cropped area was12898 ha, net sown area 12292 ha and double cropped area 606 ha (Erskine, 1908) respectively. Kharif and rabi (mainly wheat, gram and poppy) crops constitute 64% and 36% of net sown area. Irrigation wells were 2110.

*Dungarpur State:*With total area of3761 km^2 and a population of 165400 (1901), the Dungarpur State had three districts viz. Dungarpur, Aspu and Sagwara together with 748 villages (khalsa-251, jagir-356 and muafi-141). Total cultivated area in khalsa area is about 13% or 49361 ha and net cropped area 15462 ha during 1903-04 (Erskine, 1908).

*Banswara State:*Banswara Statewas having an a total area of 5058 km^2 (Banswara 4174 and Kushalgarh Estate 884 km^2). In Banswara State there were 441 villages (186 khalsa and 255 jagirs) with a population of 161350 in 1901. Total cropped area was18629 ha and net cropped area 17943 ha (Erskine, 1908). . Irrigation wells were 269. Kushalgrh Estate was having 412 villages and one town. Arthana, Garhi, Kalinjara and Kushalgarh were its four *thikana* or estates.

Impact of Feudal System on Agriculture and Peasants

During Mughal period the agriculture was ruined due to the agrarian crisis, long drawn wars, jagirdari crisis, recurring famines etc. Mughals have awarded land revenue collection rights in return for military services; those who held these grants were known as '*Mansabdars*' (Agnihotri, 2010). The association of Rajput rulers with the Mughals benefitted the business community of this region as they were involved with Rajput rajas in their administrative functions. This weakness of Rajput states opened the way for the entry of Marathas. The Rajput rulers paid huge sum of money to Marathas to buy peace and availed the services of bankers to raise money for tribute to Marathas. There was also significant expansion in the system of revenue farming (*Ijara*) during this period and even 'khalsa' lands were put on '*ijara*' which attracted a large number of mahajans and *sahukars* (Singh, 1998). The parasitic state apparatus had an adverse effect on production incentives in agriculture which was reinforced by the effect of 'built-in depressants within the village (Meddison, 1971).

Post-Independence Developments

Under State Reorganization Act, 1956, Rajasthan State was formed on 1st November, 1956 after merger of princely states of erstwhile Rajputana. Before independence there was no tenancy law and one could be thrown away from the land one cultivated at the pleasure of jagirdar. After enactment of the Rajasthan Land Reforms and Resumption of Jagirs Act, 1952 the tenants of jagir land become khatedar tenants of the state with transferable and inheritable rights. 'Jamindari' and 'biswedari' estates were abolished under the Rajasthan Zamindari and Biswedari Abolition Act 1959. Passing of Rajasthan Tenancy Act 1955 and Rajasthan Land Revenue Act, 1956 kept provision of two types of tenant viz. khatedar and gair-khatedar. Thus all the cultivators who were holding land as tenants or sub-tenants or tenants of khudkasht, become khatedar tenants on 15 Oct. 1955. Due to resumption of Jagir, settlement operation were again undertaken in 1959 and completed in 1963. Other measures taken up to ameliorate condition of cultivators were appointment of revenue courts, preparation and maintenance of land records, survey and settlement, consolidation of holdings, land utilization, agricultural loans, relief of agricultural indebtedness and imposition of ceiling on land holdings. Thereafter Rajasthan entered in the era of planned development through five year plans.

CONCLUSIONS

Begining with ancient Harappan culture of Indus Valley Civilization, the Rajputana remained under rulers of Mauriyan, Gupta; foreign invasion by Huns, Saka and Kushans; indigenous Gurjars and Pratharas; Chauhans, Marathas; and various local kingdoms of different clans of Rajput rulers under sovereignty of Mughal and British empires. Significantly, Rajputana with a group of 19 princely states, two Chiefships and Ajmer-Merwara British Province, has more relevancy since all the princely states excepting three, were ruled by Rajputs. The region is more unique in respect of diversity of its geological formations, physiography (particularly '*thar desert*'), climate, agricultural produce, minerals, culture and social system. 83% population was hindus and 9.5%. muslims. Rajputs were divided into 36 clans. The population of Rajputana was 1.1 million in 1891. There were six linguistic regions and nine eco-cultural zones. Tribal population (particularly bhils) was predominant in the states of Mewar Residency. Major causes for worst condition of agriculture and peasants were political diversity, mutual distrust and acrimony and autocratic and self–willed rulers. One of the major characteristics of this region was feudal system in which caste played an important role. A bigger portion of financial and human resources was spent on prolonged wars. Khalsa (fiscal) and jagir were most predominant land tenure system. Others were muafi, bhum,sasan and dharmada. Jimandari system was prevalent mainly in Bharatpur, Dholpur and Alwar region and istimrari system in Ajmer-Merwara.Virtually, there were no tenancy rights and farmers were over burdened with many taxes, cess and '*begars*'.The cruel land revenue system left nothing except bare subsistence with the farmer. They were suppressed under triple burden of the government, landlord and money lender. Excepting 9 princely states no relevant statistical data on agriculture was available and that too for khalsa land only. Out of total area of Rajputana, the reporting area (mainly khalsa) was 30% only. Out of total reporting area, the area available for cultivation was 78%.Net cropped area was 39% and irrigated area 7.2%. Bajra, jowar, wheat, gram, barley sesame, cotton, maize and poppy were important crops. In agricultureBagar and Shekhawati regions were more developed while Vagor, Merwara and Haroti were less developed. Major constraints for poor condition of agricultural were agrarian crisis, long drawn wars, jagirdari crisis and recurring famines etc. After independence and reorganization of Rajasthan State, the jagirs were abolished and land reforms were introduced for development of agriculture and improvement of peasantry condition. Thus long history of Rajputana warns us the ill impact of bad and anti-peoples policies and shows the neglected and important sectors for development.

REFERENCES

1. Agnihotry, V.K. 2010. Indian History. Allied Publishers Pvt. LTD., Mumbai. P.1204.
2. Anon.1879. The Rajputana Gazetteer Vol.II. Office of the Supdt. Govt. Printing, Calcutta, p.292.
3. Anon.1880. The Rajputana Gazetteer Vol.III. Govt. Central Branch Press, Shimla. p.317.
4. Anon. 1950. Report of the Rajasthan and Madhya Bhjarat Jagir Inquiry Committee, New Delhi, 1950. Govt. of India Press, P.86..
5. Anon. 1906. Agricultural Statistics for the year 1900-1901 to 1904-1905. Govt. of India, Deptt. of Revenue and Agriculture. Vol. II, Native States. Director General of Commercial Intelligence. Supt. Govt. Printing, p.90.
6. Anon. 1907. Agricultural Statistics of India for the year 1901-02 to 1905-06, Vol. I British India, p.347.
7. Anon. 1908. Imperial Gazetteer of India Vol. 21. Oxford at the Clarendon Press, London, p.423.
8. Anon. 1909. Imperial Gazetteer of India, The Indian Empire Vol. IV- Administrative. Oxford at the Clarendon Press, London, p.549.
9. Anon. 1944. Report on the Administration of Mewar State for the year 1940, 1941 and 1942. Madras Law Journal Press, Mylapore, Madras, p.124.
10. Anon.1952. Agricultural Statistics, 1951-52, Rajasthan State. The Director of Agriculture and Food Commissioner, Rajasthan, Jaipur, p. 336.
11. Anon.1966. A review of the land reform implementation committee of the National Development Council, Govt. of India, Planning Commission, New Delhi, p. 257.
12. Baden Powell, B.H. 1990. Land system of British India, Vol. II. Low Price Publication, Delhi, p.791.
13. Banerjee, A. 1945. Economic, Religious and Social Condition in Rajputana. *Journal of Indian History*, Vol. 24, Issue-3, pp. 156-165.
14. Bartholomew, 1909. India: Imperial Gazetteer of India. Map of Rajputana with Ajmer-Merwara.
15. Blackwell Fritz. 2004. India: A Global Studies Handbook. Santa Barbara, CA: ABC-CLIO, 2004.
16. Chandna , B.S., Gurjar, M.L., Srivastiva, G. and Sharma, A. 2014. Status of Adivasis/Indigenous Peoples. Land Series-8, Rajasthan Aakar Books, new Delhi, p.119.
17. CPS, 2011. Indian Agriculture between Indigenous

and Modernisation. Centre for Policy Studies. cpsindia.org

18. Erskine, K.D. 1908. Rajputana Gazetteer Vol.II-A Mewar Residency. Scottish Mission Industries Co.LTD. Ajmer, p.242.
19. Feudalism in the post Pratihara Period. Indianetzone.com
20. Fisher, R.J. 2014. Land Ownership; Caste and Economic Status. In: If Rain don't Come: An Anthropological Studies of Drought and Human Ecology in Western Rajasthan. Sydey Studies, Manohar, pp. 92-134.
21. Gibert Etenne, 2014. Indian Villages: Achievements and Alarm Bells. Graduate Institute Publications. http:/openedition.org/iheid/1744, ISBN 9782940503643
22. Gupta, A.K. 2004. Origin of Agriculture and Domestication of Plants and Animals Linked to Early Holocene Climate Amelioration. *Current Science*, 87 (1) Indian Academy of Science
23. Gupta R.K. and Bakshi, S.R. 2008. Studies in Indian History Rajasthan through the Ages: Heritage of Rajputs. Sarup and Sons, New Delhi, p.358.
24. Henry Frowde, 1908a. Imperial Gazetteer of India Vol. 11. Clarendon Press, Oxford, London, p. 403.
25. Henry Frowde, 1908b. Imperial Gazetteer of India Vol. 14. Clarendon Press, Oxford, London, p. 416.
26. Henry Frowde, 1908c. Imperial Gazetteer of India Vol. 15. Clarendon Press, Oxford, London, p. 407.
27. Henry Frowde, 1908d. Imperial Gazetteer of India Vol. 23. Clarendon Press, Oxford, London, p. 435.
28. Johnston, A.K. 1906. Map of Rajputana and Ajmer-Merwara (Scale 1: 3,990,000), London.
29. Kumar, A. 2001. Indian Agriculture-Issues and Prospects. Sarup & Sons, New Delhi, p. 328.
30. Kumar, A. (Ed.) 2011. Rethinking State Politics in India: Regions within Region. Routledge, New Delhi, p. 516.
31. Mahajan, V.D. 1972. Ancient India, Vth Edition. Chand & Co. New Delhi, p. 550.
32. Mamta Aggarwal, 2015.Expansion and Commercialization of Agriculture during the British rule in India. www.historydiscussion.net
33. Maddison,1971. The Mughal Economy and Society. In: Class structure and economic growth: India and Pakistan since the Mughals.www.ggdc.net/maddison/article/mughal
34. NBSS & LUP, 2000. Agro-ecological Assessment of Soil Resources of Rajasthan for Land Use Planning. NBSS & LUP, Nagpur, Pub. 81, p. 88.
35. Payne, C.H., 1922. Annals of Rajasthan. Indian School Supply Depot, Calcutta, P.214.
36. Rajiawani, Jan 31, 2012. www.wordpress.com
37. Randhawa, M.S. 1880. A History of Agriculture in India Vol. I, ICAR, New Delhi, p. 491.
38. Rudolf, L.I. and Sussane, H. 1966. Rajputana under British Paramountcy. The Failure of Indirect Rule. The University of Chicago press, Pp.138-160. *The journal of Modern History*, Vol. 38, No.2 (June, 1966).
39. Status of Rajputana Agency, 1931. www.gutenburgeorg/haa01/archive/haaarcd.html
40. Saran, P. 1946. The Feudal System of Rajputana. Indian Culture, Vol. XIII, Issue 2, 1946, pp. 73-78.
41. Saxena, H.C. 1952. Abolition of Jagirdari: A Landmark in the History of Rajasthan. *The Economic and Political Weekly*, pp. 186-189.
42. Sharma, C.L., 1993. Ruling Elites of Rajputana: A Changing Profile. M. D. Publications, New Delhi, p. 159.
43. Singh, K.S. 1998. Peoples of India: Rajasthan Part I, Vol. 38, Popular Prakashan, p. 1056.
44. Tod, J. 1978a. Annals and Antiquities of Rajasthan, Vol.I. M.N.Publishers, New Delhi, p.631.
45. Tod, J. 1978b. Annals and Antiquities of Rajasthan, Vol.II. M.N.Publishers, New Delhi, p.637.
46. Vyas, V.S., Acharya, S., Singh, S. Sagar, V. 2007. Rajasthan: The Quest for Sustainable Development. Academic Foundation, New Delhi, p. 380.

Table 1
Administrative Divisions of Rajputana States, 1901

Residency/Agency	*Headquarter*	*State/Chiefship*	*Present districts covered*	*Clan of Rulers*
Mewar Residency	Udaipur	Udaipur (Mewar)	Udaipur, Rajsamand, Bhilwara, Chittorgarh	Guhilot Rajput
Western Rajputana States Agency*	Udaipur	Banswara	Banswara	Guhilot Rajput
		Dungarpur	Dungarpur	Guhilot Rajput
		Partabgarh	Partabgarh	Guhilot Rajput
		Kushalgarh	Banswara	Rathore Rajput
Western Rajputana States Residency	Jodhpur	Jodhpur (Marwar)	Jodhpur, Pali, Jalor, Nagaur, Barmer	Rathore Rajput
		Jaisalmer	Jaisalmer	Jadon Rajput
		Sirohi	Sirohi	Chauhan Rajput
Jaipur Residency	Jaipur	Jaipur	Jaipur, Dausa, Sikar, Jhunjhunun. Sawai Madhopur	Kachhawaha Rajput
		Kishangarh	Ajmer	Rathore Rajput
		Lawa	Tonk	Kachhawaha Rajput
Hadoti-Tonk Agency	Deoli	Bundi	Bundi	Chauhan Rajput
		Tonk	Tonk	Muslim Pathan
		Shahpura	Bhilwara	Guhilot Rajput
Eastern Rajputana States Agency	Bharatpur	Bharatpur	Bharatpur	Jat
		Dhaulpur	Dhaulpur	Jat
		Karauli	Karauli	Jadon Rajput
Kota- Jhalawar Agency	Kota	Kota	Kota, Baran	Chauhan Rajput
		Jhalawar	Jhalawar	Jhala Rajput
Bikaner State Agency	Bikaner	Bikaner	Bikaner,Churu, Ganganagar, Hanumangarh	Rathore Rajput
Alwar Agency	Alwar	Alwar	Alwar	Kachhawaha Rajput
British Province	Ajmer	Ajmer-Merwara	Ajmer	Chief Commissioner

*This Agency was part of Mewar Residency until 1906, when it was separated.
Source: Imperial Gazetteer of India, 1908.

Table 2
Area, Village and Population Statistics of Rajputana States, 1901

State/Chiefship	Area (Km^2)	No. of Towns	No. of Villages	Total Population	Density of Population	Variation of Population 1889-1901
Udaipur (Mewar)	33145	14	6069	1030212	31	-44.7
Banswara	5058	1	1286	165350	33	-21.8
Dungarpur	3761	1	631	100103	27	-39.5
Partabgarh	2303	1	412	52025	23	-40.9
Jodhpur (Marwar)	90869	17	4030	1935565	21	-23.4
Jaisalmer	41745	1	471	73370	2	-36.6
Sirohi	5104	5	408	154544	30	-19
Jaipur	40490	38	5735	2658666	66	5.9
Kishangarh	2230	3	218	90970	41	-27.5
Lawa@	49	-	6	2671	54	-20.5
Bundi	5770	2	817	171227	30	42.1
Tonk	2895	2	542	143330	50	-28
Shahpura	1053	1	132	42676	40	-32.9
Bharatpur	5151	7	1295	626665	122	-2.1
Dhaulpur	3002	3	540	270973	90	-3.2
Karauli	3228	1	436	156786	48	+0.1
Kota	14773	4	2609	544879	37	-24.2
Jhalawar	2105	2	408	90175	43	-40.3
Bikaner	60585	9	2101	584627	10	-29.1
Alwar	8163	7	1755	828487	102	+7.9
Ajmer-Merwara	7046*		740	476912*	68	-12.1
Kushalgarh@	2443		310	29162	12	
Total Rajputana	331479	128	29901	9723301	29	

Source: Imperial Gazetteer of India, 1908. @ Chieftains * British Province

Table 3
Details of Khalsa and Non-khalsa Villages in Rajputana

District	Number of Khalsa villages	Number of non-Khalsa villages	Total villages	Area (km^2) of Khalsa villages	Area (km^2) of non- Khalsa villages	Total Area (km^2)
Ajmer	468	516	984	3943	4694	8637
Alwar	1615	334	1949	7168	1146	8314
Barmer	41	806	847	1006	25850	26856
Banswara	559	904	143	2147	2911	5058
Bharatpur	1772	240	2012	6677	1435	8112
Bhilwara	627	948	1575	4696	5824	10520
Bikaner	141	519	660	3158	22102	25260
Bundi	576	163	739	4605	1042	5647
Chittorgarh	871	1474	2345	3875	6898	10773
Churu	128	784	912	2316	13936	16252
Dungarpur	388	437	825	1414	2381	3795
Ganganagar	1635	251	1886	13424	7293	20717
Jaipur	1323	1492	2815	5661	8514	14175
Jaisalmer	84	410	494	873	40872	41745
Jalor	63	556	619	1180	9556	10736
Jhalawar	1298	285	1583	4829	1120	5949
Jhunjhunun	4	703	707	81	5954	6035
Jodhpur	458	272	730	14736	8670	23406
Kota	1660	339	2199	10003	2685	12688
Nagaur	300	954	1254	4374	13263	17637
Pali	209	693	902	3168	8977	12145
Sawai Madhopur	1013	545	1658	6484	4060	10544
Sikar	54	777	831	577	7306	7883
Sirohi	132	328	460	1757	3464	5221
Tonk	549	534	1083	3223	3979	7202
Udaipur	605	2511	3116	4171	13442	17613
Total	**16573**	**18075**	**34648**	**115546**	**227374**	**342920**

Source:Ruling Elites of Rajasthan: A Changing Profile, 1993.

Table 4
Land Use in Rajputana States 1900-01 (Area in ha)

Princely State	Forest	Area not available for cultivation	Culturable waste inc. Other fallow	Current fallow	Net area cropped	Area cropped more than once	Total cropped area	Total Area
Jaipur	6.5	20.5	25.8	20.0	27.2	1.3	28.5	918673
Bikaner	0.0	1.9	73.0	5.7	19.4	0.0	19.4	1672346
Marwar	2.5	15.7	10.8	42.1	28.9	0.2	29.1	1118757
Tonk	5.5	14.7	46.0	7.6	26.2	1.4	27.6	444218
Alwar	13.0	24.4	9.3	3.6	49.7	6.8	56.5	712764
Kishangarh	25.8	00	00	00	74.2	4.2	78.4	41145
Bharatpur	8.9	11.0	14.2	5.2	60.7	6.9	67.6	516640
Jhalawar	1.4	26.8	36.6	8.8	26.4	2.4	28.8	143777
Kota	6.2	22.6	2.3	39.6	29.3	0.9	30.2	1217939
Ajmer-Merwara	9.5	37.3	11.5	9.9	31.8	2.9	34.7	380087
Average	7.9	17.5	23.0	14.2	37.4	2.7	40.1	

Source: Agricultural Statistics for the year 1900-01 to 1904-05, Vol. II Native States

Table 5
Cropping Pattern in Rajputana States 1900-01 (Area in ha)

Crop	Jaipur	Bikaner	Marwar	Tonk	Alwar	Kishan garh	Bharat pur	Jhalawar	Kota	Ajmer Merwara
Rice	1019	00	2	268	6	22	128	149	354	105
Wheat	28079	35344	22949	13287	12203	1279	18446	2644	45699	3361
Barley	50901	20296	12169	3882	43600	5994	28567	966	7621	18958
Jowar	41997	3688	55202	60487	38708	4298	59897	23906	153224	27673
Bajra	42263	180564	124339	1937	159570	5141	86338	338	1113	13171
Maize	13511	41	3562	10172	5340	4975	661	4087	1268	29316
Gram	5585	24317	6240	11988	47285	7315	43893	1800	56227	7903
Other FC	25346	73180	67510	1231	42377	2584	4977	248	43433	8981
Sesame	10149	5306	21697	4479	4916	2104	14227	879	10649	11543
Mustard	00	00	00	00	00	00	00	00	00	279
Linseed	283	00	247	1662	00	00	00	347	7606	4
Other OS	138	11366	1065	1313	14504	00	4572	00	1504	12
C&S	1886	00	914	781	1555	161	9930	173	289	237
Sugarcane	405	00	3	92	43	00	54	27	9236	127
Cotton	35963	25	4787	6660	9444	2942	16323	3263	2613	68
Fodder Cr.	3659	00	501	419	17872	59	1558	00	1148	6
F&V	632	00	72	00	1014	212	2972	00	00	333
Others		38463	3442	5716	4426	173	13650	2873	15562	9683
TCA	261663	493185	324701	122562	402929	32259	349434	41353	356484	131760
ASMO	11998	58	1794	6210	48680	1732	35737	3443	10577	10881
NCA	249665	324494	322907	116292	354249	30527	313697	39710	356484	120879

FC: Food Crops, OS: Oil Seeds, C&S: Condiments & Spices, TCA: Total Cropped Area
ASMO: Area Sown More than Once, NCA; Net Cropped Area, F&V; Fruits & Vegetables

Table 6
Land Utilization in Rajputana States 1950-51 (Area in %)

District	Forest	Barren land & land put to non Agr. uses	Pasture	Cultu rable waste land	Current fallow	Other fallow lands	Net area sown	Irrigate d Area	Total area (ha)
Bikaner	0.2	6.0	2.4	44.3	15.6	4.8	21.7	0.0	2279590
Churu	0.0	4.9	4.7	26.0	16.0	10.1	44.3	0.0	1682708
Ganganagar	0.6	5.0	0.1	35.4	6.8	1.0	51.1	20.1	2063993
Alwar	8.6	10.0	1.9	0.0	7.3	15.2**	57.0	13.0	854306
Bharatpur	8.5	18.0	3.9	10.8	2.3	1.4	55.1	17.2	810130
Jaipur	3.3	32.1	7.8	5.3	13.0	4.9	33.6	20.2	1644644
Jhunjhunun	0.0	12.1	10.7	0.7	5.9	1.0	69.6	1.8	600814
Sawai Madhopur	15.4	13.2	16.7	19.6	3.5	1.8	29.8	12.2	1058715
Sikar	0.0	3.3	14.9	5.2	19.6	0.6	56.4	3.6	785564
Tonk	2.7	10.8	7.8	30.7	6.4	3.2	38.4	12.1	717915
Barmer	0.0	22.5	0.0	28.2	6.7	18.2	24.4	1.0	2521047
Jalor	0.4	16.5	2.0	7.8	5.4	18.1	49.8	3.4	1180255
Jodhpur	0.0	20.5	0.4	22.8	6.0	17.8	32.5	5.1	2339233
Nagaur	0.0	22.5	2.6	13.5	3.3	9.7	48.5	0.9	1766832
Pali	6.1	59.0	1.2	9.3	2.5	7.4	14.5	25.2	1191033
Sirohi	27.7	26.6	0.5	17.1	3.7	2.9	21.5	16.6	441562
Kota	17.1*	22.2	0.0	20.9	3.0	0.2	36.6	3.3	1489555
Bundi	5.8	57.1	2.2	1.7	6.9	0.0	26.3	11.0	562093
Jhalawar	14.9	25.5	12.3	6.2	2.2	2.4	36.7	10.1	566967
Banswara	28.9	9.6	7.5	15.5	0.3	11.4	26.8	0.9	508836
Bhilwara	4.4	44.3	0.0	33.4	15.6	2.3	15.6	38.3	1020244
Chittorgarh	19.2	17.5	5.8	31.5	3.2	2.1	20.7	22.3	935356
Dungarpur	25.4	25.9	14.4	6.1	5.4	1.8	21.3	5.8	378131
Udaipur	36.0	25.7	0.0	0.0	3.0	24.8**	10.5	4.27	1576690
Ajmer	3.01	38.15*		19.52	17.58#		21.74		4159961

*Includes pasture, ** includes Culturable waste, # includes current fallow

- Source; Agricultural Statistics 1951-52, Rajputana State

NATURAL RESOURCES MANAGEMENT FOR RURAL DEVELOPMENT OF GAIGHATA BLOCK IN NORTH 24 PARGANAS DISTRICT, WEST BENGAL

Chandrima BANDYOPADHYAY[1], Ajit Kumar BERA,[2]

ABSTRACT

The increasing pressure on land is a global phenomenon which possesses critical problems especially in a developing country like India. The high growth rate of population (13-18 percent) during the decade of 2001-2011 (Census of India, 2011) is increasing the pressure on the land thereby generating the environmental degradation in the rural communities in West Bengal. Land and water resources are the foundation for the agricultural production, fisheries and aquaculture that provide nutrition and income. In that context, an attempt has been made through a case study i.e. Gaighata Block of North 24 Parganas district, West Bengal which comprises the total geographical area 243.30 Km^2 and the total population is 330287 (as per 2011 census). The higher growth rate of population is the key problem in the Block. The growth rate of population is 9.88 percent (2001-2011) whereas the percentage of land use for crops cultivation is 65.39 and the density of population 1358 per km^2 in the Block. There are only 32.98 percent workers whereas about 20.00 percent workers are engaged in agricultural activities. The pattern of living is subsistence or below subsistence level of economy and poverty is the traditional nature in the rural communities of the Block. Therefore, to overcome the aforesaid problems, the land use planning should be based on local environmental potentialities which are related to demand and supply based management of sustainable development as well as more food production and employment generation in the area. The result of that planning should help the local people to develop their income levels and quality of life.

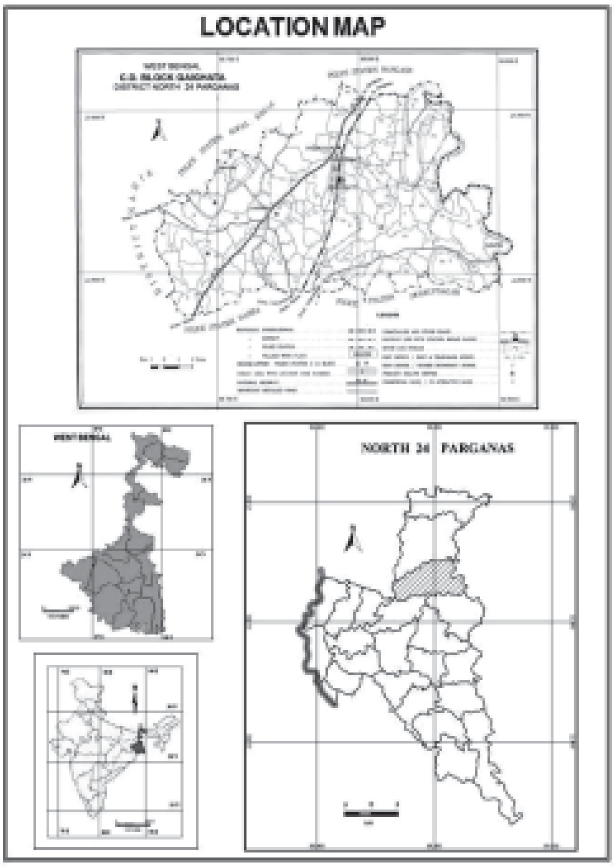
Keywords: *Land, Water, Biological Resources, Management*

INTRODUCTION

Rural development should be a process by which rural people are to be enabled to become the makers of their own destiny. It should be a process of continuous growth and development of rural communities and their territories. It should aim at the fullest possible utilization of all resources for and by the rural people (Mukherji, 1982). Natural resources such as fresh water, timber, minerals and biological resources of the land and water ecosystems provide the basis for human survival and development.

But the increasing demands on these resources have emphasized the need for a coordinated approach to sustainable management. The sustainable use and management of natural resources demand an interdisciplinary approach and sound knowledge on each specific resource as well as on the ecological, economic and social perspectives related to their uses which will help the rural livelihood pattern of the community.

West Bengal is one of the agricultural states in India where about 75% people are engaged in agriculture as primary occupation and most of them are living in rural area. Natural resources assist the rural communities for their livelihood and different types



Map 1

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of economic activities. This paper deals with a case study i.e. Gaighata Block (map 1) in North 24 Parganas district of West Bengal. The geographical location of the block is $88^0 39'$ E to $88^0 57'$ E and $22^0 52'$ N to $23^0 15'$ N. The block accounts for a population of 330287 (as per 2011 Census) and covers an area of 243.30 km^2(table 5) where about 74.00 % land is used for agriculture and paddy is the principal crop (H. Y. V. and local) in this region.

OBJECTIVES

Natural Resources Management (NRM) concerns with the sustainable utilization of major natural resources such as land, water, forest and fisheries that constitute important elements in the sustainability of ecosystems. The principal objectives of NRM and rural development in the Gaighata Block are-

(i) To identify land and soil potentiality and assessment for agricultural and other uses.

(ii) To examine the quality and present utilization process of water resources (river, ponds and other water bodies).

(iii) To assess the present condition of the natural and social forestry in the block.

(iv) To find out some key facts regarding the status and trends of natural resources utilization in the study area.

(v) Finally, to recommend for poverty alleviation, employment generation and sustainable NRM strategies.

METHODOLOGY

The aforesaid study area is an important physiographic region of the lower Gangetic delta. Selection of the study area was followed by following methodological phases. The adopted methodology can be divided into three phases.

Phase I- The objective of this phase is to gain preliminary knowledge about the area under study from the existing reports, literature, maps and diagrams, satellite imageries and aerial photograph etc. so that the field work can be carried out systematically.

Phase II- This phase consists of the following steps. The field work is divided into three phases- a) Pre-monsoon (March to May); b) Monsoon (June to October) and c) Post-monsoon (November to February) season. Information collected from the literature, maps, imageries and photographs were verified in the light of field observations. Surface and soil profile samples and ground water table data were collected from the selected sites during field tours in different seasons (i.e. Pre-monsoon, Monsoon, and Post Monsoon). During field work collection of necessary information regarding characteristics of the local hydrological conditions, nature of landforms and surface characteristics of the terrain, biological characteristics, climatological characteristics were recorded in a tabular form. Information was collected from the local people through questionnaires during the field work. The necessary information (i.e. agricultural crops cultivation, availability of ground water, demand of water etc.) and observations were also noted and recorded.

Phase III- The last phase of work includes laboratory analysis of the soil samples and hydrological samples, statistical analysis of the data and final preparation of reports. Finally, rational interpretation and necessary recommendations were made for sustainable development of the region and recommended for future socio-economic developmental planning as well as employment generation of the Gaighata Block, North 24 Parganas district of West Bengal.

DISCUSSION AND ANALYSIS

Environmental resources play an important role for the development of the Gaighata Block. Important environmental resources are landform, soil, water, population and technology which are integrated and correlated factors for socio-economic development of the area.

Landform and Soil: Elevation varies from 5 metres to 7 metres in the Block. It is a riverine plain having gentle slope towards North West to South East. Agricultural land is fragmented due to the presence of numerous ox-bow lakes and water bodies. Grey alluvial soil is formed in the Gaighata block. Soil texture varies from clayey loam to sandy loam. Fertility status varies from moderate to high. Soil has mainly prism like structure. Soil pH varies from 6.5 to 7.5. Organic matter content is moderate to low due to less vegetation cover.

River: The Ichamati and Jamuna rivers are flowing from north to south and north-west to south-east direction respectively. The Ichamati is a perennial river. The Jamuna river is perennial upto that part where tidal action is active (upto Gobardanga). The river lift irrigation system has been developed on both the sides of the river Ichamati and Jamuna.

Climate: The block is under tropical monsoon climate region (Aw Climate) having wet summer and dry winter. There are prominent seasonal variations in rainfall and temperature. Average rainfall of the block is 1800 mm (table 1). The maximum rainfall is concentrated in the month of the July to September every year. Rainfall is the key source of water for leaching and accumulation in the ponds and other water bodies. After monsoon period the crops are cultivated based on different types of irrigation such as canal irrigation, deep tube well irrigation (DTW), shallow tube well irrigation (STW) and river water lifting irrigation (table 3). Excessive use of ground water in the irrigational purpose has led to the arsenic contamination in the block. In 91 mouzas of 13 gram panchayats, arsenic concentration has been found above $0.5 mgl^{-1}$ (Roychowdhury, 2010).

Table 1
Climate of Gaighata Block (1971-2010)

Month	*Jan*	*Feb*	*Mar*	*April*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Year*
Record High (^{0}C)	32.8	38.4	41.1	43.3	43.7	43.9	39.9	38.4	38.9	39	34.9	32.5	43.9
Average High (^{0}C)	26.4	29.1	33.5	35.3	35.4	34	32.3	32.1	32.4	32.3	30.3	27	31.7
Daily Mean (^{0}C)	20.1	23	27.6	30.2	30.7	30.3	29.2	29.1	29.1	28.2	24.9	20.8	26.9
Average Low (^{0}C)	13.8	16.9	21.7	25.1	26	26.5	26.1	26.1	25.8	23.9	19.6	14.5	22.2
Record Low (^{0}C)	6.7	7.2	10	16.1	17.9	20.4	20.6	22.6	20.6	17.2	10.6	7.2	6.7
Average Rainfall(mm)	11	30	35	60	142	288	411	349	288	143	26	17	1800
Avg Rainy Day	1.2	2.2	3	4.8	8.7	14.7	20.5	20.2	15.7	8.1	1.5	0.9	101.5
Avg Relative Humidity	66	58	58	66	70	77	83	83	81	73	67	68	71
Mean Monthly Sunshine Hours	203.9	201.2	225.8	235.4	227.1	123.1	93.1	104.9	116.2	182.6	190.8	203.4	2107.5

Source: Department of agriculture, Government of West Bengal

Vegetation and Agriculture: There is sparse vegetation of deciduous trees like Sal (Shorearobusta), Teak (Tectonagrandis) in Gaighata block. About 7 per cent of total area is under forest cover including mango (Mangiferaindica), jamun (Syzygiumcumini), coconut (Cocosnucifera) and other fruit trees. The principal crops are- rice (Aus, Aman, Boro), wheat, jute, pulses (Musur, Gram), oilseeds (Mustard seeds, Til seeds), potato and sugarcane. The land is cultivated under different types of agricultural crops (Table 2). Currently, 65.39 per cent of land is under cultivation whereas 1.75 per cent of land is under pasture and 0.33 per cent is under cultivable waste land. It is to be noted that 58.36 per cent of land is cultivated with the practice of crop rotation and 37.71 per cent of land is irrigated from canal, tank, river lift irrigation, deep tube well, shallow tube well, open dug-well (Table 3)

Table 2
Distribution of Land in the Block

Land Use	*% To Total Area*
Net Area Under Cultivation	65.39
Area Under Pasture And Orchard	1.75
Cultivable Waste Land	0.33
Homestead Land	6.42
Residual Area	33.97
Area In Which Crop Rotation Practiced	58.36
Land Under Irrigation	37.71

Source: Department of Agriculture, Government of West Bengal

Table 3
Area Irrigated By Different Sources in The Block

Irrigation Type	*% To Total Irrigated Land*
Canal	3.55
Tank	0.88
River Lift Irrigation	4.18
Deep Tube Well	30.26
Shallow Tube Well	36.77
Others	32.97

Source: Department of Agriculture, Government of West Bengal.

Pisciculture: There are different sizes of ponds, water bodies and ox- bow lakes where pisciculture is widely practiced in the Gaighata block. Around one tenth of land (an increase of four percentage points over 2001-02) has been under effective pisciculture in 2012-13 It is remarkable that the total fish production is 63037 quintal in the year of 2012-13 (Table 4). There are 3.78 per cent primary workers engaged in pisciculture.

Table 4
Area and Production of Pisciculture

Status Of Land Under Pisciculture	% Of Area To Total		Production (Quintal)		% Of Persons Engaged	
	2001-02	2012-13	2001-02	2012-13	2001-02	2012-13
Net Area Available For Pisciculture	5.57	9.93	1500	63037	0.13	3.78
Net Area Under Effective Pisciculture	5.01	8.93				

(Source: Department of Agriculture, Government of West Bengal)

Population: The area is very densely populated as 1358 persons live in a land of one square kilometre (2011).People are mostly engaged in primary activity i.e. agriculture and pisciculture. The occupational pattern of the block is given below (table 4, 5 & 6). The salient features are-

i. Population growth and density are gradually increasing since 1981.

ii. There is an increase of three percentage points in the main workers during the period of 1991 - 2011.

iii. The livelihood of most of the people is derived from agriculture and related activities.

Table 5
Population Structure (1981- 2011)

Year	*Area (sq. km.)*	*Population*	*Growth Rate*	*Population Density (Persons/ sq. km)*
1981	246.65	192111	-	779
1991	246.65	257373	33.97	1043
2001	243.3	300588	16.79	1235
2011	243.3	330287	9.88	1358

Table 6
Occupational Structure (1991- 2011)

Worker	*% of Persons to Total Population*		
	1991	*2001*	*2011*
Total Main Worker	30.11	30.93	32.98
Cultivator	8.39	6.59	6.4
Agricultural Labourer	10.59	9.56	11.71
Household Industry	1.23	2.76	1.79
Other Workers	9.89	16.57	16.93
Marginal	0.83	4.58	3.87
Nonworkers	69.06	64.49	63.15

Developmental Strategies

The analysis of the aforesaid environmental conditions of the Gaighata block necessitates that steps should be taken for natural resources management and rural development to achieve employment generation, poverty alleviation in coming decades. The following developmental strategies and models are recommended for future environmental resource management in a broader policy framework. The strategies are recommended through diagrams (fig. 1, 2, 3, 4 and 5) for sustainable socio-economic development of the local people in the study area.

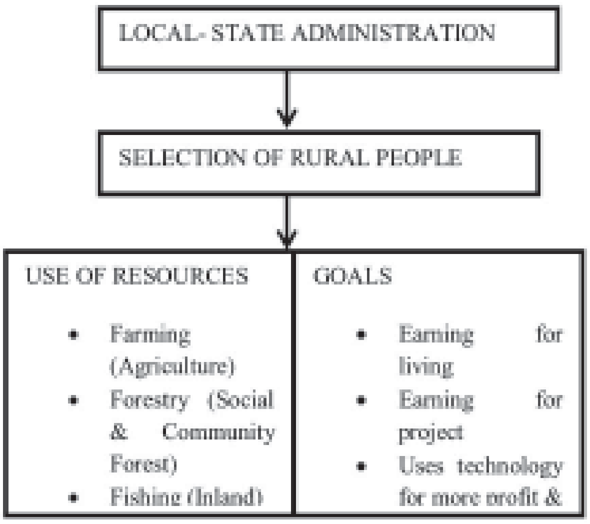

Fig. 1. Components of Rural Resources Use

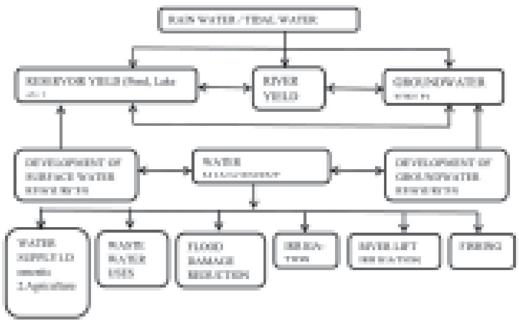

Fig. 2. The Water Resource Management System

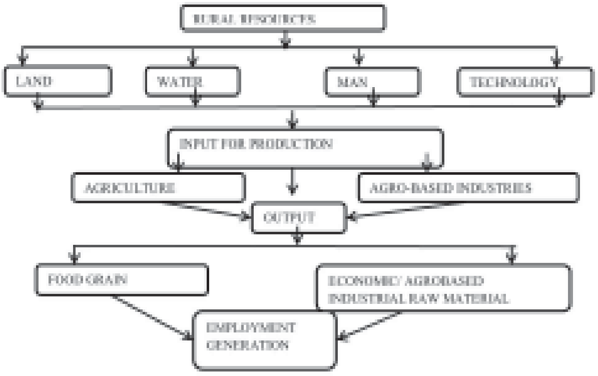

Fig. 3. Primary Development and Food Production

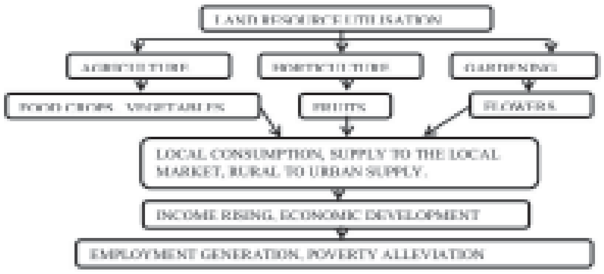

Fig. 4. Land Utilisation for Employment Generation

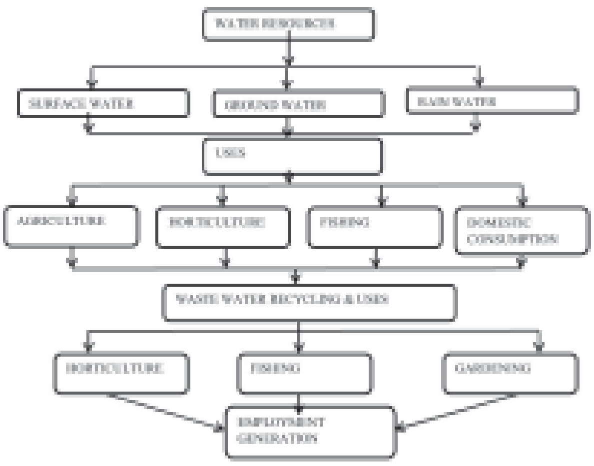

Fig. 5. Water Resources and Employment Generation

The said strategies will help in natural resource management and sustainable development which will benefit the local community as well as district and state's economic prosperity in future.

CONCLUSION

This rapid growth of population is creating high demand of food and other necessities of livelihood. The nature of unemployment, poverty and socio-economic conditions of the Gaighata block is becoming alarming day by day. Therefore, some developmental models and strategies are recommended by which natural resources management and employment generation as well as economic condition of local inhabitants will be increased. These strategies should be implemented through a) Short term plan (up to 3 years), b) Long term plan (3- 5 years) for planning and development of the area. Some other recommendations are as follows:

1. Self-help project should be encouraged among the rural communities by local and state government.
2. Youth and women organizations must be involved in the programme of rural development.
3. Private companies should be encouraged to invest and build industries in rural communities with abundant raw materials.
4. Government should develop a contracting system in which a family per village will take the responsibility of the surveillance of sustainable use and protection of the natural resources in the area (Gaighata Block).
5. Finally, an information system should be established related to the management, protection and rational utilization of natural resources under the direction of the Government and in collaboration with the international organizations, enterprises and research institutions.

REFERENCES

1. Arora, R. C. (1978): "Industry and Rural; Development", S. Chand & Company Ltd, New Delhi.
2. Bera, A. K. (2013): "Land and Water Resources Management for Sustainable Development of Salboni Block in Paschim Medenipur Destrict", Resources and developmental issues and concerns, Progressive Publisher, Kolkata, pp 191- 199.
3. Bhattacharya, N. N. (2008): "West Bengal: Land, People, and Economy", Rajesh Publications, New Delhi.
4. Bose, S. C. (1979): "Geography of West Bengal", National Book Trust, New Delhi.
5. Chowdhury, D. Paul (1978): "New Partnership in Rural Development", M. N. Publishers, New Delhi.
6. Clayton, B. D. et. al. (2003): "Rural Planning in Developing Countries: Supporting Natural Resource Management and Sustainable Livelihoods", Earth scan India, New Delhi.
7. Desai, B. M. (1979): "Intervention for Rural Development", Indian Institute of Management, Ahmadabad.
8. Gill, G. J. (1991): "Seasonality and Agriculture in the Developing World: A Problem of the Poor and Powerless", Cambridge University Press, Cambridge.

9. Government of West Bengal (1979): "The West Bengal Land Management Manual, 1977", West Bengal Governmental Press, Alipore, Kolkata.

10. Hester, R. E. and Harrison, R. M. (1994) ed.: "Waste Inclination and the Environment", Royal Society of Chemistry, Cambridge.

11. Kadekodi, G. K. (2004): "Common Property Resource Management: Reflections on Theory and the Indian Experience", Oxford University Press, New Delhi.

12. Lavrov, L. and Sdasyuk, G. (1988): "Concept of Regional Development", Progress Publishers, Moscow, pp 155- 180.

13. Mackenzie, A. et. al. (1999): "Instant Notes in Ecology", Viva Books Private Limited, New Delhi.

14. Menon, M. G. K. and Sharma, V. P. (2009) ed.: "Sustainable Management of Water Resources: Emerging Science and Technology Issues in South Asia", Indian National Science Academy, New Delhi.

15. Mollinga, P. P. et. al. (2000) ed.: "Water for Food and Rural Development: Approaches and Initiatives in South Asia", Sage Publication, New Delhi.

16. —— (2006) ed.: "Integrated Water Resource Management: Global Theory, Emerging Practice and Local Needs", Sage Publications, New Delhi.

17. Mukherjee, S. (1982): "Essays on Rural Development", Utsarga Publication, Varanasi.

18. Roday, S. (2007): "Food Science & Nutrition", Oxford University Press, New Delhi.

19. Roychowdhury, T (2010); "Groundwater arsenic contamination in one of the 107 arsenic-affected blocks in West Bengal, India: Status, distribution, health effects and factors responsible for arsenic poisoning" ,International Journal of Hygroscopic Environmental Health. vol 213(6), pp 414-27.

20. Samal, K. C. (2007): "Poverty, Social Capital and Natural Resource Management", Rawat Publication, New Delhi.

21. Singh, I (1984): "Rural Development in India", National Council of Educational Research and Training, New Delhi.

22. Yakowitz, Marilyn(1997) ed.: "Sustainable Development", OECD Policy Approaches for the 21st Century Organisation for Economic co-operation and Development, Paris, France.

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BIOPHYSICAL ZONATION FOR SUSTAINABLE AGRICULTURAL LAND USE PLANNING: A STUDY IN KALLADA RIVER BASIN, KERALA

Jayapal G.[1] , R. ANILKUMAR[2] & Akhil R. [3]

ABSTRACT

Micro-level terrain studies are found to be most effective tools to formulate and implement suitable action plans to attain sustainable development of specific regions. The present study attempts to identify areas with different potentialities and their amenabilities for the development and finally to suggest an environmentally viable land use plan for the entire region. The study area chosen is Kallad river basin comprising an area of 1717 sq.km in the southern part of Kerala. The basin forms a typical natural unit with very complex physical exchange of energy, matter and human transference.

Physical and cultural attributes, different geo-units, current land use practices, environmentally hazardous and hazard prone areas of the basin were delineated and analysed. The multidisciplinary nature of the problem calls for the identification and measurement of various parameters and selection of suitable techniques necessary to derive the required findings. Survey of India topographic maps were used as the base map and relevant remote sensing data formed preliminary source of data for the present study. The method of overlay has been used to delineate different geo-units within the study area and trend of land utilisation has been analysed by employing appropriate statistical and cartographic techniques. Data from secondary sources related to spatial and socio-economic characteristics of the basin were also analysed. Quantitative analysis like correlation and ranking were also extensively applied to arrive at reliable conclusions.

Bio-physical characteristics of the basin possess a good control over the prevailing land use practices within the basin. It is established that for any land use planning aimed at sustainable development of any region, an appropriate land classification on the basis of suitability assessment should form an essential pre-requisite of the investigation. Unscientific land use practices and intensification of different human activities in the basin result in cumulative impact on the system, which directly affects the productivity and development. The present study could reveal the possibility of delineation of the river basin into five major zones each one being characterized by distinct association and their mutual interaction of various abiotic and biotic attributes.

Keywords : *Biophysical Zones, Sustainable Agricultural Land Use Planning*

INTRODUCTION

Micro-level biophysical studies of spatial units are found to be the most effective tools to formulate and implement suitable plans to attain sustainable development of specific regions. The present study attempts to identify areas with different potentialities and their amenabilities for the development and finally to suggest an environmentally viable land use plan for the Kallada river basin comprising an area of 1717 sq.km in the southern part of Kerala State.

METHODOLOGY

The Kallada river basin constitutes a well defined and distinct portion of land as it forms a clearly demarcated geomorphological and spatial unit, unified by the areal extent of the drainage net forming the river system. In the present investigation of the Kallada river basin, the technique of "landscape synthesis" is adopted for the identification of biophysical zones and units. This technique involves the process of integration of large quantity of data pertaining to the spatial variation of the various landscape elements within the basin. The data comprise distribution pattern of specific elements such as altitude, geology, slope, soil, drainage, vegetation, crops etc. Subsequent analysis of the resultant composite map enables one to further divide the basin into a number of major biophysical zones, each having a distinct combination of attributes or zones that differ markedly from one another in terms of one or more attributes.

OBSERVATION AND RESULTS

The present study could identify five major biophysical zones, each characterized by unique characteristics in the Kallada river basin such as i) Coastland zone ii) Lowland zone iii) Zone of undulating midland iv) Foothill zone and v) Scarp land zone. Of these zones, the scarp land zone covers nearly 45 per cent of the total basin and coastland zone has the minimum share of 2.3 per cent.

Altitude from the mean sea-level forms the dominant element for the recognition of the five biophysical zones of the river basin. The associated natural flora

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and the concomitant elements of agricultural crops of the recognised zones explain the relevance of zonation and attested the intricate potentiality for different uses. However, the magnitude of transition of the floral elements and crops is not abrupt from one biophysical zone to the adjacent one, but these are gradual and transitional across the zonal boundaries. Each of these is further subdivided into smaller biophysical units mainly on the basis of the associated landforms. The landform attributes that are taken into consideration in the present study included origin, lithology and morphometric characters. Other attributes that are given cognizance in the recognition of minor units in the basin include pedological features, hydrology, flora, fauna and the degree of human influences. A brief description of each zone with the desirable land use for sustainable land use planning is discussed below.

Coastland Zone

The coastland biophysical zone of the Kallada river basin is situated at the western portion of the basin. The portion of the basin where the land surface does not exceed 10 m above MSL is designated as the coastland zone in the present study. A region with gentle slope with scattered flat land characterizes this zone. The lower units that are recognized in the coastal biophysical zone are runnels, ridges, lacustrine terraces, flood plains and alluvial islands enclosed by water bodies. This zone is entirely blanketed by a thick layer of sandy alluvium of variable thickness, occasionally changing to loamy texture in some pockets. However, its western most part is mostly covered with coastal sand deposits. The lithological types are of recent to sub-recent age. This zone constitutes a portion of an extensive coastal sedimentary basin and there is a thick sedimentary sequence of Tertiary (Miocene) age under the deep layer of superficial alluvium and sand deposits. The Tertiary succession of this part of Kerala is known as "Quilon formation" and "Warkalli formation". The former is a marine succession while latter is lacustrine and these are well exposed at "Padappakkara" at cliff section that border the Ashtamudi Kayal. Being characterized by the presence of sandy alluvium and beach sands, which are highly permeable surface materials of considerable thickness, the coastland biophysical zone has no well-defined drainage. However, shallow man-made ponds are found almost throughout the zone without any feeder channels. The coastland zone is characterized by very shallow water table. Most of the wells of region are fed by shallow aquifers and deeper aquifers create salinity problems all along the coastal zone.

Because of the high density of settlement, the natural vegetation in coastland biophysical zone of Kallada river basin is found only in certain pockets. The floral types noted *include Calotropis gingantea, Iopmoea bilobam, Ipomea repens, Dregia volubilis, Crotalaria striata, Cleomie viscoasa, Leucas aspera, Portulaca tuberose, Rathia tofoliataeto* and few species of grasses. In stagnant pools are floating water plants like *Pistia stratiotes, Eichhomia crassipes* submerged plants like *Ottelia alsmoides, Hydrilla verticallata, Blyxa* and water plants with gloating leaves like *Nympaea, Nelumbium speciosum, Alisma, Limnanthenum*. The major portion of the costland zone is presently under coconut cultivation. Paddy lands which once covered extensive tracts in this zone are at present found replaced by coconut farms and by plantain cultivation.

The coastland zone supports 8.7 per cent of the total population of Kallada river basin. The settlement pattern in this zone can be described mostly as 'linear' along the closely-knit network of roads as well as parallel to the littoral zone. However, towards the interior the settlement becomes scattered and haphazard.

Table 1
Biophysical Units of the Coastland Zone

Biophysical units	*Area in sq.km*	*per cent of the zonal area*	*Land suitability assessment for agricultural land use*
Alluvial island	5.55	14.02	Medium productivity for coconut plantations
Runnels	2.96	7.48	Medium productivity for wetland agriculture
Ridges	20.72	52.37	Medium productivity, suitable for coconut plantation
Laccustrine terrace	0.74	1.80	High productive for wetland agriculture
Flood plain	2.95	7.47	High productive for wetland agriculture
Alluvial terrace	2.23	4.81	High productive for wetland agriculture
Water bodies	4.77	12.05	

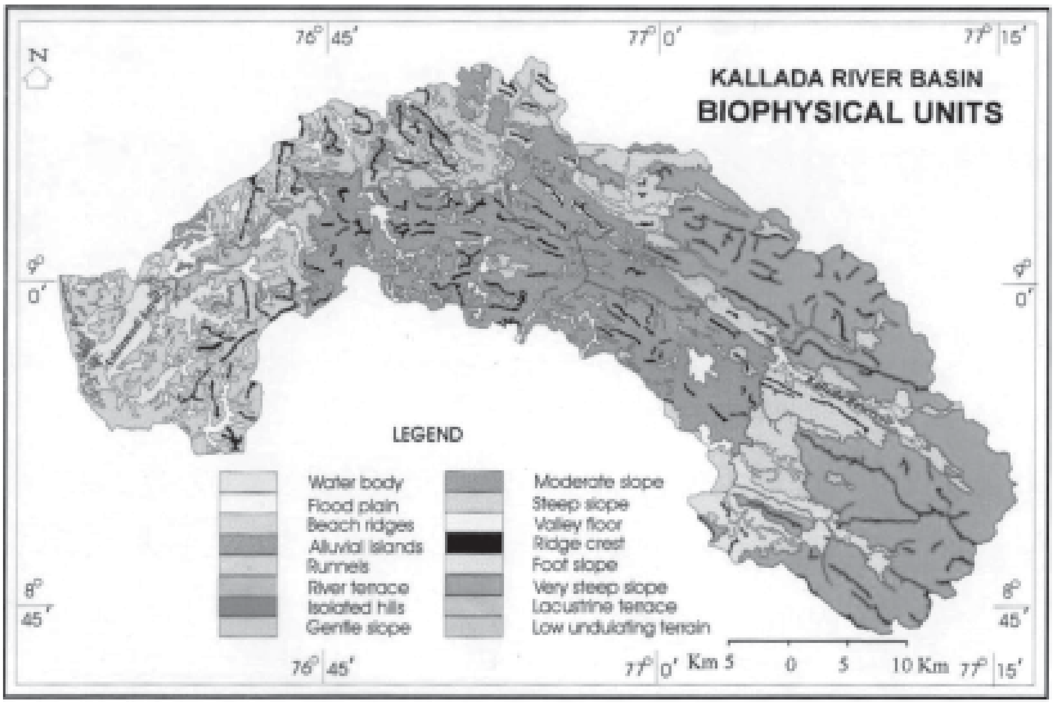

Fig.1: Biophysical Units of Kallada River Basin

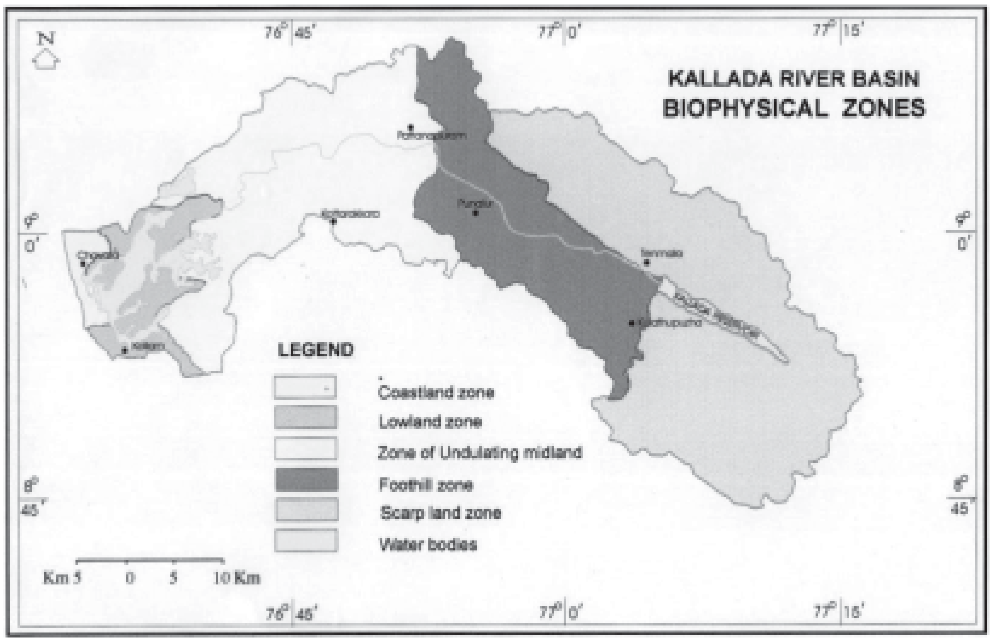

Fig. 2: Biophysical Zones of Kallada River Basin

Lowland Zone

The lowland zone of the Kallada river basin is that portion of the basin where the altitude ranges between 10m to 20m above MSL. This zone is characterized by a land surface with gentle (0-5^o) to moderate (5-10^o) slope. The zone is dominantly made up of lateritic soil of colluvial nature. The soils of these tracts exhibit textural characteristics typical of gravel rich in sandy loam to gravelly loam. However, the major drainage lines exhibit the presence of ribbons of alluvial soils of variable width and thickness. These soils exhibit all the characteristics of alluvium from sandy loam to clayey loam and occasionally grading over to clay-enriched zones. The lateritic cappings with associated superficial layers of soils begin to appear in the Kallada river basin from the lowland zone onwards. But these soils are restricted only in tracts with elevations higher than the surrounding areas. The soils of these tracts exhibit textural characteristics typical of gravel rich sandy loam to gravelly loam. The lithological makeup of the lowland zone is dominated by laterites. These laterites are geologically classified under the category of "low-level laterites" and these overlies the Tertiary sedimentary successions (Warkalli Formation and Quilon Formations) occurring at deeper horizons in most places, as evidenced and recorded in deep well-cutting in most parts of this zone. The low level laterites constitute "secondary laterites" and these almost completely conceal the sedimentary litho-types almost throughout the entire lowland without any outcrops.

The magnitude of internal relief in the lowland zone nowhere exceeds 5 m. Most of the lowland zone is under cultivation. Natural vegetation is nowhere encountered in this zone except as insignificant patches. Coconut cultivation dominates over other types. However, arecanut, tapioca, various fruit trees, plantains, sesamum and other tuber crops are cultivated as intercrops in this zone. Paddy is cultivated in low lying regions throughout the zone and after harvest season various pulses and vegetables crops replace the paddy and intercrops. Economic reasons have prompted conversion of paddy fields intro tracts of banana cultivation in some pockets. The zone accounts for 23 percent of the total population of the basin. The density of population in the lowland zone is relatively less (261 persons/ sq.km) as compared to that of the coastland zone. The zone is also relatively low in accessibility. The settlement pattern is dominated by linear pattern along transportation routes, but as a whole it is random and scattered.

Table 2

Biophysical Units of the Lowland Zone

Biophysical units	*Area in sq.km*	*per cent of the zonal area*	*Land suitability assessment for agricultural land use*
Runnels	2.52	1.89	Highly productive for wetland agriculture
Ridges	15.15	13.01	Medium productivity, suitable for tree crops
Laccustrine terrace	1.01	0.86	High productive for wetland agriculture
Flood plain	13.13	11.28	High productive for wetland agriculture
Stream terrace	1.26	1.08	Highly productive for coconut plantation
Isolated Hill	2.47	2.21	Highly productive for plantation crops
Low undulating terrain	4.77	12.05	Highly productive for tree crops and plantation, suitable for developments of settlements
Water bodies	45.47	39.07	

Zone of Undulating Midland

The zone of undulating midland is defined as the portion of the Kallada river basin where the general altitude of the land ranges from 20m to 100m above MSL. It constitutes the second most extensive zone of the Kallada river basin. The topography of the zone is dominated by numerous rounded mounds, hillocks and smaller topographic highs most of which are generally of equi-dimensional shape ridges and occasional isolated hills. The surface is characterized by moderate relief (seldom exceeding 50m) with slopes varying from moderate to steep. The soil types

Table 3

Biophysical Units of The Zone of Undulating Midland

Biophysical units	*Area in sq.km*	*Per cent of the zonal area*	*Land suitability assessment for agricultural land use*
Valley floor	44.00	7.52	High productivity and suitable for wetland agriculture
Flood plain	57.75	9.87	High productivity for wetland agriculture
Ridges	55.50	9.40	Low to moderate productivity, suitable for tree crops
Isolated hill	9.62	1.64	Low to moderate productivity, suitable for plantation crops
Side slope – gentle	214.50	37.60	Medium productivity, suitable for plantation crops
Side slope-moderate	165.00	28.33	Medium productivity, suitable for plantation crops
Side slope-steep	11.00	1.88	Fragile zone, suitable for social forestry and tree crops
Water bodies	22.00	3.76	

noticed in this zone are genetically referable to residual laterites interspersed with areas of alluvial and colluvial types. In general, these soils are enriched in humus and sufficiently deep and exhibit relatively high water retention capacities. This zone is characterized by the presence of crystalline rocks of Pre-cambrian age overlain by residual laterits of variable thickness. The general depth of the water table in the zone varies from 7 to 10 m on the average, with moderate annual fluctuations.

Human interference with the landscape is indicated by the extensive and locally intensive agricultural activities prevailing over most parts of the zone. The natural vegetation cover has almost completely vanished in this zone. This is because of the fact that nearly 51 percent of the total population of the Kallada river basin live here.

Foothill Zone

This is a zone of relatively low, sharp-crested hills or ridges located at the base of the fringe the Western Ghats. The foothill zone is defined in the present study as the portion of the Kallada river basin where the general altitude of the land varies from 100 to 300 m above MSL. Mean slope of the zone grades from moderate to steep. Among the five zones of the Kallada river basin, the degree for dissection reaches maximum magnitude in this zone. The same is also true with regard to the topographic ruggedness. Soils encountered in the foothill zone are predominantly of residual types developed over laterites and these comprise mostly coarse sand and gravels. The soils of some pockets of the zone have relatively high organic content. A notable pedological feature of the zone is the relatively higher intensity of soil erosion. The zone is also characterized by the presence of scattered occurrence of numerous large and medium exposures of pre-cambrian crystalline rocks (gneisses and chanockites). However, the major portion of the zone is occupied by residual laterites of varying thickness. Detached pockets of natural vegetation of varied dimensions are a peculiar feature of this zone. Accounting for about 11 percent of the total population of the basin, the human influence on natural landscape is observed in this zone in the form of conversion of forest vegetation into plantation crops especially oil palms and rubber.

Table 4
Biophysical Units of the Foothill Zone

Biophysical units	*Area in sq.km*	*per cent of the zonal area*	*Land suitability assessment for agricultural land use*
Valley floor	21.70	13.16	Medium productivity for all crops
Side slope – gentle	11.62	6.87	Moderate productivity, suitable for tree crops
Side slope-moderate	81.84	49.67	Low to moderate productivity, suitable for tree crops
Side slope-steep	27.90	16.93	Low productivity for all crops. Suitable for social forestry
Ridge crest	12.40	7.53	Low productivity for all crops
Water bodies	9.30	5.84	

Scarpland

Scarpland is defined for the present study as the portion of Kallada river basin where the general altitude of the land ranges over 300m above MSL. The highest point of the Kallada river basin, which is located in this zone (Karimalai Kadakkal) has an altitude of 1758 m above MSL. The degree of lithological complexity in this zone is very high as revealed by the variety of crystalline rock types that form the bedrocks of this zone. Steep slopes dominate

Table 5
Biophysical Units of the Scarpland Zone

Biophysical units	*Area in sq.km*	*per cent of the zonal area*	*Land suitability assessment for agricultural land use*
Valley floor	26.24	3.33	Medium productivity for all crops
Foot slope – gentle	91.84	11.69	Moderate productivity for tree crops
Side slope-steep	157.44	19.98	Low to moderate productivity, suitable for tree crops
Side slope – very steep	374.11	47.51	High productivity for forests
Ridge crest	104.96	13.33	High productivity for forests
Water bodies	32.80	4.16	

almost throughout the zone and locally the slopes grade over to very steep altitudes forming extensive linear zones. The soils in this zone are loamy with great admixture of humus and are generally deficient in nitrogen and phosphorous. Dense growth of natural vegetation in the form of a variety of forest types are observed in this zone. Giant grasses like *Bambusa* and *Ochlandra* occupy a good portion of scrub jungles. The forested regions contain deciduous trees as well as evergreen species. Human interference is the lowest in this zone. Shifting cultivation is practiced at certain pockets of this zone by the native tribals. Selective felling of trees and plantation activities are noted in some regions. Scattered settlements of tribes are found in most parts of the zone. Only 6.2 percent of the total population of the basin lives here.

CONCLUSION

Micro-level work by incorporating the tools in participatory research appraisal made during the research attested the relevance of the methodology adopted for the planning of desirable agricultural land use taking into account the environmental suitability. Analysis of the biophysical elements constituting a spatial unit and the integration of data as attempted in the study is found to be relevant for any exercise attempting to evolve comprehensive land use plan to achieve sustainable development of the region concerned.

REFERENCES

1. Chattopadhyay S, Carpenter R A (1990): A Theoretical Framework for Sustainable Development Planning in the Context of a River Basin, Unpub. Report, East West Centre, Hawaii.
2. Sharma H S, Srikumar Chattopadhyay (1998): Sustainable Development, Issues and Case Studies, Concept Publishing Company, New Delhi.
3. Van Lier N Hubert (1994): Land Use Planning in Perspective of Sustainability: An Introduction to Sustainable Land Use Planning, Elsevier, New York.

CONVERSION OF LAND AND ITS ECONOMIC EVALUATION OF A PART OF BIDYADHARI BASIN OF NORTH 24 PARGANAS, WEST BENGAL

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ABSTRACT

Study of land use land cover in the tidal river basin is a complex and important problem in the deltaic part of West Bengal. Nonagaon, a spill channel of Bidyadhari tidal river was an important trading route in the last century. Nowadays the upland flows of these spill channels were reduced due to head cut-off from the main channel. These silt laden river made the land highly productive for agriculture. With the progress of time, the siltation within the riverbed resulted to these tidal channels shallow in depth and frequent floods occur due to rain water and tidal water accumulation in this region. This basin covers 147.89km^2 areas. Most of the part of river bank is the bed of red brick producing centres. Several brick kiln come into existence to supply the raw material to the newly expanding urban centres surrounding Kolkata city. These brick kiln make huge loss of top soil up to 3 meter in depth at rupees fifteen lac per acre of land for 10 years. This loss of top soils left the land unproductive. Remote sensing and GIS technique has been applied in this study to assess impact of brick kiln on conversion of land use and land cover. From this study it reveals that the area gets lowering due to loss of top soil. The height of this basin varies from 1 meter to 15 meter. In the surrounding region of the river valley water stagnated due to overflow especially during rainy season. The low land terrain remains water logged. It results loss of fertile agricultural land of this basin. Loss of productive top soil from agricultural land causes 7.19 Km^2(4.05 Km^2 of cropland and 3.14 Km^2 of current fallow land) of the basin area converted to water bodies during this time. Three hundred people are getting jobless per year per acre of land and losing agricultural crop production of total rupees of ninety thousand in case of double crop lands. If the land is triple crop in nature, the loss will be of rupees one lac thirty five thousand per year per acre of land. Natural and anthropogenic impact result the land degradation of this region. The large saline water covered land causes the miseries of the local people. Several NGO's are working on livelihood development of the workers and their families. Participation of local people is necessary to restrict/control the loss of land.

Keywords: *Land Conversion, Brick Kiln, Land Degradation And Economic Valuation, RS and GIS Technique.*

INTRODUCTION

Land degradation refers to 'the disturbances in the natural structure and properties of soil due to direct or indirect anthropogenic (human) influences'. They may be caused not only by improper methods and means of soil development, but also by violating the relations between natural and cultivated lands' (Zone, 1986). Soil degradation and environmental pollution is one of the most serious problems in the world today, because of their adverse effects on agriculture and the life on Earth. Three quarters of the world soil degradation occur in tropical areas (Eswaran, et al.,1993). Brick kiln is one of the principal agents of topsoil degradation and environmental pollution. Generally the brick production causes digging to the depth of 3meters which leads to degradation of land of that area(Harish Vyas et. al., 2009).Brick kilns are destroying large areas of lands every year in Bangladesh where bricks are made by collecting soils from a depth of about 1 to 2 meters in agricultural land which extended over about 5000 ha during the 1998-99 period in different pockets of brick fields (Rahman and Khan, 2001). Brick industries are important small scale industries which gradually grow with urbanization process. The expansion of urban centers surrounding Kolkata resulted huge demand of red bricks. Number of brick kiln increased day by day in the lower Gangetic delta region, because of availability of good quality clay soil. Along the tidal channel like Nonagaon a large number of brick kilns are clustered around the bank. Bricks are usually made of clay in traditional small scale industries. These are not only important building materials, but also provide employment to unskilled labours and essential for economic development. But the brick kiln on the agricultural land caused a huge loss of food production. Brick firing in the kilns causes serious environmental pollution and largely influences the greenhouse gases. It results serious human health of the workers and people of surrounding areas e.g. respiratory disease. Also it affects the health of vegetation due to nutrients disorders. This study is a preliminary approach to evaluate the impact of brick kiln on land degradation

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e.g. waterlogging and wastage of arable land as well as financial loss due to conversion of land use and land cover.

STUDY AREA

Nonagaon river basin is located between latitude 22°372 53 to 22°492 13 N and longitude 88°322 353 to 88°392 273 E with an area of about 147.89Km^2. It is situated on the east of Kolkata. Nonagaon basin is surrounded on its northern flank by Jamuna basin. It is flanked by Sealdahgong and Sunti basin on its eastern and western part respectively (Hunter, 1998 and Majumder, 2001). On the southern boundary lies the Haroagong basin. River Nonagaon originates from the low-lying areas named Bagra Beel slightly down the Naharukra-Haringhata road.

DATA AND METHODOLOGY

Image Rectification and Subset

The area of Nonagaon river basin covered by Landsat image of path 138 and row 44. Two images of 1990 and 2011 ware downloaded from GLCF website (http://glcf.umd.edu/). The acquisition date of the images was 14th November 1990 and 8th November 2011. The images were rectified with UTM projection using WGS 1984 datum system. The boundary polygon layer of Nonagaon river basin has been prepared from rectified map of Bidyadhari river basin. From the boundary polygon of the basin, the same area has been subset from images. TNT mips pro, Arc GIS, and ERDAS software are used for image processing.

Optimum Index Factor

Combination of R.G.B. band is very complex and changeable, by which the visual interpretability of the images differ (Qaid and Basavarajappa, 2008). In this purpose Optimum index factor (OIF) technique has been applied to select the possible three-bands rendered as R-G-B. This method has been developed by Chavez et.al. in 1982 to designate the most favorable band combination for LULC classification. It is based on the amount of total variance and correlation between various bands. The used algorithm to compute the OIF for any subset of three bands is:

$$\text{OIF} = \sum_{j=1}^{3} SDi \Big/ \sum_{j=1}^{3} |CCj| \qquad (1)$$

Where, **SDi** means the standard deviation. **|CCi|** means the absolute value of correlation coefficient. Standard deviation represents the discrete degree. The bigger **OIF** value, the more information than the standard False Colour Composite (Standard FCC) image contains, and the less redundancy information as well. From Landsat TM5 of the year 1990, 35 combinations are obtained, from which band 5, 4, 1 combination achieved highest **OIF** value (Table 1). The same process has been carried out for the year 2011, and calculated **OIF** as 5, 4, 1band combinations.

Table 1
Different Band Combinations and OLF Value, 1990

Combination	$\sum \sigma$	$\sum$ correlation values	$\text{OIF} = \sum_{i=1}^{3} SDi / \sum_{j=1}^{3} \lvert CCj \rvert$
1,4,5	36.815022	1.3819865	26.6390[illegible]

Source: Data Based on Image Analysis by the Authors

Land Use Land Cover Classification

Total 7 bands of Landsat TM5 are used to OIF calculation (Formula 1) in this study. From table 1, the maximum value of OIF derived for the combinations of 5, 4, 1 bands (R.G.B) for both the year. The OIF value for 5, 4, 1 band combinations calculated 26.69. The best combination (5, 4, 1) consist of middle infra red, infra red and one visible (Blue-green) bands which have the lowest correlation value of 1.38. The combinations of 5, 4, 1 has the best interpretability for land use land cover calculation of this study area for 1990 and 2011. Supervised classification technique with maximum likelihood classification algorithm has been carried out to prepare LULC map (Figure 1) using NRSC/ISRO LULC classification scheme of the study area on OIF combination. From the LULC classification four major LULC has been delineated (Table 2).

On the basis of two OIF band combinations of the year 1990 and 2011, supervised classification has been done for land use classification using maximum likelihood algorithm. Four land use classes are categorized using training sets data obtained from ground truthing. This classification helps to delineate

Table 2
Definitions and Land Use and Land Cover Classes with Classification Accuracy, 1990 and 2011

N O.	Class	Definition	User's accuracy		Producer's accuracy		Khat statistics		Area in %	
			1990	2011	1990	2011	1990	2011	1990	2011
1	Settlement	Residential, Mixed built-up.	79.9	80.0	80.0	100	90.8	98.7	7.3	7.9
2	Cropland	Kharif, Rabi, Zaid,	75.7	97.9	79.6	98.2			29.4	37.3
3	Current fallow	Current and Long Fallow	93.6	98.9	94.3	98.6			56.3	41.2
4	Water	Perennial &Dry Riverand reservoir	93.8	100	93.8	99.7			6.8	12.9

Source: Data Based on Image Analysis by The Authors

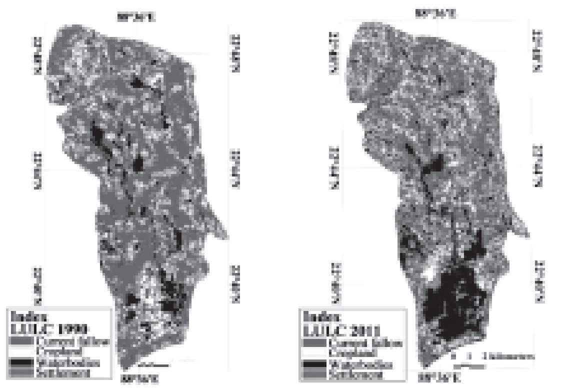

Fig. 1. LULC of Nonagaon River Basin of 1990 and 2011.

water bodies, cropland, current fallow and settlement. The Khat statistics shows 90.8 and 98.7 % variability for the year 1990 and 2011 respectively (Table 2).

Extraction and Overlay Analysis of Arable Land and Water Bodies

To map changes that have been occurred between the two dates, four different land use land cover were individually used as input for overlay analysis (Mas, J.F. 1990). For change detection arable land and water bodies have been extracted from supervised classification for the year 1990 and 2011. In case of arable land (cropland and current fallow) it is seen that the land under agriculture decreases sharply in last 20 years.

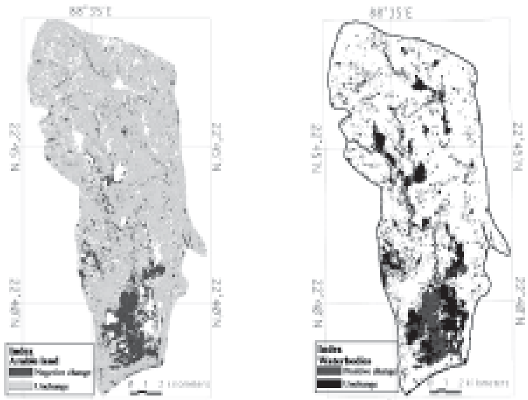

Fig. 2: Temporal Change of Arable Land and Water Bodies from 1990 To 2011

LULC Conversion

The major conversions of land use land cover are shown in the table 3 and figure 3. From the table 3, it is seen that 4.05 % of total basin area i.e. 5.99 Km^2 of area is converted into water bodies.

Table 3
Major Conversions of Land Use and Land Cover (1990-2011)

Previous LULC (1990)	*Present LULC (2010)*	*Area in %*	*Area in Km^2*
Cropland	Residential	2.99	4.42
Cropland	Water bodies	4.04	5.99
Current fallow	Residential	2.35	3.47
Current fallow	Water bodies	3.14	4.64
Water bodies	Cropland	0.99	1.46
Water bodies	Current fallow	1.08	1.59
Water bodies	Residential	0.45	0.66

Source: Data Based on Image Analysis by the Authors

Fig. 3: Major Conversions of LULC from 1990 To 2011

Economic Valuation of Changing Land Use / Land Cover

In our study, economic valuation of agricultural land and water bodies are made through house hold survey from stakeholders of the study area. The economic value of land depends on cost and benefit analysis of land. The economic valuation is only been done here. Paddy and Jute are the main crops of North 24 Parganas. Maximum agricultural lands are cultivable twice in a year.

Table 4
Economic Benefit of Agricultural Land

Valuation	*Item/ Acre/Season*	*Paddy*	*Jute*	*Vegetable*
Investment/ Cost	Price of seeds	3000/-	2000/-	5000/-
	Fertilizer and irrigation	2000/-	2000/-	1000/-
	Hiring Labour	25000/-	20000/-	15000/-
Production	Crop production	20000/-	25000/-	27000/-
	Other (Jute stick, pasture etc.)	5000/-	2000/-	3000/-
Economic Benefit	Employment (Hiring labour)	25000/-	20000/-	15000/-
	Price of production	25000/-	27000/-	28000/-

Source: Data Based on Household Survey by the Authors

The cost of cultivation is calculated in terms of price of seeds, fertilizer, hiring machineries and labours etc. From the stakeholders of this basin area, it is observed that an average of Rs. 25, 000/- is earned as the production from an acre of land in a single crop season. In triple crop agricultural land, total cost of production will be of Rs. 75, 000/- per season (table 4). At the same time agricultural land provides employment to the local people. This study remarkably shows that an acre of agricultural land generates an average of Rs.20, 000/- as wage for the agricultural laborers

FINDINGS AND CONCLUSION

From the satellite imageries it is seen that the number of brick kiln increased 5 times more from1990 to 2011. From overlay analysis of major land use and land cover of the basin it is observed the arable land decreased 10.64 Km^2 (i.e. 7.2 % of the total land)from 1990 to 2011 and on the other hand water body increases 9.02 Km^2 (i.e. 6.1 % of the total land) in between those years (table 2). After ten years the total land converted into permanent water bodies having depth of 4 meters which is not useable for pisciculture. This deltaic part is almost flat or with gentle slope where heavy monsoon rainfall occurs for three months of each year. This heavy surface runoff washes the top soil especially where it exposes due to deforestation. Soil collection, brick baking make a large area exposed. Gradually a secondary slope developed from the agricultural hamlets to those pits. The agricultural lands surrounding these pits are gradually degraded due to subsidence. Locally it is called as '*dhoat*'. From the field survey it is revealed that the kiln owners hire the land on lease basis for eight to ten years and the collected soil upto 4 meters. It makes the land lower than the river bed, and results permanent changes in ecology. An acre of agricultural land gives employment of 200 peoples in a year. Due to lowering of land, employment of agricultural labour is in threat. It is observed that 1 acre of land gives total Rs. Of 1, 35,000/- (crop and wages) in a year if the land is triple crop land in nature. That means 1 acre of land (double crop) gives return of Rs. 9, 00,000/- in form of crop and wage in 10 years. It also marginalized the landowners and agricultural labors. The study area shows that the pits became very large and its aggression to the settlement threaten the livelihood of the residences of the village of the basin. Water logging is increasing rapidly in the basin area. To protect the most valuable arable land, it is very urgent to stop top-soil extraction from the basin areas. It is also necessary to develop participatory management and awareness programme with local government to defend the land degradation of this area.

REFERENCE

1. Ali M. Qaid and Basavarajappa, H.T. (2008): "Application of Optimum Index Factor Technique to Landsat-7 Data for Geological Mapping of North East of Hajjah, Yemen,"American-Eurasian Journal of Scientific Research, Vol. 3, No. 1, pp. 84-91.
2. Chavez, P.S., Berlin, G.L. and Sowers, L.B. (1982): "Statistical Method for Selecting Landsat MSS Ratios," Journal of Applied Photographic Engineering, Vol. 8, pp. 23-30.
3. Eswaran, H.; Virmani, S.M.; Spivey Jr.L.D., (1993). Sustainable Agriculture in Developing Countries: Constraints, Challenges, and Choises. In Technologies for Sustainable Agriculture in the Tropics, (Eds.) J. Ragland and R. Lal. ASA Sp. Publ. 56, Madisin, WI. 7-24.
4. Eswaran, H., (1999). Recommendation in the Proceedings of the 2nd International Conference on Land Degradation. January 25-29, Khon Kaen, Thailand. 9.
5. Harish Vyas, AlkaVyas and Rizwana Khan (2009): "A Study of Land Degradation Due to Brick Industries in Ujjain (india)," Journal of Environmental Research and Development, Vol. 3, No. 4, pp. 1174-1177.
6. Hardisky, M.A., Klemas, V., Smart, R.M., 1983:"The Influence of Soil Salinity, Growth Form, and Leaf Moisture on the Spectral Radiance of Spartinaalterniflora Canopies,"Photogr. Eng. Remote Sens. Vol. 49, pp. 77–83.
7. Hunter, W.W. (1998): A Statistical Account of Bengal; the district of 24 Parganas, eds. W.W.Hunter, Published by K.R. Biswas, I.A.S., State editor, West Bengal District Gagetteers, Higher Education Department, Govt. of West Bengal, Bikash Bhavan, CalcuttaVol. I(I), pp. 9-13.
8. Majumder, S.C., Willcocks, Sir. William & Fergussion, James. (2001): Rivers of Bengal, Volume – I, West Bengal District gazetteers. (Eds.) W. Hunter, Chatterjee Chakroborty and Co. Ltd, Kolkata.
9. Mas, J.F. (1990): "Monitoring Landcover Changes; a Comparison of Change Detection Techniques," International Journal of Remote sensing, pp. 139-152.
10. Rahman, M.K., and Khan, HR.(2001):"Impacts of Brick kiln on Topsoil Degradation and Environmental Pollution". Project Report Submitted to the Ministry of Science and Information and Communication Technology, Bangladesh Secretariat, Dhaka.
11. Zone S.V. (1986): Tropical and Subtropical Soil Science, Mir Publishers, Moscow, pp. 389-390.
12. http://glcf.umd.edu : visited 25th June 2012 at 2:10 pm.

NEED AND PROSPECTS OF USING GEOSPATIAL TECHNOLOGY IN FARM SECTOR IN INDIA

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ABSTRACT

Farm sector is not only the India's largest employer and largest industry but also a stagger of life for almost two-third of employed class in India. This sector has occupied almost 43 per cent of India's geographical area and comprised 18per cent of India GDP. Albeit, all this shows that this sector is the backbone of Indian economy but still this sector is continuously dragging down. And the reason is not new. These are the natural ones like monsoon weakening, hailstorm, drought, flood, drying up of ground water etc. It is possible to control the implications of these hazards by providing the farmers proper compensation at a proper time, giving them quality seeds and fertilizers for improving the yield capacity, providing them accurate information at time, giving them training of using advance technology for irrigation purposes. So, there is a need in this sector for better improvement otherwise the farmer suicide cases will not stop. In this regard, geospatial technologies can be useful sources of fulfilling the need of farmers as it has a lot of prospects of development like to build the crop resilience to hazards, can identify the geographical hotspots like land degradation, crop damage, change of land use, ground water conditions and can aid in sustainable land management and risk assessment and the Government can make better policies to manage farm sector. At micro level, it can also help in providing the data related to the crop pattern, crop production, yield estimation etc. So, all these aspects can help India make "Climate Smart Agriculture".

Keywords: *Land Degradation, Geospatial Technology, Remote Sensing*

INTRODUCTION

Farm sector is not only the India's largest employer and largest industry but also is a stagger of life for almost two-third of employed class in India. This sector has occupied almost 43 per cent of India's geographical area and comprised 18per cent of India GDP. So, accelerating the growth of agricultural production is very crucial. But looking into the growth rate of farm sector, the story is something different. Albeit India has got a faster growth rate in the productivity after the Green revolution and came out from "ship to mouth, to self sufficiency" but this pace decelerated after the economic liberalization introduced in 1991 as the attention of the Government shifted to the other economic sectors of the economy leading to shrinking in the field of agriculture. On one hand the high use of chemical fertilizers the land was losing its productivity, on the other hand the government was declining its agricultural budget and policy support continuously. Now looking into the present budget scenario, it is even less than 1 per cent of GDP which is 22662 crore (Kumar, 2014) whereas it is serving almost two third of employed class. This shows the pathetic condition of farm sector and the people who are dependent on it. About half a century ago, the then Prime Minister Lal Bahadur Shastri had given the slogan of "Jai Jawan, Jai Kisan" but now the vigorous and hardworking farmers are victim of benign negligence and disappearing from the policy priorities of the Government. And the result is coming out in form of suicide of farmers.

The story of farmer suicide is not new, its history traced back to 1980s when the agrarian crisis started and after 1991 it took pace. At one side government continuously withdrew its hand on the other side, natural factors like unseasonal rain, hailstorm, cyclones, long dry spell continued making farm sector full of uncertainties. Also, multiple risk factors like income, yield, price, spurious input and obsolete technology put the farmers in a quandary. This triple burden and vagaries nature broke the backbone of farmers and thereby resulting into high indebtedness and poor socioeconomic condition. All these factors are throwing the farmers into the well of despair. Now looking into the farmer suicide cases in India, it is found that since 1997, more than 2500 farmers have taken their lives and the starting of this game of blood started under the regime of globalization where the Government has transferred the control of seeds in the hand of multinational seed corporations. This seed monopoly has robbed the farmers and more than 90 per cent of suicide victims plunged into debt (Shiva and Jalees, 2009). Highest suicide cases are recorded in the Vidhrbha region of Maharastra which is the cotton belt of India. The region has been termed as 'Suicide Belt' by Vandana Shiva (2006) an agricultural economist and environmentalist. So there is a need of miracle in farm sector which could prevent the death of innocent farmers. This paper attempts to make a glance on the present condition of farm sector in India; to analyze the need and status of Geospatial technology in Indian Farm sector and to assess the

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potential of development of Geospatial technology and how it can help in improving the condition of farmers.

Condition of Farm Sector at Present

Indian agriculture is not only known as a provider of food and economic securities but it is a means of livelihood of vast section of population so it serves multifunction (Patil et al, 2002). Looking into past history of agricultural sector of India, it shows high fluctuations in the production. After the independence and with the beginning of planning, it was realized that rural economic development is only possible by the development of agriculture sector. But many a time, performance of the agricultural sector was not satisfactory and the country was going through the miserable condition that it has to import the food grain to serve its starving population. Frequent drought or drought-like condition; primitive nature of agriculture and small land holdings, all these showed the cumulative effect and the Indian agriculture was continuously dragging down which was the server of livelihood of 70 to 80 per cent of population. Then the ray of hope came up in the form of Green Revolution which has boosted up the production and productivity of Indian agriculture. In India, development of agriculture can be divided into following phases (Chand and Parappurathu, 2011):

Phase I: Pre –green revolution period (1950-51 to 1967-68).

Phase II: Early green revolution period (1968-69 to 1985-86).

Phase III: Period of Wider dissemination (1986-87 to 1996-97).

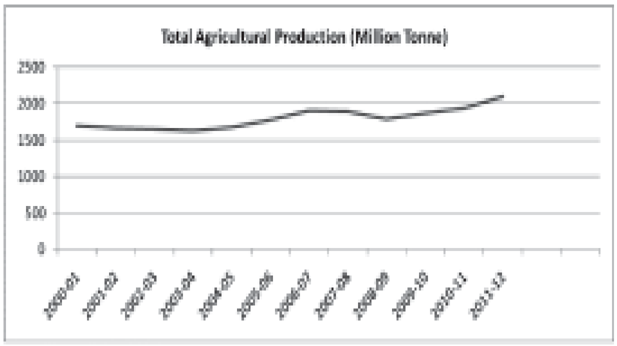
Phase IV: Post reform period (1997-98 to 2005-06).

Phase V: Period of Recovery (2007-07 to 2009-10).

Source: Chand and Parappurathu, 2011

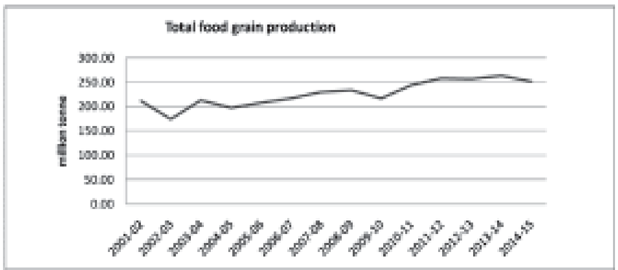
Fig. 1: Growth Trend in GDP-Agriculture

The vagarious nature of agricultural production is very much conspicuous. In 2001 the total production was 1697 million tons but on the very next year drought has occurred and the production came down and it was 1667 million tons. After this shock, farm sector once again took its pace and in next 6 years the production increased continuously but then in 2009, drought occurred again and consequently production went down. 2012 was the best year in last 12 year when the production reached to its highest level and then again due to hailstorm and unseasonal rainfall, the production fell down. So it is the natural calamities which are dragging the farm sector downward. The compensation policy of Government is not in the favor of farmers as the compensation paid is very low and Government takes too much time to pay compensation price. This drags the farmers into the indebtedness and there starts the vicious circle of impoverishment.



Source: Reserve Bank of India.

Fig. 2: Agricultural Production (2001-2012)



Source: Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India & Reserve Bank of India.

Fig. 3: Total Food Grain Production in India (2001-2015)

Problems of Farm Sector

Weather Vagaries: Weather and climate both are the two important factors which have profound impact on the agricultural productivity, yield capacity, incidence of pest and diseases and the growth of farm sector. Unseasonal rainfall in last year and hailstorm and thundershowers this year have left behind a trail of destruction devastating the Rabi crops across the whole north India, viz., U.P, Punjab, Haryana, Madhya Pradesh and most importantly Maharashtra's Marathwada and Vidarbha region. According to an estimate of the agriculture ministry, the crops grown on around 62 lakhs hectare out of a total sown area of 306 lakh hectare have been damaged. Therefore, from the above discussion it is clear that it has become very important to supply a long term weather forecasting before the starting of the cropping season in order to adopt proper mechanism to cope with vagaries of weather (Rathore, 2013).

Table1
Selected/State-wise Crop Area Affected Due to Hailstorm and Unseasonable Rains in India (As on 13.04.2015)

States	*Total Area (lakh Ha)*
Gujarat	1.8
Madhya Pradesh	5.7
Maharashtra	9.9
Rajasthan	16.9
Haryana	22.2
Punjab	2.9
Uttar Pradesh	29.6
Uttarakhand	0.4
Himachal Pradesh	0.7
Bihar	1.9
Jammu and Kashmir	1.3
Telangana	0.0
Kerala	0.0
West Bengal	0.5
India	93.8

Source: Lok Sabha, Unstarred Question No. 5728

Drought: Indian agriculture is totally dependent on the monsoon rainfall as it has around 60 per cent of the cultivable land area which comes under rain-fed or unirrigated. So whenever a drought year is occurred, the effect is manifested in terms of the shortfall of agricultural production. Looking into the historical background of drought and contemporary time, it is found that, from 1877 to 2009, India has witnessed 24 major drought years. During this period, 2002 and 2009 also come under the severe drought years. Rainfall deficit in these two years was 19 per cent in 2002 and 23 per cent in 2009, affecting 29 per cent and 59 per cent of county's total area respectively. But the loss of food grain was more in 2002 due to variability in occurrence of monsoon (Aijaz, 2013). Forecasting of drought is very important because flood and hail occur suddenly but drought persists for a longer period. So there is a need of monitoring the drought, its onset condition, progression etc.

Soil Erosion and Land Degradation: Soil erosion, land degradation and ground water depletion are other important problems in India. Soil decides the productivity of the crop. But because of the high soil erosion due to wind and water, upper most layer of the soil which is very important for crop is taken away making the soil infertile. Furthermore, land is degrading because of the desertification. As Indian agriculture is monsoon based, whenever there is weak monsoon, farmers adopt irrigation practices. This is resulting into the depletion of ground water on one hand and problem of salinity due to over-irrigation on the other hand. The cumulative effect of all these factors is showing in the output of agriculture sector.

NEED OF GEOSPATIAL TECHNOLOGY

From the above discussion it is clear that the need of the hour is to find solution for the distress in agriculture sector which could prevent farmers' suicide and chain migration and can help them to come out from the vicious cycle of poverty. It is true that the Indian agriculture is mostly affected by natural factors as it is totally dependent on monsoon which is erratic and unevenly distributed so it is rightly said- "Indian agriculture is a gambler of Monsoon". As one cannot control the natural factors but obviously can reduce their impact and can help to improve socioeconomic condition of the farmers. Technology advancement in the form of modern Geo-Spatial technology- GIS, GPS and Remote Sensing- can be used to cure the ailing farming sector. It has an immense value in planning and development of farm sector. Drought, hailstorm and flood damage the crop of whole region and of a farmer whose livelihood is only dependent on the farming. Though, there is a clause of compensation in government

documents but this compensation reaches to the farmers so late that they have to take loan again for next crop and this resulted into the trapping of vicious circle of poverty. After coming of the green revolution, the achievements in the yield is very high but, in long run, it has resulted into poor land quality and land degradation. Because of the irrational irrigation, the soil is facing the problem of salinization and over withdrawal of the ground water is resulting into declining water table (IFAD, 2011). So all these effects are gradually lowering the productivity of land. There is a need of sustainable approach which could keep raising efficiency and production in sustainable way and a "climate smart technology" to make climate smart agriculture. To achieve the goal of sustainable agriculture, a comprehensive and reliable information on land use/cover, soils (extent of wasteland and degraded land), water resources both on surface and underground water table, agricultural crops (a season wise information along with area under the particular crop and their yield capacity to decide the procurement prices) and most importantly natural calamities is very essential (Patil *et al,2002*) **.**

Status of Geo-Spatial Techniques Used in Farm Sector

Remote sensing provides the information about the crop identification, estimation of crop and production, diseases and stress detection, soil profile and moisture capacity, waste land which is cultivable and most importantly about the water resources. These are useful information for making the policies. With the help of remote sensing, government can estimate the total production of crops and accordingly can make the import-export policy and decide the pricing of different crops. Remote sensing also works as an input provider for GIS. With the help of data we can prepare the thematic maps and models. Remote sensing techniques such as satellite imageries, aerial photography and drones are used in developed countries for data collection. This technology can also be used in India that will not only save time but also reduce wastage of resources and tedious work in statistical data collection on agriculture production. Also, satellite will provide real-time required information. In India, ISRO coordinates a wide range of remote sensing applications which are used for forecasting of weather condition and monitoring the crop production.

Government of India has started a project named CAPE (Crop Acreage and Production Estimation) in 1988 for the estimation of acreage and production for principle crops such as wheat, rice, cotton, mustered, sorghum and groundnut but it was realized that to forecast of crops at sowing stage requires many multiple sources information like weather, econometric and field survey. Then a new concept named FASAL (Forecasting Agricultural output using Space, Agro meteorological and Land based observation) has been implemented in 2007-08. The main aim of FASAL is to collect Monsoon data, economic data and monitoring crops when growing. Since soil erosion and degradation are major problems faced by agriculture sector in India, geospatial technology is of immense importance in monitoring and measuring the area under land degradation and rate of erosion. Not only measurement but estimation and prediction of soil erosion are also possible using GIS and Remote Sensing technologies. The prediction is done using modeling of soil erosion of different kinds. Some of the models are USLE (Universal Soil Loss Equation); MUSLE (Modified Universal Soil Loss Equation) and EUROSEM (European Soil Erosion Model). These models require information on soil characteristics, land use type, topography, climatic condition, vegetative covers and so on. Data on these variables can easily, accurately as well as on real-time can be collected using GIS and Remote Sensing technologies as other convention methods of collecting this information are time and money consuming, tedious and require a lot of man power. Earth observational satellites can be used to collect data on vegetation cover, geology, drainage, slope gradient, interception loss and erosional factors such as gullies, rivulets etc. DEM (Digital Elevation Model) can be used to study topographic characteristics of a region.

The use of GIS and GPS is becoming a core function in farm sector. GIS translates the information provided by the satellites through maps. Now with the help of GIS, farmers can easily demarcate the various kinds of areas, for example, high and low productivity; drought prone and flood affected. And accordingly they can diversify their cropping pattern. Information about the use of pesticides, fertilizers, diseases and most importantly weather has made their life simple by reducing level of uncertainty. GPS and GIS are also being used now in precision farming for farm planning, field mapping, yield mapping, sampling of the soil, tractor guidance. With the help of satellite, one can also trace the new areas of farming and the area which is cultivable but is idle. With the help of GIS, we can demarcate those areas and bring them under cultivation. All these informatics tools not only save the time but also save the money and helps in increasing the production capacity of land.

Table 2
Major Indian Remote Sensing Missions for Agriculture

Mission	Year of launch	Sensors
IRS-1A, IB	1988 1991	LISS-I (72.5 m resolution;148 km swath) LISS-II (36.25m resolution;142 km swath)
IRS-P2	1994	LISS-II (36 m resolution; 142 km swath)
IRS-1C, ID	1995 1997	PAN(5.8m resolution;70 m swath) LISS-III (23.5m, 70.5 m resolution; 141 km, 148km swath) WiFS(188.3 m resolution; 774 km swath)
IRS-P3	1996	WiFS (188.3 m resolution; 774 km swath)
TES	2001	PAN (1m resolution;14 km swath)
RESOURCESAT-I	2001	LISS-IV (6 m resolution: 25 km swath / LISS-III /23 m resolution; 140 km swath/ AWiFS /80 m resolution;800 km swath)
CARTOSAT-1	2002	PAN Stereo (2.5 m resolution;30 km swath)
CARTOSAT-2	2002/03	PAN Stereo (1 m resolution;12 km swath)

Source: Gowrisankar and Adiga,2001, Patil et al, 2002

Table 3
Important Remote Sensing Application Projects in Agriculture

S.No	Project	User organization
1.	Crop Acreage and Production Estimation (CAPE)	State Departments of Agriculture / Ministry of Agriculture
2.	Cotton Acreage and Condition Assessment (CACA)	Ministry of Textiles.
3.	Forecasting of Agricultural output based on Satellite, Agrometeorology and Land based observation (FASAL)	State Department of Agriculture
4.	Nation wide mapping of soil resources on 1:250000 scale	Ministry of Agriculture
5.	Mapping of saline/alkaline soils of India	Central and State Agricultural Departments.
6.	National wasteland mapping on 1:1 Million scale/1:50,000 scale	Wasteland Development Department / District Authorities
7.	Nationwide mapping of landuse/land cover for agroclimatic zones on 1:2,50,000 scale	Planning commission
8.	National Agricultural Drought Assessment and Management Systems (NADAMS)	Department of Agriculture and Co-operation, State Agricultural Departments and District Authorities.
9.	Forest cover mapping for the entire country	Department of Forest, Forest Survey of India, State Forest Departments.
10.	National drinking water technology mission on 1:2,50,000 scale	Ministry of Rural Development, Ground Water Department
11.	Satellite monitoring of command areas for crops, salinity/alkalinity and waterlogged areas	Central Water Commission / State Command Area Development Authorities.
12.	Integrated Mission for Sustainable Development (IMSD)	Planning Commission, Ministries of Rural Development, Agriculture, Environment and Forests, State governments.

Source: Venkataratnam, 2001, Patil et al, 2002

New and Upcoming Projects

After the occurrence of any natural calamity it is very important to reduce its ramifications by providing the compensation to the farmers. So Government of India has come up with a new project named KISAN to make fasten payment of crop insurance claimed by the farmers. This is a pilot program which will be based on the use of high resolution remote sensing data extracted from both satellite and drone based imaging and sophisticated modeling to get crop yield. Time and accuracy is very important in this project. An Android based app is also launched to make the assessment of damage of crop because of the hailstorm which will be used by the state and union ministry of agriculture. Initially, the program will be implemented in four districts viz. Karnataka (Shimong), Maharastra (Yavatmal), Haryana (Kurukshetra) and Madhya Pradesh (Seoni) on rice and cotton field then it will be implemented on whole India. Furthermore, NISAR is an upcoming project with U.S.A which is a earth observation satellite, is slated to be launched in 2020-21. It will help in estimating the soil moisture, agriculture and forest biomass. Some "hyper spectral" studies are being undertaken to identify and prevent the yellow rust disease in wheat crop through remote sensing.

Prospects and Challenges

Precision Farming: Precision farming is technique of sustainable farming using information from remote sensing and other geospatial technology. By using these technologies, farmers can easily determine the crop specific requirements regarding agriculture inputs such as fertilizers, irrigation, pesticide, herbicide and so on. This practice ensures optimum utilization of resources without wastage. Therefore, this practice helps better land management and efficient use of resources. Following information is needed in precision farming. This information includes data on crop characteristics such as stage of growth and health of crops; soil characteristics such as texture, moisture contain and nutrients; micro climatic condition like wind speed, humidity, temperature and rainfall, and drainage conditions.

The fruits of integration of geospatial techniques with the farm sectors can be ripen only if the farmers are equipped with mobile and internet and they are digitally literate. Also spread of digital infrastructure is equally important. There is need for every village to be connected with internet so that regular information on the weather events such as hailstorm, rainfall, unseasonal rain etc is easily available. Moreover, language is a very big hindrance for the farmers as all kind of app which is being developed and information on internet is provided only in English language which cannot be understood by the farmers. If the farmers do not understand the information then there is no use of any app or development. So the information for the farmers should be in the regional languages because looking into the farmers condition, there are many who do not understand even Hindi. In order to overcome this problem government should telecast such programs which provide every kind of information related to weather, price and any new policy on regional languages and should give an option of question answer session if they have any.

CONCLUSION

After looking at the growth rate of India's population, it becomes clear that the demand for the food grain will increase in near future. Due to increasing pressure of growing industrialization and urbanization, it becomes clear that the extension of the cultivable land will be very difficult. So, there is a need of huge increase in the agricultural productivity and this is possible only technological advancement which is sustainable in nature. And above all, there is a need of controlling the impact of natural calamities which destroy thousands of acres of crops. But agricultural expenditure is less than 1per cent of GDP which is not sufficient for the investment in geospatial technologies. From the above discussion, it is very much clear that there is an urgent need of new and advance technologies which could solve the problem of agricultural sector. People who are engaged in the farm activity, dependent on it for their livelihood and food security of millions of people depend on the farm sector. So there is a need of making the agricultural sector very strong and sustainable and climate smart.

REFERENCE

1. Aijaz , Rumi(2013): "Monsoon Variability and Agricultural Drought Management in India"; ORF issue brief # 53.
2. Andreo, Verónica (October, 2013): "Remote Sensing and Geographic Information Systems in Precision Farming" Maestría en Aplicaciones Espaciales de Alerta y Respuesta Temprana a Emergencias - CONAE – UNC.
3. Chandh, Ramesh and Parappurathu, Shinoj(2011): "Historical and Spatial Trends in Agriculture: Growth :Analysis at National and State Level in India" India International Centre, New Delhi.
4. Digital Globe Magazine (2014): "Remote Sensing Technology: Trends and Agriculture"; America, November 2014.
5. Economic Times (2015): "Government Unveils KISAN Project; Hailstorm App to Assess Crop Damage". Economic Times, 5 Oct., 2015.
6. Geospatial Media Report (2015): "Geospatial Technology in Agriculture Industry Trends & Prospects 2015".
7. Goswami, Jonali *et al.,* (2012): "A Geospatial Approach to Climatic Zone Specific Effective Horticultural Planning in East Khasi Hills District of Meghalaya, India". Journal of Geographic Information System, 4, 267-272.
8. Guiteras, Raymond (2007): "The Impact of Climate Change on Indian Agriculture" Department of Economics, MIT.
9. Hassanein, Neva (2003); "Practicing Food Democracy: A Pragmatic Politics of Transformation"; Journal of Rural Studies. Vol. 19(1), p. 77-86.
10. Hindu (2015): " Kisan to Provide Accurate Data on Crop Yields"; The Hindu, October 12, 2015
11. Kannan, Elumalai and Sundaram, Sujata (2011): "Analysis of Trends in India's Agricultural Growth". The Institute for Social and Econo5mic Change, Bangalore.
12. Mishra, Srijit(2007): "Risks, Farmers' Suicides and Agrarian Crisis in India: Is There A Way Out?". Indira Gandhi Institute of Development Research, Mumbai.
13. Patil V.C et al (2002): "Remote Sensing, Geographical Information System and Precision Farming: Opportunities and Challenge". Asian Agricultural Information Technology & Management. Proceedings of the Third Asian Conference for Information Technology in Agriculture, Beijing, China. P. 478-483.
14. Pye-Smith, Charlie (2011): "Farming's Climate-Smart Future: Placing Agriculture into the Heart of Climate Change Policy" DIGIGRAFI BV Publication; The Technical Centre for Agricultural and Rural Cooperation (CTA) and CGIAR.
15. Rathore, L.S (2013): "Weather Information for Sustainable Agriculture in India" Journal of Agricultural Physics. Vol.13 (2). pp. 89-105.
16. Shiva, Vandana and Jalees, Kunwar (2009): "Farmers Suicides in India". Research Foundation for Science, Technology and Ecology. The University of Michigan.
17. Sharma, Devinder (August, 2014): "67 years of Independence, Indian farmers have disappeared from economic radar" My Interview.
18. Tripathi, Amarnath and Prasad A.R (2009): "Agricultural Development in India since Independence: A Study on Progress, Performance, and Determinants". Journal of Emerging Knowledge on Emerging Markets. Vol I.

IDENTIFYING AND ASSESSING THE FACTORS INDUCING LAND DEGRADATION AND DESERTIFICATION IN DHARMAPURI DISTRICT OF TAMIL NADU THROUGH GEO-STATISTICAL MODEL

Shoba P[1] & S.S.RAMAKRISHNAN[2]

ABSTRACT

Desertification is an important endangering phenomenon which affects the environment, inhabitants and economy of the country directly. Desertification is a prolonged stage of land degradation process from which the land cannot be replenished and suited for vegetation production anymore and it is mainly induced by two vital components namely rainfall and anthropogenic activities. The current study concentrates on identifying and assessing the area of desertification with respect to above mentioned factors using long term (2001-2015) Landsat satellite imageries and rainfall data of crop growing period (June-October). Based on the successful hypothesis we formulated at 0.05 % significance level, spatial correlation coefficient analysis has been performed between long-term rainfall and NDVI which revealed the rainfall affected and human affected zones. In order to differentiate the desertified area from degraded land, the resultant map was cross verified with recent short-term negative $NDVI_{observed}$ *trend. Initially identified a desertifying area of 23 % has been significantly reduced by 14 % after short term NDVI negative trend is taken into account. Since, Dharmapuri is located in rain shadow region, the higher proportion of rainfall induced desertified land was found in the lee ward side or western part of the region where the rainfall distribution is being steadily hampered by the Western Ghats over a period. Natural soil salinization was observed in the rainfall affected zone due to the natural inheritance of fluoride content from ground water. Some portion of human induced desertified land has also been identified in the eastern part of the region due to improper management of the fragile land by the local community results in human made salinity at a higher rate. In addition to that, the long-term rate of human occupancy was also raised on the productive land. This effect has been magnified by 69 % within three years of time frame (2012- 2015) on the places where the NDVI has been stable for a decade. The present study glows light on the new ideology to assess and differentiate the long term and short term land degradation and desertification took place in the rain-fed region by means of the geostatistical model and in-situ reports.*

Keywords: *Land Degradation and Desertification; Spatial Linear Regression and Correlation Coefficient Analysis; NDVI.*

INTRODUCTION

The Earth provides an ultimate platform and natural resources for the human beings to consume at a possible rate for their survival and economic, social, and cultural development. Earth has both renewable and non-renewable resources. The land is a terrestrial bio-productive system that comprises soil, vegetation, other biota, and eco and hydrological processes that operate within the system (Article 1 of the UNCCD). The land is considered as a renewable resource when it is managed properly to maintain the consistency to respond to the regeneration process. Similarly land can be a non-renewable resource when the land is utilised in such a way the soil is completely degraded and not be replenished at any cost hence desertification taken place. In developing countries like India, the most of the economical activities rely on the land stability. The land is a primary component of the earth surface and its degradation can affect the environment, people and economy of the country directly.

Desertification is a slow and onset hazard, initially provoked by climatic factors (persistent droughts due to insufficient rainfall event) and accelerated when combined with human actions (population pressure and intensive land use etc.,) on degraded land, which produces an adverse effect to people and ecological system by affecting soil fertility directly. Desertification is a prolonged stage of land degradation process in which the land cannot be replenished and suited for vegetation production anymore. In the reorganisation phase of desertification, it was believed that the process of the deterioration of both soil and vegetation, which was caused by human activities (Dregneet al.1986). Later it was perceived as degradation of the biological potential of the land due to adverse climatic events. Finally, UNCCD has declared an authentic definition of desertification as degradation of the soil, landscape and bio-productive terrestrial system, in arid, semi-arid and sub-humid areas resulting from several factors including climate change and human activities (UNCCD1994; UNCCD2012).

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Maria et al. (2001) have defined desertification in the perception of soil degradation through the continuous loss of soil fertility by damage of structure and composition of the soil which ultimately affects the sustainable agricultural production. Desertification is also defined as the consequence of important processes set, which are active in arid and semi-arid environment, where water is the main limiting factor of land use performance in the ecosystems (Batterbury & Warren 2001). In dry areas Land degradation coupled with extreme bio-physical and socio-economic phenomena, may turn into an irreversible process of environmental degradation that is desertification (Montanarella 2007).In the recent era, Desertification is recognised as one of the most serious social and economic issues in arid, semi-arid and dry sub-humid areas (Sepehr &zucca 2010). In India desertification has emerged as a social, economic and environmental problem (Arnab & Dipanwita 2011). So, it's very essential to identify and quantify the current status of desertified area before the process completely hampers the inner stability of the ecosystem.

STUDY AREA DESCRIPTION AND PREVAILING PROBLEMS

Dharmapuri is a located in the northern western part of Tamil Nadu, India which lies between 11°47′ & 12° 33′ degrees of northern latitude and 77° 28′ and 76° 45′ degrees of eastern longitude. The prevailing climate of the whole region is semi-arid and slightly humid. The Study region has been facing maximum temperature of about 37°C in the month of April - May and the minimum temperature of about 25°C. Precipitation rate in the study region is 760 mm/year. The district is benefited by the south-west monsoon. By analysing the two decades of climatic data it is found that the district has faced the maximum temperature i.e. above 35°C, from 2006 to 2012.

The Socio-economic condition of the region is very poor due to poor rainfall and frequent monsoon failure and thus leads to drought in many parts of the region (Anbazhagan et al.2000). The District is also facing strong salinization, affecting 6615 ha of land. About 3000 ha of land is affected by waterlogging and it's proved with the presence of hard pans. The entire district is having water scarcity and out of five taluks, four are over exploited and Pennagaram is critical (Central Ground water Board Report 2009). The increasing trend of growth rates of the wasteland is the highest for Dharmapuri at 2.37 per cent (Unnamalai& Namasivayam 2012). The presence of Fluoride is more than the permissible limit in the study region. Positive correlation between F and pH indicated that alkaline condition improved solubility of Fluoride (Partha et al. 2014). So Ground water in aquifers in general is slightly alkaline in nature.

Dharmapuri is one of the districts affected regularly by drought. The drought is the visible evident of a degrading ecosystem of which land is a main component (Budihal 2005). Drought also was rather seen as a catalyst which exposed the effects of the long-term degradation caused by people (Thomas & Middleton 1994). Among many events which affect earth's environment and ecosystem, drought is often having a direct association with desertification (Shewale and Shravan kumar2005). Drought, a period of unusually dry weather with no land management, can cause loss of vegetation, which in turn leads to desertification (Sharmia 2008).

The share of agriculture in the state domestic product of Tamil Nadu has shown a severe decline from 52 to 18 percent between 1960-61 and 2007-08 and to 8.2 percent during 2010-11.The erratic climatic events, socio-economic developments supported by welfare measures and unsustainable agricultural practices in the past decades, exert strong pressure on natural resource such as land. Agriculture is a major profession in Dharmapuri District which supports 70 percent of the population. The planned agricultural growth rate of 4 percent in the 10th plan couldn't be achieved due to not only the drought conditions existing in the region but also unavailability of system or model which analyses the current trend of the phenomena. So it's very essential to create a model to identify the contributing factors of desertification in order to recommend the control measures that has to be taken before the phenomena completely hamper the inner stability of the land.

RESEARCH RATIONALE

In the past days desertified areas were identified and mapped by conventional survey and mapping techniques. This kind of assessment has been done without considering any supplementary details such as rainfall, temperature, slope, soil quality etc. which ultimately leads to uncertainty in the evaluation. Later it was assessed through available data sources such as climate data, soil maps, geology maps, land use and land cover maps which in turn yields moderate results of desertification severity. In the recent era, the research has started moving in a systematic way with the aid of scientific advancements such as optical remote sensing, geo-statistical methods and models. Remote sensing yields reliable results due to the synoptic coverage and temporal availability of the satellites scenes.

Indeed, the world wide attention has been brought by desertification process for last 30 years as it relatively affects the biomass, soil and socio-economic condition of the inhabitants. Remote sensing technology is successfully applied to the process of monitoring desert expansion and to the assessment of factors that cause desertification (Hanan et al. 1991). Adopting Remote sensing techniques and geo-statistical models in identifying the prime factor has been started since 2000. The land degradation of arid and semi-arid zones often called as desertification when it is irreversible in form and the factor of this phenomena either climate or human has been much debated since the mid -1970s (Rasmussen et al. 2001).Desertification can be primarily assessed by the vegetation degradation or low NDVI trend. NDVI is a good indicator for estimating the biomass, Leaf area index and productive capability of the land (Thinkable et al. 2004). In arid and Semi-arid regions, Multi-temporal NDVI and vegetation production are very much correlated (Prince and Tucker 1986~ Nicholson et al. 1998~ Wessels et al. 2006). Climate ûuctuations and human activities together induce desertiûcation in semiarid region, their individual impacts should be assessed in detail in order to resolve the ambiguity over which the primary cause is (Runnstrom 2003; Wang et al. (2006)).

Hountondji et al. (2006) & Munkhnasan Lamchin et al. (2014)have identified rainfall induced desertifying area by taking the negative deviation or residues of an observed NDVI from predicted NDVI into account. Sandra Eckert et al. (2014) & Sohou et al.(2014) have also explored the ideology of correlation analysis between NDVI and Rainfall in the identification of desertification. The above studies are highly concentrated only on rainfall induced desertification.

Some authors like Hielkema et al.(1986), Oldeman et al. (1990),Yang et al. (1997), Schmidt (2000), Evans & Geerken (2004), Propastin et al. (2006) have concentrated on identification of rainfall and human induced desertification through linear regression analysis. This is a best method for the baseline identification of accelerating factor. Jing zhang et al. (2013)has removed the effect precipitation to reveal areas of human-induced land degradation. Wang et al. (2006) assessed the relative role of climate and anthropogenic factors on desertification process in semiarid China over the past 50 years. Propastin & Muratova (2008) and Arnab &Dutta (2011)have proved the potentiality of linear correlation analysis between mean rainfall & mean NDVI and long-term NDVI trend in the identification of human and climate induced desertifying area.

The above mentioned works are significantly different in the way the geo-statistical models are applied in the extraction of desertified area. But there is not much reportemphasising the differentiation of land degradation and desertification from the previous studies. This is the first time the completely desertified area has been identified and extracted from the degraded area with the help of recent short-term vegetation trend. Because approximately 11% of degraded land could have been wrongly demarcated as desertified area if the cross verification and inclusion of short term NDVI are not taken into account in the current study. The previous studies have also not concentrated on the long term "**no correlation"** places which may produce significant information when examined with the short term trend. The spatial linear regression analysis is done with respect to long-term rainfall in order to extract the NDVI predicted. We tested the hypothesis at 0.05% level of significance to confirm the adequacy of string correlation between predicted NDVI and rainfall event. The actual spatial correlation analysis is done between NDVI predicted-mean and rainfall mean after the finalisation of hypothesis in order to find out the actual correlation that should have been existed in the region.

Bands of satellite imageries are preprocessed and topographically normalised using modified cosine correction in order to eliminate the illumination variations of the land cover among shadowed and non-shadowed region. Long term (2001-2011) and Short term (2012-2015) NDVI observed-trend have been estimated using normalised bands in parallel. The rainfall induced degraded area has been identified initially where the positive correlation with long-term negative NDVI trend is found. In the same way,human induced desertification is also identified where the negative correlation with long-term negative NDVI trend is found. And again the resultant raster datasets have been cross verified with short term NDVI in order to differentiate the land degradation and desertification. In semi arid regions the ecosystem retains its consistency and ability to respond to the recurrence of the rainy season (Kassas 1977). If the degraded land is not responding to the adequate rain, its termed as desertification.

OBJECTIVES

The objective of the current study is i) To identify the factors that are contributing to land degradation and desertification process using appropriate geo-statistical model. ii) To differentiate the desertified land from the degraded, this is considered to be a prime need on evaluating desertification in semi-arid ecosystem. iii) To assess the recent status of long term no correlation places due to human activities.

DATABASE AND METHODOLOGY

Satellite Data

Since MODIS and NOAA AVHRR satellites have high temporal resolution, they have been adopted for long-term change detection, land degradation and desertification analysis so far by various researchers across the world. But the limiting factor which hinders the applicability to employ those imageries in the sub-regional level assessment is a low spatial resolution. Therefore, moderate spatial resolution imageries are required to assess the phenomena at the sub-regional level. So, the present study is carried out using ETM+ (Enhanced Thematic Mapper) and OLI (Operational land Imager) Imageries on board Landsat 7 & 8 Mission from 2000-2014. The two satellites are in a sun-synchronous, near-polar orbit at 705 km altitude and have the moderate spatial resolution of 30 meters for multispectral bands. ETM+ data of path no143 path and row no 52 were collected from 2001-2012 and OLI imageries were collected for 2012-2015 from Glovis online free resource centre. Bands are stacked and Subset operation has been performed in order to clip the imagery with respect to study area. From **2004 to 2012** the Landsat 7 mission has acquired the data with SLC-off mode. SLC images are collected for the corresponding years, spatially corrected using focal analysis and spectrally equalised using histogram equalisation method to make the data ready for further geospatial analysis.

Desertification Phase Identification through Meteorological Data

Rainfall data from 2001-2015 has been collected from Centre for climate change and adaptation research, Anna university, India. Dharmapuri is one of the districts of Tamil Nadu which gets benefited by kharif reason or south-west monsoon rain (June-October). So the crop growth is considerably high from June to October. So from monthly data, the crop growing months are extracted and plotted as points in the ArcGIS environment. There are 6 stations distributed in and around the study region. Plotted points are interpolated using IDW (Inverse distance weighted) method with the same resolution (30m cell size) of Landsat data. The rainfall raster of different months of growing season was then averaged to obtain the mean rainfall of growing season.

Land degradation to desertification Phase identification plays a vital role before entering into an assessment of desertification. The phase can be initially identified through rainfall distribution. The land degradation period has to be identified in order to recognise the period when the desertification invokes. Fig-1 clearly shows the long term distribution (2001 -2015) of rainfall of the Study region. From 2006 to 2011 there was a significant decline of rainfall observed followed by immediate high rainfall occurred in 2012. So the land degradation should have been occurred in 2006- 2011 time frame. If the land degradation is not responding to the immediate high rainfall of 2012, then it's termed as desertification. If it responds good and renewed after sufficient rain, then the land cannot be categorised as desertification, it is just land degradation.

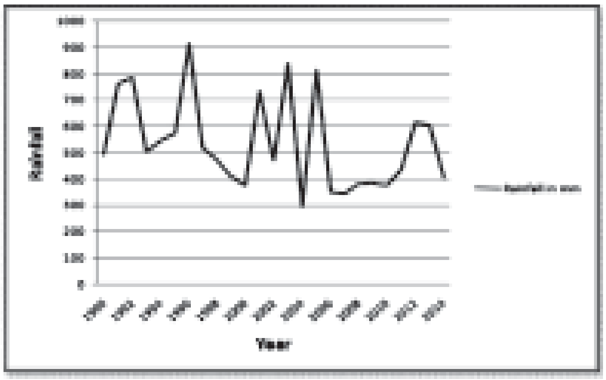
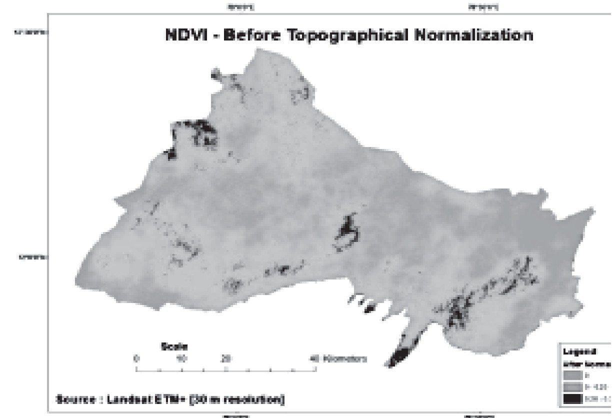


Fig.1: Identification of Land Degradation to Desertification Phase through Long-term Rainfall Distribution

NDVI Topographical Normalization

Before estimating the NDVI (Normalized differential Vegetation Index), the bands of the imageries have to be topographically normalised in order to eliminate the effects from the shadowed region on NDVI imagery. Bands 3 and 4 of ETM+ and OLI are topographically normalised using modified cosine correction (Peter Meyer et al. 1993) to eliminate the illumination variation which hampers the ability to discriminate ground features as the same features will have different spectral responses among shadowed and non-shadowed region. It is very important to eliminate the topographical effects in the present study as the correlation analysis is highly affected by the shadow region. Say example the water body in the NDVI and rainfall has no correlation over a period of time, thus the result of the correlation analysis should have been zero on those places. Some locations of the eastern part of the region are occupied by shadow because of the slight elevation and dense vegetation. Because of the presence of dense vegetation and occurrences of high rainfall the area has to be shown as highly correlated. But the shadow region is considered as a water body by the system because of the spectral coincidence of shadow region and water body and the resultant correlation is zero (no correlation). Hence some portion of high dense vegetation area has high possibility to be wrongly estimated as no correlation if the topographical effects are not eliminated.

Topographical correction was carried out for 14 years of Landsat data using modified cosine formula. Topographically corrected NDVI has shown in Fig-



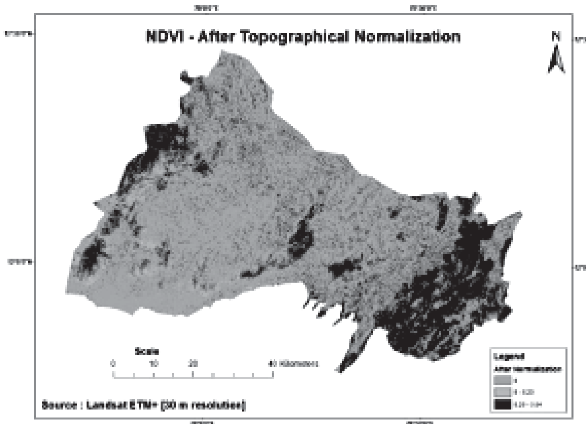


Fig. 2: NDVI 2001 – before and after topographical normalized images. The eastern part of the study region is well normalised.

2. The eastern and western parts of the hilly regions are well enhanced after normalisation.

$$L_H \quad L_T \quad \frac{(IL_m \quad IL)}{IL_m} \tag{2}$$

Where

IL_m = Average IL value

L_H = Radiance of the horizontal surface

L_T = Radiance of the inclined surface

Spatial Linear Regression and correlation Model

Since the Rainfall and NDVI follow linear trend, a spatial linear regression model is formulated by taking rainfall as an independent variable and $NDVI_{predicted}$ as a regressed parameter which yielded the NDVI that should have been present in the study region with respect to rainfall hence called $NDVI_{predicted}$. In order to perform the regression analysis, the Slope (b) and Intercept (c) are estimated spatially as mentioned below

$$\text{Slope (b)} = ((N^*\Sigma xy) - (\Sigma x) * (\Sigma y)) \ / \ (N\ \Sigma x^2 - (\Sigma x)^2) \tag{3}$$

$$\text{Intercept (a)} = (\Sigma y - b(\Sigma x))/N \tag{4}$$

Where

N = Number of years taken into account

x = Rainfall

y = $NDVI_{observed}$

$NDVI_{predicted}$ was estimated for the study region for a period of 12 years (2001-2012). In order to identify the statistical significance of the correlation between Rainfall mean and $NDVI_{predicted-mean}$, t- test has been carried out with 5 % level of significance (Two tail test) for the slope value between $Rainfall_{mean}$ and $NDVI_{predicted-mean}$ data. If there is any correlation, the slope of the two rasters ($Rainfall_{mean}$ & $NDVI_{predicted-mean}$) cannot be zero. This is the base for the formulation of Null (Slope = 0) and Alternative hypothesis (Slope ≠ 0). It was observed that the area under acceptance of H_0 (*i.e.*, the slope is equal to zero) have not been facing any NDVI change over 12 years. Hence the area has not been subjected to the significant correlation between $Rainfall_{mean}$ and $NDVI_{predicted}$. From the hypothesis, we found higher proportion of the study region was obtained greater t score than the tabulated value (t= -2.228 & t=2.228)which indicates the high correlation between $Rainfall_{mean}$ and $NDVI_{predicted-mean}$. With that evidence, we performed spatial grid correlation coefficient analysis (Equ 6) between $NDVI_{predicted-mean}$ and $Rainfall_{mean}$ which resulted in three zones of correlation namely i.e positive, negative and zero correlation.

$$r_{xy} = \frac{cov(x,y)}{\sigma x.\sigma y} = \frac{E(xy) - E\ (x).E(y)}{Var(x).Var(y)} \tag{5}$$

$NDVI_{observed}$ Trend Analysis

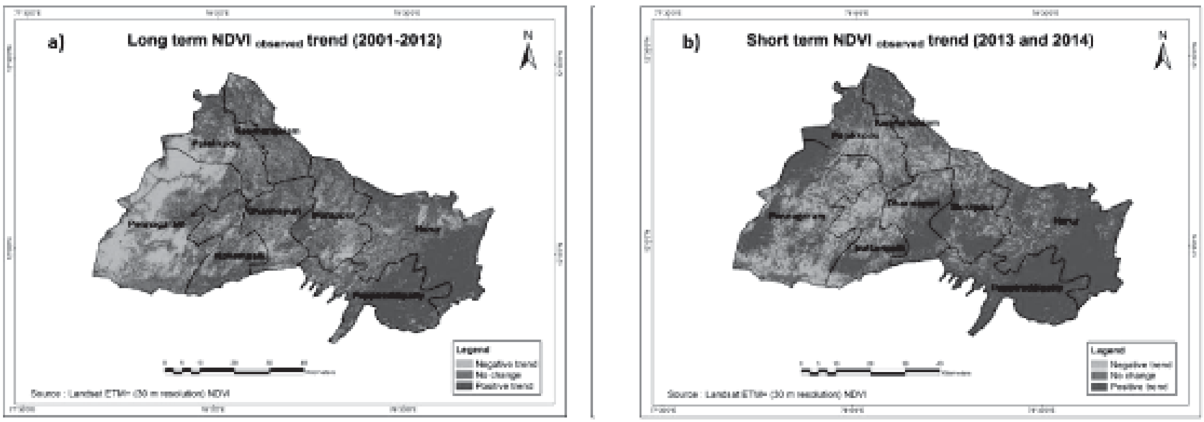
The overall rate of change and detection of gradual trends of NDVI over a period of time was estimated through time trend analysis with time as an explanatory variable. Trend or slope has been estimated for Maximum NDVI using below mentioned equation. Long term (2001-2011) and short term (2012-2015) observed NDVI trend maps are shown in Fig-3 a & b.

$$\text{Slope } (\theta) = n \times \Sigma\, i.\, NDVI_i - \Sigma\, i.\ \Sigma\, NDVI_i \ / \ n \times \Sigma i^2 - (\Sigma\, i)^2 \tag{6}$$

Where

n = number of years taken for estimating the slope.

i = each year say 1,2,3…,12



$NDVI_i = NDVI_{observed}$ of the corresponding year i

Fig. 3: (a) Long-termblock-wise NDVI observed trend. (b) short term block-wise NDVI observed trend.

DISCUSSION AND ANALYSIS

Fig. 4. Raster based Spatial correlation coefficient analysis Map of $NDVI_{predicted\text{-}mean}$ and $Rainfall_{mean}$. Positively correlated places have shown a significant relationship that should have been existed between rainfall and NDVI for a decade. Similarly, negative correlation places illustrate that the NDVI remains exploited even after experiencing adequate rain. Some portions of the study region have not been facing any change for a long period and are termed as No correlation area.

The correlation coefficient (r) map (Fig-4) between mean rainfall and $NDVI_{predicted\text{-}mean}$ reveals the spatial pattern that the North West, South West and some eastern part of the regions are having a strong positive correlation. Hence the vegetation responses on those areas are highly depending on the rainfall distribution. Eastern part of the region has shown a high negative correlation which indicates that there may not be any impact of vegetation growth due to rainfall distribution. Some part of South western and North-western area have shown no correlation (r=0) that indicates that NDVI remains constant and rainfall keeps on changing over a period of time. Over the entire district, 35 % of area have experienced negative correlation (r=-1), 5 % of area has no

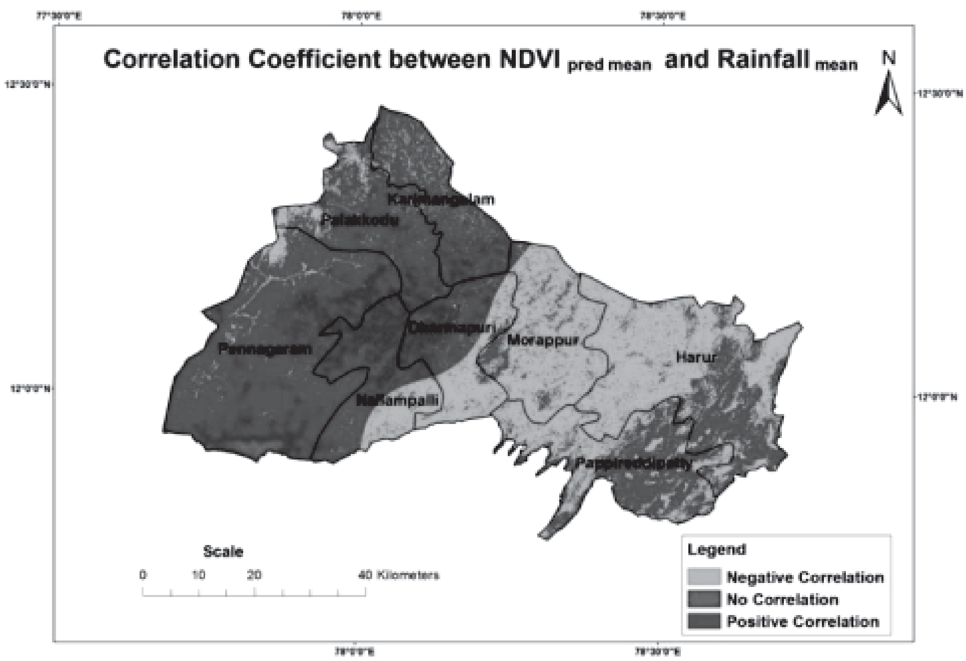


Fig. 4

correlation(r=0) and 60% of area have shown strong positive correlation (r=1).

From spatial $NDVI_{observed}$ trend analysis, a strong negative trend has been observed in Pennagaram block followed by Palakkodu, Harur and Morappur as shown in Fig-3. No change trend is highly observed in Pennagaram followed by Nallampalli and Dharmapuri block. The Very Strong positive trend is seen in Harur and Pappireddypatti.

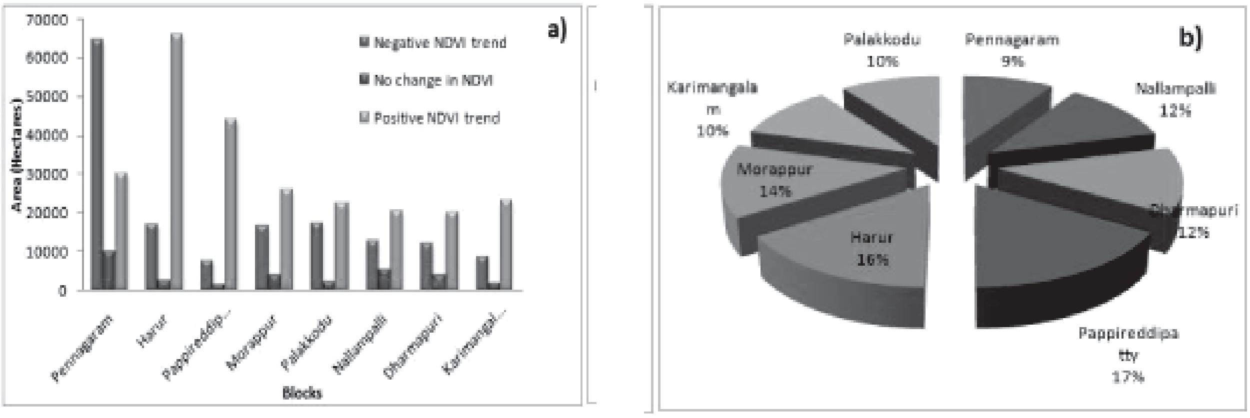


Fig. 5: (a) Area wise distribution of NDVI observed trend. (b) Rainfall distribution of 8 blocks of the study region in the crop growing period.

From NDVI observed trend map the high negative trend of vegetation is identified in Pennagaram block than the other blocks where the average rainfall distribution has been very low (46.69 mm) in the growing season for last 14 years as illustrated in the Fig. 5. This statistical inference proves that there must be a positive correlation between rainfall and NDVI in the Pennagaram block. Conversely, an increasing trend is observed in Harur block followed by Pappireddypatti because of the high average rainfall distribution on the growing season. The total net irrigated area in the Harur block is 15409 hectares. Though the Morappur is the second largest irrigation block and has high rainfall distribution like Harur and Pappireddypatti, it is the fourth block which shows a strong negative trend among all other blocks. This may be due to human intrusion on the study region. The NDVI observed trends were analysed with grid correlation coefficient result in order to extract the rainfall or human induced desertification

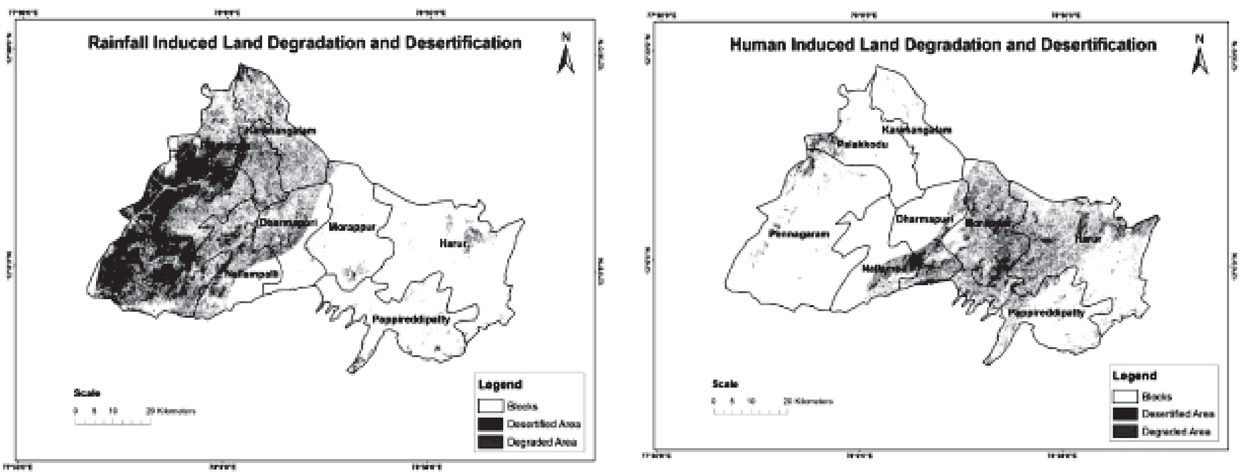


Fig. 6: (a) Block wise Distribution of Rainfall induced Land Degradation and Desertification. (b) Human Induced Land Degradation and Desertification.

Desertification can be monitored through the long term degradation of NDVI (Hill et al. 2005). The decreasing or increasing trend of NDVI as an indicator of desertification is a combined result of climate and anthropogenic activities (Arnab & Dutta 2011). The Rainfall induced Land degradation has been found out if the areas are having apositive correlation between Rainfall_{mean} and $\text{NDVI}_{predicted}$ with decreasing trend in $\text{NDVI}_{observed}$ (Fig-3a). Similarly, human induced Land degradation has been found out if the areas are having anegative correlation between Rainfall_{mean} and $\text{NDVI}_{predicted}$ with decreasing trend in $\text{NDVI}_{observed}$. And again the resultant raster datasets have been cross examined with short term NDVI (Fig-3b) in order to differentiate the land degradation and desertification (Fig-6). Some portions of the study region have not been renovated even after experiencing an adequate rainfall occurred from 2013-2014, hence termed as desertification. Therefore desertified area has been extracted with the aid of short term NDVI trend. No correlation places of long-term correlation map (2001-2011) and zero trends of the long-term NDVI trend map are significantly changed into negative NDVI trend in 2012-2015. The rate of built-up lands has been increased significantly during this period. So the recent degradation has also been considered as an accelerating effect, induced by human (Table-3).

Pennagaram is the block which has been highly (58%) affected by land degradation due to rainfall deficiency from 2001-2011 among which 35 % of the land is not renewed even after adequate rain occurred in 2012-2015. Rainfall induced desertification is least in Harur block (0.05%) because of the sufficient rainfall distribution over a period of time (Table-1).

Table-1
Block wise Areal Extent of Rainfall Induced Land Degradation and Desertification

S. No	*Block*	*Total Area (ha)*	*Total Affected Area (ha)*	*Rainfall Induced Desertificaion (ha)*	*Land Degradation (ha)*	*% of Desertification*	*% of Degradation*
1.	Pennagaram	104316	60352	36185	24167	34.69	23.17
2.	Harur	85456	1131	40	1091	0.05	1.28
3.	Pappireddipatty	52823	970	23	738	0.44	1.40
4.	Morappur	46164	729	258	471	0.56	1.02
5.	Palakkodu	42193	15186	9762	5425	23.14	12.86
6.	Nallampalli	38244	9217	6666	2551	17.43	6.67
7.	Dharmapuri	36044	5622	3262	2360	9.05	6.55
8.	Karimangalam	33945	7986	5555	2431	16.37	7.16

The reliability of the work has been hampered in some of the areas because of the combined effect produced by human and rainfall as mentioned in the Fig-7. Palakkodu is recognised as second largest block which gets desertified by rainfall factor. From the model, the few locations of Palakkodu have been identified as rainfall induced, but in ground, the land has been affected by thehuman intrusion. So, during the rainfall deficiency, human intrusion should have been started in the region in order to support the growing population or to attain the financial security as agricultural practice was not that much feasible in the period.

Though , Morappur has high rainfall distribution like Harur and Pappireddypatti, it is highly desertified i.e about 19 % by human intrusion such as Salinization, intensive agricultural practices beyond the limit, overgrazing, urbanisation etc., (Table-2). Morappur block was highly affected by Salinization process over others. Over cultivation beyond the land productive capacity by feeding more fertilisers have made the land less productive and saline. Socio-economic development leads people who have been engaged in agriculture activities over a period of time, to leave the land as uncultivated for a significant period which in turn converted the land into fallow and salinized state. During the rainfall, the nutrients present in the topsoil are eroded in the absence of vegetation and thus reduces the stability of the soil structure.

Table-2
Statistical measure of Block wise distribution of human induced land degradation and desertification.

S. No	*Block*	*Total Area (ha)*	*Total Affected Area (ha)*	*Human Induced Desertificaion (ha)*	*Land Degradation (ha)*	*% of Desertification*	*% of Degradation*
1.	Pennagaram	104316	1735	127	1607	0.12	1.54
2.	Harur	85456	14349	5644	8705	6.60	10.19
3.	Pappireddipatty	52823	5720	3951	1769	7.48	3.35
4.	Morappur	46164	14927	8794	6132	19.05	13.28
5.	Palakkodu	42193	1508	102	1405	0.24	3.33
6.	Nallampalli	38244	2745	1811	933	4.74	2.44
7.	Dharmapuri	36044	5760	2973	2786	8.25	7.73
8.	Karimangalam	33945	133	13	120	0.04	0.36

Table 3
Block wise Distribution of Recent Human Induceddegradation, Analyzed with Short term NDVI Trend where the Rainfall is Sufficient Enough for Crop Production

S. No.	Block	Total Area (ha)	Short term Human induced Degradation (ha)	% of Degradation (2012-2015)
1.	Pennagaram	104316	4970.7	4.8%
2.	Harur	85456	537.03	0.63%
3.	Pappireddipatty	52823	139.05	0.26%
4.	Morappur	46164	1850.94	4 %
5.	Palakkodu	42193	1133.82	2.69%
6.	Nallampalli	38244	4019.67	10.5%
7.	Dharmapuri	36044	2560.5	7 %
8.	Karimangalam	33945	1052.55	3.1 %

Ground Validation

The in-situ observations are required to elucidate the uncertainties in the result obtained from the scientific analysis. In addition to that, the knowledge of how the land has been managed and utilised at the time of inadequate rain will reveal the information of soil fertility. 10 in-situ observation points are selected randomly from the resultant degradation and

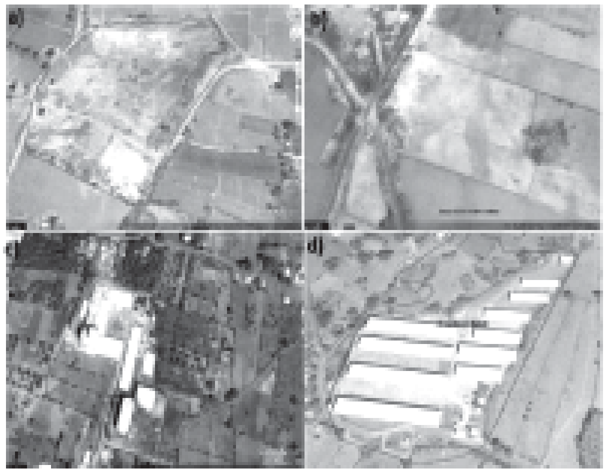


Fig.7: (a) Soil Salinity in Pennagaram Block. (b) Soil Salinization in Morappur Block. (c) Combined effect of desertification in Palakkodu block. (d) Combined effect of desertification in Pennagaram block: Desertified area overlaid on Google earth imagery.

desertification maps and the selected locations were photographed on the site and survey has been conducted with local people to know the human effects on agricultural land. Four validation sites are shown in the Fig-8.

Soil Salinity (Fig-8a) has been inherited from the ground water fluoride during high temperature. Since these areas are experiencing low rainfall, the farmers are not able to perform the desalinization process as it is highly dependent on water availability. The effect has been magnified in the Human affected regions because of the improper land management (Fig-8b). In order to remove the salinity and increase the fertility of the soil, the farmers in the study region have adopted leaching process using Gypsum ($CaSO_4$ $2H_2O$) over a period of time. After removing the salt concentration from the soil, the land has been filled up completely with the new fertile soil of other area and planted with shallow fibrous root system plants such as coconut. The regenerated degraded land is shown in Fig-8c&d .

The transition from zero long term trend to negative recent trend illustrates the human activities such as the construction of structures on the stable land over a period of time. Conversely, the transitions from zero to positive trend areas are rehabilitated zones with proper land management. The salinization rate is increased in the human affected zones because of the improper land management. Some areas of long-term negative trend have been renewed after adequate rainfall and that is proved with there cent short-term positive trend and vegetation growth in the site (Table-2&Table-4).

The study region has been planted based on the

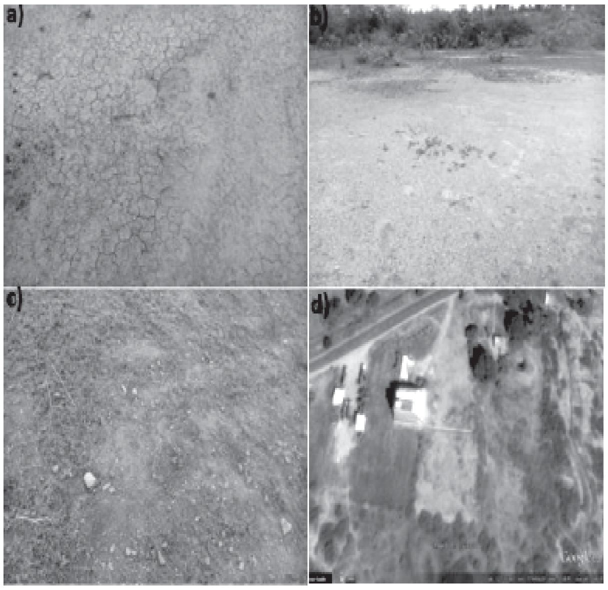


Fig. 8: **(a) Soil Salinity in Pennagaram Block.b) Soil Salinization in Morappur Block.c) Degraded land got renewed after receiving sufficient rainfall.d) The same renewed Degraded land on Google earth imagery.**

Table-4

In-situ Points and Resultant Desertified and Degraded Map Points Together Used for Validation

S. No.	*Location*			*In-situ Survey Scientific Analysis*	
	Latitute	*Longitude*	*in-situ survey*	*Long term NDVI trend*	*Recent Short term NDVI trend*
1.	11.985	77.755	Salinity	-0.034	-0.014
2.	11.946	78.363	Paddy	0.250	0.291
3.	11.904	77.821	Water body	0.000	-0.112
4.	12.368	78.005	Cereal crops	0.023	0.120
5.	12.305	78.075	Manmade structure	0.000	-0.236
6.	12.212	78.281	Man made structure	0.010	-0.113
7.	12.079	78.544	Regenerated Area	-0.025	0.152
8.	12.050	78.536	Salinization	-0.027	-0.109
9.	12.023	78.063	Soil acidity	-0.08	-0.07
10.	12.083	78.368	Rehabilitation work started	0.000	0.020

climatic variations to sustain in the drought period. From the survey, it was observed that during dry period the drought tolerant cereals such as Solam, varagu and Minor millet like Ariyam and little millets crops like samai, are cropped. The farmers are also practicing mist farming during the month of November-December if they have not received enough rain in the south west monsoon. Upon the period crops will take enough moisture from the mist to grow up further. Tapioca is the crop usually planted in this kind.

CONCLUSION

However desertification is closely associated with land degradation and drought, the irreversible effects produced by the process is not at all comparable with land degradation and drought. The desertified soil cannot be reversed at the expected human time frame. The short term NDVI is estimated and used in the final phase of the research work to avoid the misinterpretation of degraded land as desertified which improved the reliability of the result. The land degradation phase is identified from 2006-2012 followed by sufficient rainfall in 2013 and 2014. The degraded land which is not responding to that rain is termed as desertification. So the entire concept has provided a clear insight into the process of extracting desertified area.

In both the cases either rainfall or human, the foremost component that gets deteriorated by the process is soil. Long-term rainfall sufficiency reduces the soil moisture and keeps the moisture level at a wilting point during the period and that significantly affects the vegetation production. In addition to that by nature, salinity is inherited from ground water. Primary nutrient like nitrogen and micronutrients such as Iron, Manganese, Copper and Zinc are less available to the saline affected the soil.

Human intrusion like overgrazing increases the soil compaction, intensive application of fertilisers increases the salinity and urbanisationreduce the agricultural land and rainfall infiltration. The saline soil is generally lack in major primary and secondary plant nutrients such as Nitrogen, Phosphorous, Potassium, Sulfur, calcium and magnesium (N, P, K, S, Ca, and Mg) .Temperature and the wind are also an important climatic component may accelerate the desertification through the process called evapotranspiration. Extreme temperature and wind speed events accelerate evaporation and evapotranspiration, resulting in soil textural variations, soil salinity and wind erosion.

The soil degradation process is not quantified in the study. Since soil salinity is a dominant feature distributed in the surface and sub surface level, the recent advanced technology like microwave remote sensing should be employed in order to quantify the salinity regions accurately. Because of the all weather capability and response towards the electrical properties of the target, Microwave remote sensing can be able to provide adequate ground for extracting the saline affected area than other sources such as optical and multispectral remote sensing.

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REFERENCES

1. Anbazhagan,S., Palpandian,P., Jothibasu Arumugam, Uma Maheswaran,S., Venkatesan,A., Ramesh Veerappan. (2000):"Water Management - Historical Perspective and Development, Chapter: GIS Spatial Analysis for Artificial Recharge - A Case Study from Drought Prone Area",*Research Gate*, pp 107-133.

2. Arnab Kundu, Dipanwita Dutta. (2011):" Monitoring Desertification Risk through Climate Change and Human Interference using Remote Sensing and GIS Techniques",*International Journal of Geomatics and Geosciences*, Vol 2,No 1,pp 21 -33.

3. Batterbury, S. P. J., & Warren, A. (2001): "Desertification", *International Encyclopedia of the Social and Behavioral Sciences*, pp 3526–3529.

4. Budihal, S.L., Raj, G.K., Reddy, R.S., Natarajan, A., Paul, M.A., Bandyopadhyay, Thomas, J.V., Arya, A.S., Ajai. (2005):"Assessment and Mapping of Desertification Status in Bellary District, Karnataka State, Using IRS Data", *ISPRS Proceedings*.

5. Dregne, H. E., (1986):*Desertification of arid lands*: Physics of Desertification.

6. Evans, J., & Geerken, R. (2004): "Discrimination between Climate and Human-induced Dryland Degradation", *J. Arid Environ*, Vol. 57, pp. 535–554.

7. Hanan, N.P., Prince, S. D., & Hiernaux, P. H. Y. (1991): "Spectral Modeling of Multi Component Landscapes in the Sahel", *International Journal of Remote Sensing*, Vol. 12, pp. 1243-1258.

8. Hielkema, J.U., Prince, S.D., Astle, W.L. (1986): "Rainfall and vegetation monitoring in the savanna zone of the democratic-republic of Sudan using the NOAA advanced very high-resolution radiometer", *International Journal of Remote Sensing*, Vol. 7, No. 11, pp. 1499–1513.

9. Hill J. (2005): *Land and Soil Degradation Assessments in Mediterranean Europe*: LADAMER:

10. Hountondji, Y.C., Sokpon, N., & Ozer, P. (2006):"Analysis of the Vegetation Trends Using Low Resolution Remote Sensing Data in Burkina Faso (1982–1999) for the Monitoring of

Desertification", *International Journal of Remote Sensing*, Vol 27, No. 5, pp. 871-884.

11. Jing Zhang, Jian Ming Niu, Tongliga Bao, Alexander Buyantuyev, Qing Zhang, JianJun Dong, XueFeng Zhang (2013):" Human Induced Dryland Degradation in Ordos Plateau, China, Revealed by Multilevel Statistical Modeling of Normalized Difference Vegetation Index and Rainfall time-series", *Journal of Arid Land*, Vol. 6, No. 2, pp. 219-229.
12. Kassas, M (1977):"Arid and Semi-arid Lands: Problems and Prospects. Agro-Ecosystem", Elsevier Scientific Publishing company, Vol. 3, pp. 185-204.
13. Maria, J.R., Pedro, C.C., & Tiago, M.S (2001): "What is Desertification, Desert Links project", Framework- European Union.
14. Montanarella, L(2007): "Trends in Land Degradation in Europe. In: Sivakumar MV, N'diangui N (eds) Climate and Land Degradation", Springer, Berlin.10.1007/978-3-540-72438-4_5.
15. Munkhnasan Lamchin, Taejin Park, Jong-Yeol Lee (2014): "Monitoring of Vegetation Dynamics in the Mongolia Using MODIS NDVIs and their Relationship to Rainfall by Natural Zone", *Journal of the Indian Society of Remote Sensing*, Vol. 43, No. 2, pp. 1-15.
16. Nicholson, S.E., Davenport, M.L., & Malo, A.R (1998):" A Comparison of the Vegetation Response to Rainfall in the Sahel and East Africa using Normalized Difference Vegetation Index from NOAA AVHRR", *Climatic Change*, Vol. 17, No. 2, pp. 209–241.
17. Oldeman, L.R., Hakkeling, R.T.A., & Sombroek, W.G (1990): "World Map of the Status of Human-Induced Soil Degradation. An Explanatory Note",*ISRIC Report*.
18. Adhikary Partha Pratim1, Dash Ch Jyotiprava, Sarangi, A, Singh, D.K (2014): "Hydrochemical Characterization and Spatial Distribution of Fluoride in Groundwater of Delhi State, India", *Indian Journal of Soil Conservation*, Vol. 42, No. 2, pp. 170-173.
19. Pavel P. Propastin & Martin Kappas, Nadiya R. Muratova (2006): "Application of Geographically Weighted Regression Analysis to Assess Human-Induced Land Degradation in a Dry Region of Kazakhstan",*Photogrammetry and Remote Sensing*, pp. 1-16.
20. Peter Meyer, Klaus I. Itten, Tobias, K., Stefan, S., & Ruth, S (1993):"Radiometric Corrections of Topographically Induced Effects on Landsat TM Data in an Alpine Environment", *ISPRS Journal of Photogrammetry and Remote Sensing*, Vol. 48, No. 4, pp. 17-28.
21. Prince, S. D., & Tucker, C. J (1986): "Satellite Remote Sensing of Rangelands in Botswana II: NOAA AVHRR and herbaceous vegetation", *International Journal of Remote Sensing*, Vol. 7, No. 11, pp. 555–1570.
22. Rasmussen, K., Fog, B., & Madsen, J.E. (2001): "Desertification in reverse? Observations from Northern Burkina Faso", *Global Environmental Change*, Vol 11, No 4, pp 271–282.
23. Runnstrom, M.C. (2003):"Rangeland development of the Mu Us Sandy Land in Semiarid China: an Analysis using Landsat and NOAA Remote Sensing Data", *Land Degradation and Development*, Vol 14, No 2, pp 189–202.
24. Sandra Eckerta, Fabia Hüslerb, Hanspeter Linigera, Elias Hodela (2014): "Trend Analysis of MODIS NDVI time Series for Detecting Land Degradation and Regeneration in Mongolia", *Journal of Arid Environments*, Vol. 113, pp. 16-28.
25. Sohou Enagnon Brice, Constant Houndenou, Michel Boko (2014): "NDVI Sensibility to Rainfall Spatial Distribution in ADJOHOUN (Benin, West Africa)", *International Journal of Current Engineering and Technology*, Vol 5, No 1, pp 269-273.
26. Schmidt, H., & Karnieli, A. (2000): "Remote Sensing of the Seasonal Variability of Vegetation in a Semi-arid Environment", *Journal of Arid Environments*, Vol. 45, No. 1, pp. 43–59.
27. Sepehr, A., & Zucca, C. (2010): "Ranking Desertiûcation Indicators using TOPSIS algorithm", *Academia Natural Hazards*, Vol. 62, No. 3, pp. 52.
28. Sharmia Sultana (2008): "Desertification- about Drought, Desertification and Poverty in the Drylands", *Google Blog.*
29. Shewale, M.P., & Shravan kumar (2005): "Climatological Features of Drought Incidences in India" *India Meteorological Department Report*.
30. Thinkable, P. S., & Gamage, M. S. D. N (2004): "The Use of Remote Sensing Data for Drought Assessment and Monitoring in Southwest Asia, Colombo, Srilanka", *International Water Management Institute*, Vol 123.
31. Thomas,D.S.G., & Middleton,N.J (1994): *Desertification. Exploding the Myth*: John Wiley & Sons
32. Unnamalai R & Namasivayam D (2012): "Common Property Resources and Land Degradation in Tamil Nadu, India", *Indian J. Innovations Dev*, Vol. 1, No. 2, pp. 80-86.
33. UNCCD (1994): "United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa", Paris.
34. Wessels, K.J., Prince, A.S., Carroll, M., Malherbe, J. (2007): "Relevance of Rangeland Degradation in

Semiarid North Eastern South Africa to the Non-equilibrium Theory", *Ecological Applications*, Vol. 17, pp. 815-827.

35. Xunming Wang, Fahu Chen & Zhibao Dong (2006): "The Relative Role of Climatic and Human Factors in Desertification in Semiarid China", *Global Environmental Change*, Vol. 16, No. 1, pp. 48–57.

36. Yang, W., Yang, L., & Merchant, J.W. (1997): "An Assessment of AVHRR/NDVI-ecoclimatological Relations in Nebraska, USA", *International Journal of Remote Sensing*, Vol 18, No 10, pp 2161–2180.

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GEOSPATIAL ANALYSIS OF SELECTED DEMOGRAPHIC PARAMETERS FOR COMPREHENSIVE RURAL DEVELOPMENT PLANNING STRATEGY: A CASE STUDY OF MADURAI DISTRICT, TAMILNADU

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ABSTRACT

In spite of rapid urban growth in the country, rural population still accounts for a share of nearly 70 per cent of the total population of India. Rural development planning, therefore, is a vital component of economic planning in the country. One of the barriers in the successful implementation of various projects undertaken in this regard is the size of the population and their economic and social status. There exist very wide variations in this status in rural areas of different parts of the country. Hence, it is essential to have a detailed study of demographic parameters at meso level so that appropriate modification to the rural planning strategy may be made to suit the local condition. The present study is such an attempt to study a district in Tamil Nadu. From the planning point of view, the crucial demographic parameters include sex ratio, literacy, SC/ST population, work participation rate and occupational structure. In addition to that, the vital statistics component of birth rate, death rate and infant mortality rate also play a significant role in deciding the status of population in an area. Madurai district covers a total area of 3700 sq.km. and has a total population of 3038252 persons in 2011. It has a negative sex ratio of 981 and a literacy rate of 66 per cent in the rural areas. About one-fifth of its total rural population comes under the socially downtrodden section. It also has a birth rate of about 16.5, death rate of 7 and an infant mortality rate of 36 per thousand in 2011. Within the district, there are variations at the block level.

Keywords: *Rural Planning, Demographic Parameters, Vital Statistics*

INTRODUCTION

There is no universally accepted approach for rural development. It is the process of improving the quality of life, economic conditions and security of people living in relatively isolated and sparsely populated areas. Rural development has been traditionally centered on the exploitation of land and natural resources such as agriculture and allied activities. However, these areas also have village and cottage industries and crafts, community services, facilities and above all human resources. Srivastava (1961) states that in rural areas, people are engaged in primary industry in the sense that they produce things directly for the first time in cooperation with nature. According to Agarwal (1989), rural development is a strategy designed to improve the economic and social life of rural poor. It connotes overall development of rural areas to improve the quality of life of rural people. Successful implementation of any planning measure depends upon the participation of people. Hence the demographic parameters of an area are to be understood properly in this regard. The present investigation attempts to portray the selected demographic and vital statistical parameters for the study area in order to bring out the sub regional variations which may help to develop suitable development planning strategies.

OBJECTIVE OF THE STUDY

The following broad objectives are formulated for the present study:

- To identify the spatial patterns of rural sex ratio, rural SC/ST population and rural literacy in Madurai district in 2001 - 2011.
- To analyze the status of rural work participation rate and rural other workers category in Madurai district between 2001 and 2011.
- To discuss for the selected vital statistical parameters in the study area for the selected time points.

STUDY AREA

Madurai district is one of the important southern districts in Tamil Nadu. The geographical area

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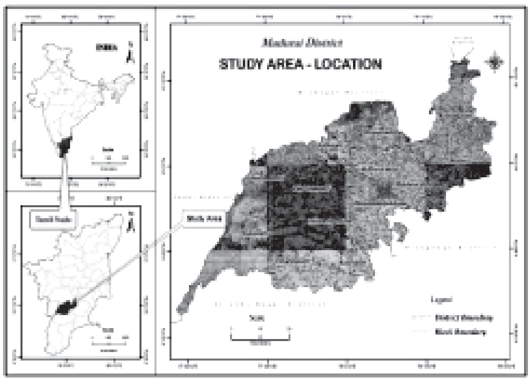


Fig. 1. Location map of Madurai District.

extends between 9° 30′ North and 10° 30′ North latitudes and between 77° 28′ East and 78° 28′ East longitudes. The district headquarters is Madurai city which is situated on the banks of the river Vaigai. Madurai district consists of 7 taluks and 13 blocks. These blocks, namely Kottampatti, Melur, Madurai West, Madurai East, Alanganallur, Vadipatti, Chellampatti, Usilampatti, Sedapatti, T.Kallupatti, Thirumangalam, Kallikudi and Thiruparankundram are considered as the sub units for the study area. The total geographical area of the district is 3697 sq.km. The total population of the area is 30, 38,252 in 2011 (Fig. 1).

MATERIALS AND METHODS

The following data base and techniques are used to the present study area:

- SOI Topographic sheets 1: 50,000 number 58 F/ 12, 58 F/16, 58 G/6, 58 G/9, 58 G/10, 58 G/13, 58 G/14, 58 J/4, 58 J/7, 58 J/8, 58 K/1, 58 K/2, 58 K/5.
- Primary Census Abstracts of Tamil Nadu 2001 and 2011.
- Vital statistical data 2002 and 2011.
- Relevant literature.

RESULTS AND DISCUSSION

(a) Selected Demographic Parameters:

Rural Sex Ratio

The average rural sex ratio for the district as a whole in 2001 was 979 females per thousand males (Table 1). Three categories of Low (less than 980), Moderate (980 - 1000) and High (more than 1000) are considered in the present analysis. Kottampatti, Kallikudi and T.Kallupatti blocks had higher and positive sex ratio in 2001. Chellampatti block had the lowest sex ratio. All other blocks come under Moderate category.

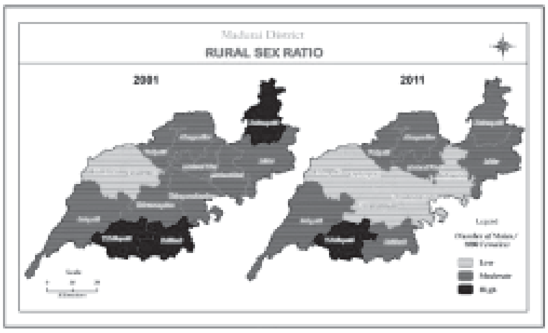


Fig. 2: Rural Sex Ratio.

Table 1
Selected Rural Demographic Parameters in Madurai District

S. No	*Blocks*	*Sex Ratio*		*SC/ ST Population in per cent*		*Literacy Rate in per cent*	
		2001	*2011*	*2001*	*2011*	*2001*	*2011*
1.	Kottampatti	1032	994	13.6	14.9	55.0	63.8
2.	Melur	993	987	19.1	19.2	60.3	68.1
3.	Madurai East	969	972	24.9	26.4	60.0	68.2
4.	Madurai West	991	990	24.7	30.9	66.9	70.9
5.	Alanganallur	983	988	21.8	23.3	58.4	68.1
6.	Vadipatti	986	988	26.1	29.5	59.7	68.1
7.	Chellampatti	904	952	16.3	17.3	57.1	63.5
8.	Usilampatti	936	949	15.8	16.5	56.3	63.2
9.	Sedapatti	967	980	26.8	29.5	54.1	60.6
10.	T.Kallupatti	1019	1025	24.8	26.0	57.1	64.7
11.	Thiruman-galam	959	975	17.9	21.1	61.9	68.7
12.	Kallikudi	1021	998	16.9	18.7	58.4	64.8
13.	Thiruparan-kundram	975	969	14.8	18.7	63.4	65.6
	Madurai District	979	981	19.9	22.1	59.4	66.1

Source: Census of Tamil Nadu in 2001 and 2011.

In 2011 the rural sex ratio of the district improved marginally to 981 females per thousand males. Positive sex ratio is seen in T.Kallupatti block while Usilampatti block had the lowest. Kottampatti and Kallikudi blocks shifted from positive to negative sex ratio in 2011 while Madurai East, Thiruparankundram and Thirumangalam blocks shifted from Moderate to Low category. T.Kallupatti is the only block that had positive sex ratio during both time points of study (Figure 2).

Rural SC/ST Population

In 2001 the average share of rural SC/ST population to the total rural population in the district as a whole was 19.9 per cent (Table 1). For the present analysis three groups of Low (less than 15 per cent), Moderate (15 to 20 per cent) and High (more than 20 per cent) are considered. Melur, Thirumangalam, Kallikudi, Chellampatti and Usilampatti blocks come under Moderate category while Thiruparankundram and Kottampatti blocks have low share.

The average share of rural SC/ST population in the study area increased to 22.1per cent in 2011 (Table 1). Here also Melur, Thiruparankundram, Kallikudi, Chellampatti and Usilampatti blocks have moderate concentration while only Kottampatti block comes under Low category. Only Thiruparankundram block had moved from Low to Moderate category. All other blocks had an increase in the share of rural SC/ST population and there is no change in the grouping during the study period (Fig. 3).

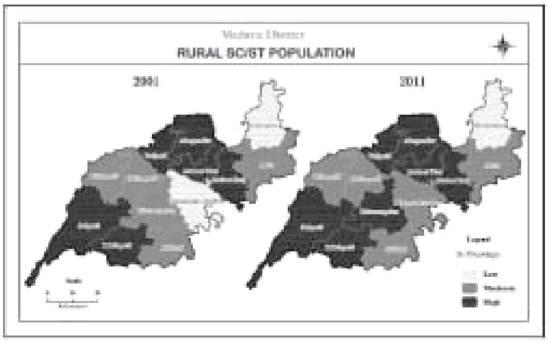


Fig. 3: Rural SC/ST Population.

Rural Literacy Rate

In 2001 the average rural literacy rate for the district as a whole was 59.4 per cent. Low (less than 60 per cent), Moderate (60 – 65 per cent) and High (more than 65 per cent) are considered in the present analysis (Table 1). Only Madurai West block has a high rural literacy rate. Thiruparankundram, Thirumangalam and Melur blocks have moderate literacy. All the other blocks have low level of literacy rate. The average rural literacy rate in the study area increased to 66.1per cent in 2011 from 56.4 per cent in 2001. Kallikudi, T.Kallupatti, Kottampatti, Chellampatti, Usilampatti and Sedapattti blocks have moderate literacy while all the other blocks come under high category in 2011 and no block is found in low category. Between 2001 and 2011 Madurai East, Vadipatti and Alanganallur blocks moved from Low to High category. Kallikudi, T.Kallupatti, Kottampatti, Chellampatti, Usilampatti and Sedapattti blocks shifted from low to moderate literacy rate. Thiruparankundram, Thirumangalam and Melur blocks moved from Moderate to High category (Fig. 4).

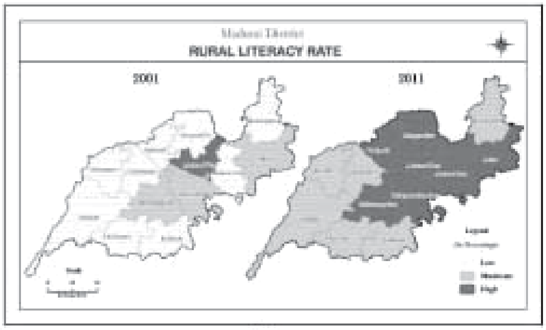


Fig. 4: Rural Literacy Rate.

Rural Work Participation Rate

Table 2 shows the block wise data for the selected time points with regard to work participation rate and other workers category parameters.

Table 2
Selected Rural Occupational Structure
Madurai District (in %)

S. No	*Blocks*	*Work Participation Rate*		*Others Workers Category*	
		2001	2011	2001	2011
1.	Kottampatti	38.8	40.6	22.4	23.0
2.	Melur	37.3	41.6	18.1	24.0
3.	Madurai East	34.6	37.0	40.6	55.1
4.	Madurai West	30.4	36.5	47.2	52.7
5.	Alanganallur	44.3	44.2	21.6	33.1
6.	Vadipatti	42.6	43.4	20.7	29.3
7.	Chellampatti	45.2	44.2	15.7	20.4
8.	Usilampatti	41.9	46.6	25.8	20.6
9.	Sedapatti	42.4	46.0	14.8	18.7
10.	T.Kallupatti	47.9	49.7	21.7	25.0
11.	Thirumangalam	44.5	43.5	28.0	38.7
12.	Kallikudi	53.5	49.7	22.6	29.1
13.	Thiruparankundram	40.5	40.2	55.8	55.1
	Madurai District	41.3	43.0	28.0	31.9

Source: Census of Tamil Nadu in 2001 and 2011.

In 2001 the average rural work participation rate in the district as a whole was 41.3 per cent. For the present analysis three groups of Low (less than 40per cent), Moderate (40 to 45per cent) and High (more than 45per cent) are considered. Kallikudi, T.Kallupatti and Chellampatti blocks come under High category while Madurai West, Madurai East, Melur and Kottampatti blocks have the lowest share. All the other blocks have moderate rural work participation rate.

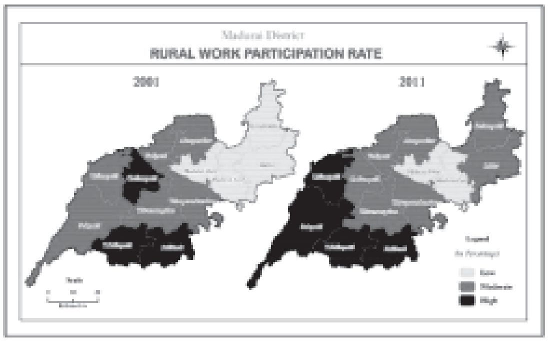


Fig. 5. Rural Work Participation Rate

The average rural work participation rate in the study area slightly increased to 43 per cent in 2011 (Table 2). Kallikudi, T.Kallupatti, Usilampatti and Sedapatti blocks are in High category. Madurai East and Madurai West blocks have lower share while all other blocks come under Moderate category. Only Chellampatti block moved from High to Moderate category. Usilampatti and Sedapatti blocks shifted from Moderate to High while Melur and Kottampatti blocks moved from Low to Moderate category between 2001 and 2011 (Fig. 5).

Rural Other Workers

In 2001 other workers in the rural area constituted only 28 per cent of the total rural main workers in the district. Low (less than 25 per cent), Moderate (40–45 per cent) and High (more than 45 per cent) are considered in the present analysis (Table 2). Only Thiruparankundram block had the highest share while Madurai West, Madurai East, Thirumangalam and Usilampatti blocks have moderate share. Rural other workers for the district had an increased share of 31.9per cent in 2011 (Table 2). Madurai West, Madurai East and Thiruparankundram blocks have a higher share in this regard. Thiruparankundram, Alanganallur, Vadipatti, Kalikudi and T.Kallupatti blocks have moderate share. Usilampatti block shifted from Moderate to Low category while Madurai East and Madurai West blocks moved from Moderate to High category. Alanganallur, Vadipatti, T.Kallupatti and Kallikudi blocks shifted from Low to Moderate between 2001 and 2011(Fig. 6).

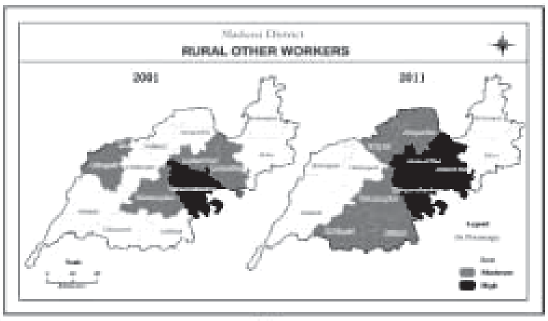


Fig. 6 : Rural Other Workers

(b) Vital Statistics

In this present analysis 2002 and 2011 are considered as the selected time points. Taking data for these selected time points, a block wise explanation of selected vital statistical parameters is attempted here. Birth rate, death rate, infant mortality rate, still birth rate and maternal mortality rate are the parameters taken for the present study.

Birth Rate

The average birth rate for the district as a whole was 19.4 in 2002 (Table 3). For the present analysis three groups of Low (less than 18), Moderate (18 to 20) and High (more than 20) per 1000 persons for birth rate are considered. Kottampatti, Madurai East, Madurai West, Melur and Alanganallur blocks have the highest birth rates. Usilampatti, T.Kallupatti and Thirumangalam blocks have low birth rate. In 2011 birth rate in the district declined notably to 16.7. All the blocks exhibited notable decline in the birth rate while in Melur block it is comparatively less. None of the blocks in the study area showed higher birth rate in 2011. Kottampatti, Madurai East, Madurai West and Alanganallur blocks moved from High to Low category. Melur block shifted from High to Moderate category. Thiruparankundram, Chellampatti, Kallikudi, Vadipatti and Sedapatti blocks shifted from Moderate to Low category

Table 3
Vital Statistical Parameters in Madurai District

S. No.	*Blocks*	*Birth Rate*		*Death Rate*		*Infant Mortality Rate*		*Still Birth Rate*		*Maternal Mortality Rate*	
		2002	*2011*	*2002*	*2011*	*2002*	*2011*	*2002*	*2011*	*2002*	*2011*
1		2	3	4	5	6	7	8	9	10	11
1.	Kottampatti	20.4	17.1	8.5	7.7	41.8	15.0	22.7	11.4	188	50
2.	Melur	20.1	18.3	7.4	6.8	35.1	29.0	17.3	13.7	198	123
3.	Madurai East	20.2	16.2	5.9	4.8	33.8	14.7	17.3	17.1	0	165

1	2	3	4	5	6	7	8	9	10	11
4. Madurai West	20.1	17.7	6.7	5.6	26.9	10.3	20.0	5.0	43	25
5. Alanganallur	20.1	16.8	7.4	7.2	41.4	21.9	19.2	12.1	373	273
6. Vadipatti	18.3	15.5	6.8	6.5	35.8	25.6	27.5	21.0	45	192
7. Chellampatti	19.7	17.4	7.5	7.8	33.6	21.1	25.0	12.6	0	117
8. Usilampatti	17.8	17.3	6.8	7.4	39.8	15.5	33.0	13.8	107	231
9. Sedapatti	18.7	17.1	8.6	7.7	55.2	24.9	31.6	19.8	233	149
10. T.Kallupatti	17.6	12.5	8.2	7.0	29.0	15.5	20.6	19.3	135	59
11. Thirumangalam	17.8	14.9	8.0	6.6	54.0	30.4	21.5	17.6	240	136
12. Kallikudi	18.9	16.8	9.4	8.7	22.4	29.5	25.5	20.8	0	176
13. Thiruparan-kundram	19.8	17.5	6.6	6.2	35.8	20.4	20.3	9.8	114	113
Madurai District	19.4	16.7	7.9	6.5	36.4	19.5	21.3	13.4	130	130

Source: Statistical Hand Book in Madurai 2002 and 2011.

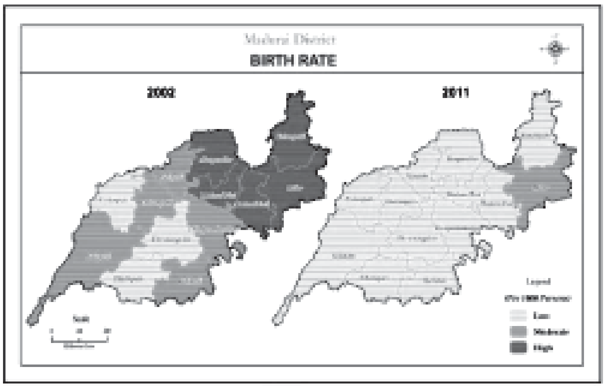


Fig. 7 : Birth Rate

Death Rate

In 2002 the average death rate for the district as a whole was 7.9 (Table 3). For the present analysis three groups of Low (less than 6), Moderate (6 to 8) and High (more than 8) are considered. Kallikudi, Sedapatti, Kottampatti, T.Kallupatti and Thirumangalam blocks have higher death rate while Madurai East is the only block that comes under Low category.

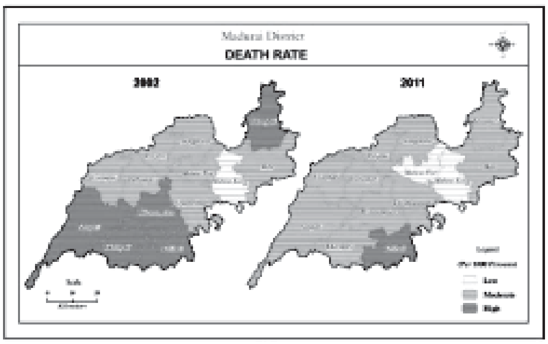


Fig. 8 : Death Rate

In 2011 death rate in the study area slightly decreased to 6.5. Only Kallikudi block comes under higher death rate while Madurai East and Madurai West blocks belong to Low category. All the blocks showed a decline in the death rate between 2002 and 2011 except Usilampatti block which showed a slight increase in death rate. Sedapatti, Kottampatti, Thirumangalam and T.Kallupatti blocks moved from High to Moderate category and Madurai West block moved from Moderate to Low category (Fig. 8).

Infant Mortality Rate

In 2002 the average infant mortality rate in the district as a whole was 36.4 (Table 3). For the present analysis three groups of Low (less than 20), Moderate (20 to 40) and High (more than 20) are considered. Sedapatti, Thirumangalam, Kottampatti and Alanganallur blocks have higher infant mortality rate. The average infant mortality rate for the study area declined sharply to 19.5 in 2011 from 36.4 in 2002. Usilampatti, T.Kallupatti, Kottampatti, Madurai East and Madurai West blocks come under Low category. Only Kallikudi block has shown an increase while all other blocks experienced decline in the infant mortality rate. Highest decline occurred in Kottampatti block which moved from High to Low group. Sedapatti, Thirumangalam and Alanganallur blocks shifted from High to Moderate category. Usilampatti, Madurai East, T.Kallupatti and Madurai West blocks moved from Moderate to Low group between 2002 to 2011 (Fig. 9).

Still Birth Rate

In 2002 the average still birth rate for the district was 21.3. For the present analysis three groups of Low (less than 20), Moderate (20 to 40) and High (more than 40) are considered (Table 3). Usilampatti, Sedapatti, Vadipatti, Kallikudi and Chellampatti

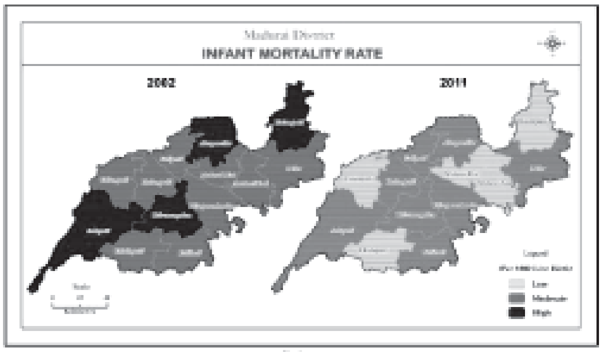


Fig. 9 : Infant Mortality Rate

blocks have higher still birth rate. Alanganallur, Madurai East and Melur blocks come under Low category.

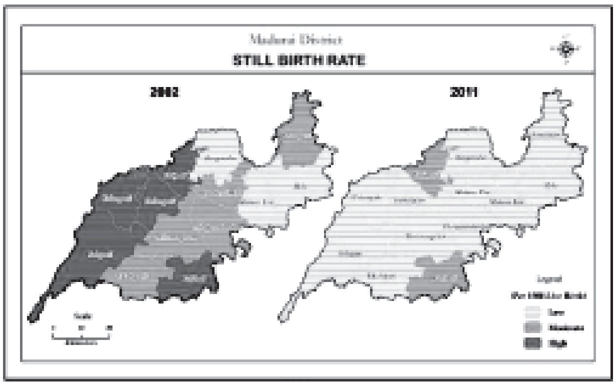


Fig. 10 : Still Birth Rate

The average still birth rate for the district as a whole sharply decreased to 13.4per cent in 2011 (Table 3). All blocks have low still birth rate except Vadipatti and Kallikudi which come under Moderate category. All the blocks have experienced a decline in the still birth rate. However this decline is very high in Madurai West, Usilampatti and Sedapatti blocks in the district (Fig. 10).

Maternal Mortality Rate

In 2002 the average maternal mortality rate for the district as a whole was 130 (Table 3). Low (less than 100), Moderate (100 - 200) and High (more than 200)

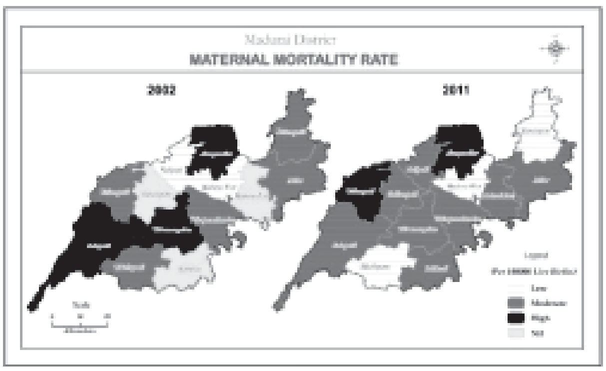


Fig. 11. Maternal Mortality Rate

are considered in the present analysis. Alanganallur had the highest maternal mortality rate while no maternal mortality rate is reported in Madurai East, Chellampatti and Kallikudi blocks.

There is no change in maternal mortality rate in 2011 at the district level (Table 3). Alanganallur continued to have the highest maternal mortality and T.Kallupatti, Kottampatti and Madurai West blocks have the lowest. Madurai East, Chellampatti and Kallikudi which did not report any maternal mortality in 2002 have moderate maternal mortality rate in 2011. Only Vadipatti block shifted from Low to Moderate while T.Kallupatti block has moved from Moderate to Low category. Sedapatti and Thirumangalam blocks moved from High to Moderate. Notable decline is observed in Kottampatti and T.Kallupatti blocks during the study period (Fig. 11).

LEVEL OF DEVELOPMENT OF BLOCKS

The analysis has brought out the fact that there has been wide variation in the status of demographic and vital statistical parameters among the blocks. Using the rank average method of Alexander (1963), blocks are grouped into Very High, High, Moderate and Low levels of development as per the 10 variables which have been taken for the analysis (Table 4).

Table 4
Level of Development of Blocks - Madurai District

S. No	*Blocks*	*Rank Average*		*Level of Development*
		2001/2002	*2011*	
1.	Kottampatti	7.7	5.1	Moderate
2.	Melur	6.3	7.6	Moderate
3.	Madurai East	5.15	5.2	High
4.	Madurai West	4.1	3.8	Very High
5.	Alanganallur	8.2	7.5	Moderate
6.	Vadipatti	7.5	7.9	Moderate
7.	Chellampatti	7.9	8.6	Moderate
8.	Usilampatti	7.2	8.5	Moderate
9.	Sedapatti	10.9	10.2	Low
10.	T.Kallupatti	7.1	6.6	Moderate
11.	Thirumangalam	7.65	6.3	Moderate
12.	Kallikudi	6.55	8.5	Moderate
13.	Thiruparankundram	4.75	5.3	High

Source: Compiled by Researcher.

Fig.12 shows the level of development of blocks. Madurai West is the only block which comes under Very High category. Any rural development planning can be easily implemented in this block.

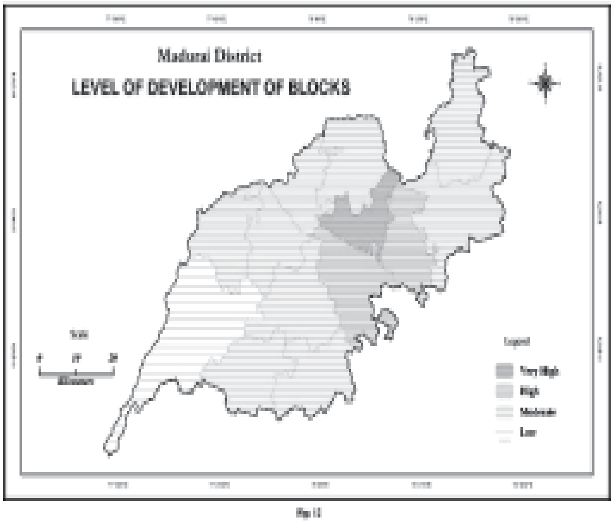


Fig. 12

Thiruparankundram and Madurai East blocks come next. Sedapatti is the only block that has the lowest development. Special attention must be given to this block whenever rural development initiatives are taken by the Government. Other blocks come under Moderate category and require continuous monitoring for successful implementation of rural development planning measures.

REFERENCES

1. Census of India (2001): *"District Census Handbook of Madurai"*, Tamil Nadu series 33, Part 1, A & B. pp. 95.
2. Census of India (2011): *"District Census Handbook of Madurai"*, Tamil Nadu and India (State Views) series.
3. Chandana R.C. (1986): *"A Geography of Population"*, Kalyani Publishers, New Delhi. pp. 217.
4. Cleark John I. (1972): *"Population Geography"*, Pergmon Press Oxford. pp. 88-89.
5. Ghosh B.N. (1985): *"Fundamentals of Population Geography"*, Sterling Publishers Private Limited. New Delhi. pp. 217.
6. Pathak Lalit (1998): *"Population Studies"*, Rawat Publications, Jaipur. pp.1 -12.
7. Sawant S.B and Athawale A.S. (1994): *"Population Geography"*, Metha Publishing House, Pune. pp. 30 - 52.
8. Government of Tamilnadu (2002 and 2011): *"Madurai District A Statistical Hand Book"* Assistant Director of Statistics, Department of Economics and Statistics, Chinna Chokkikulam, Madurai district.

Mountain Cartography : Cartography Education and E-Learning Courses

NATMO'S CONTRIBUTION INMOUNTAIN CARTOGRAPHY : A CASE STUDY OF SIKKIM

Anjana BANDYOPADHYAY[1]& Sonali GHOSH[1],

ABSTRACT

The topography of the mountain area has its own unique signature and has reflection in different socio-economic aspects. NATMO as a pioneer mapping organization contributes in the field of Mountain Cartography through its different publications. This study shows how successfully NATMO has contributed to achieve Government's endeavors of NATION BUILDING.

In this study, the hilly state of Sikkim has been taken into account to analyze the contribution of NATMO in the field of mountain cartography. Sikkim is a landlocked frontier state of India with its own nature and prospects.

A proper development planning plays a pivotal role in order to protect the natural environment, to mitigate any natural disaster, to promote tourism and develop the economy. It requires the detailed understanding of the regional set up from different perspectives. NATMO through its different thematic mapping contribute significantly in good governance. It helps the other Government, Semi Government and local bodies to make informed decisions through spatial understanding. From Developmental point of view there is a wide scope of work where NATMO can provide more value added services to different stretches of our country specially a state like Sikkim.

***Keywords**: Mountain Cartography, Sikkim, Adventure Tourism, Planning, Governance*

INTRODUCTION

Cartography involves both the art and the science for a realistic representation of the real world. Technological revolution in different associated fields has influenced the practice and process of map making in wide way. Evolution in Mechanical, optical and photo-chemical technologies along with the discoveries in electronic capabilities made a new dimension in map production. Many examples of new and innovative mapping are being produced outside the normal orbit of existing cartographers or map producers.[1] In the era of Neocartography & Geovisualization the boundary between map producers and map users has been blurred in a remarkable way. Application based cartography has become the thrust area. Integration of cartographic researches with the other fields of expertise has become the common practice. Government initiatives, decision maker's view and decisions, in the process of making policies and implementation of good governance cartography has established itself as a potential contributor.

Mountain Cartography is an approach to depict the mountainous region considering its morphometric specialty along with the regional setup. The topography with own unique signature has its reflection in the different aspects - landuse, people, occupation, economy, culture. Proper visualization enables to assess the pros and cons of the development of the stretch.

It is obvious that, different regional setup with varying topography require distinct techniques and technologies. In recent times, mountain areas are gaining economic and social importance, especially for its richness in natural resources, potential tourism destination, fresh environment, as well as disaster mitigation. Consequently, mountain cartography is a resurging discipline that involves cartographic techniques beyond the traditional cartography.

In India, the number of natural disasters with devastating consequences in the mountain region is increasing. This is mainly due to the unplanned development activities, high population pressure and partially due to recent climatic changes owing to global warming. Hence economic, societal, cultural and scientific development actions in mountainous areas is the need of the hour in India, which in turn requires a better understanding of the locality through detailed spatial database represented using cartography.

National Atlas & Thematic Mapping Organization (NATMO) is in service to the nation for the last 60 years. This organization has been founded by Prof. (Dr.) S.P. Chatterjee in the year 1956. NATMO started its journey with the publication of 'Rashtriya Atlas' and till date it is contributing for the welfare of different stratum of our society with maps of different themes. In India NATMO is one of the biggest shelters for cartographers & researchers.

1. Research Assistants, NATMO, Deptt. of Science & Technology, GOI

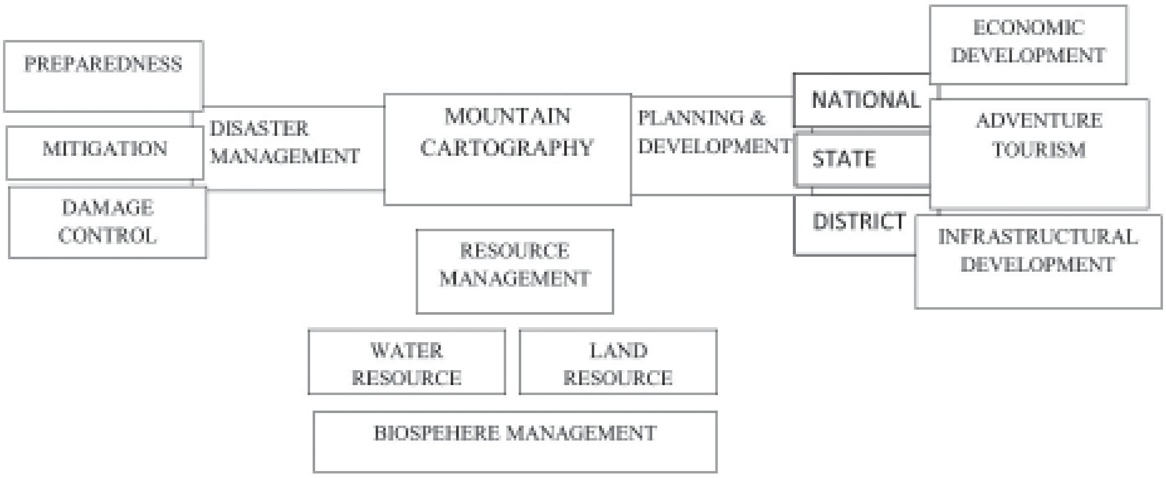


Fig. 1 : Scope of Mountain Cartography

NATMO published more than 2000 maps, atlases & monographs over the years. It covers a very wide range of publications. Starting from School atlases for the children to Braille Atlas for visually impaired persons, NATMO publishes maps and atlases for almost every section of our Society. Including the field of Mountain Cartography NATMO has contributed a lot with its cartographic perception and research oriented approach towards this special kind of regional stretch.

OBJECTIVE

The main objective of this paper is to highlight and analyze the evaluation of the cartographic methods and models used for visualizing mountain topography used in NATMO. This paper also highlights how NATMO has incorporated distinct cartographic techniques, beyond the traditional cartography, for better representation and understanding of the mountain areas of India.

LITERATURE REVIEW

With the growing importance of mountain areas, the demand for adequate cartographic base data with respect to its contents, application, graphic design and the media is increasing. Today's spatial tools and techniques, including Geographical Information Systems (GIS) still lack cartographically adequate and sophisticated visualisation functions. Therefore the development of specialised tools, especially for difficult visualisation tasks of mountainous terrain is a foremost task of cartographic application developers. During the 19th International Cartographic Conference in Ottawa in 1999, a new ICA Commission on Mountain Cartography was established in order to meet the new demands in this domain.

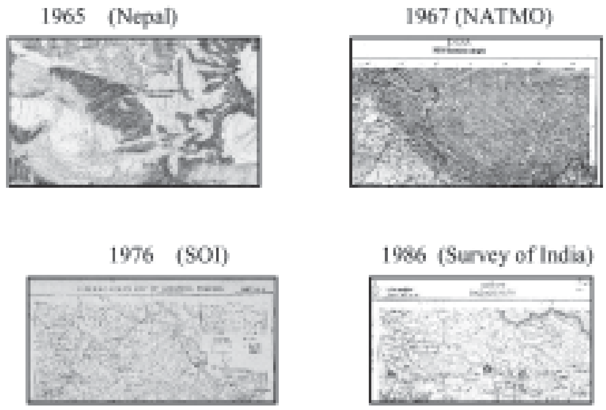


Fig 2: Evolution of Techniques in Mountain Cartography

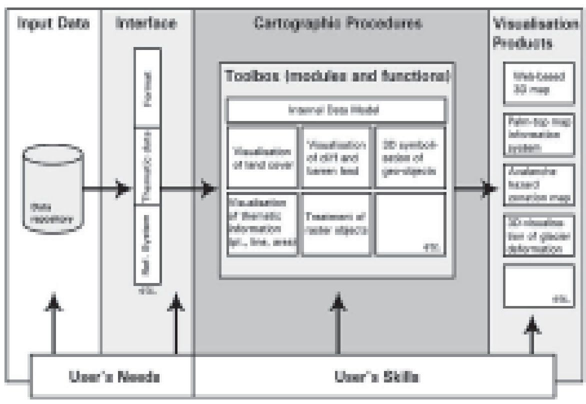
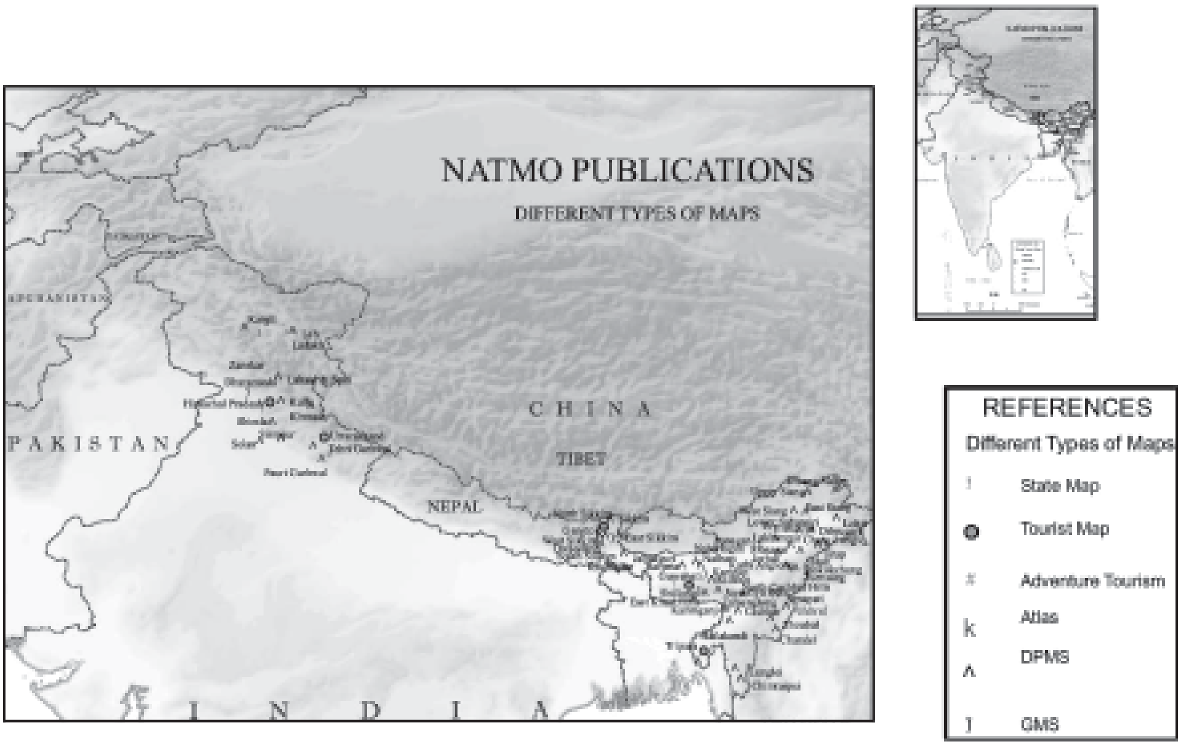


Fig 3: Components of a Cartographic Mountain Information and Visualisation System

DATABASE & METHODOLOGY

The present study illustrates the contribution of NATMO specifically in the field of Mountain Cartography. NATMO is engaged in scientific pursuits for thematic mapping at local, regional and national levels. Previously maps prepared manually. But at present digital technology has brought in new dimensions in mapping.



Map 1 Different Maps & Atlases on Mountain Cartography published by NATMO

NATMO contributes in the field of Mountain Cartography through the following publications:

- DPMS to emphasis the planning aspects
- GMS signifies the mapping of the urban nodes
- Adventure Tourism & Tourist maps emphasize the special tourist attractions and connectivity.
- Geomorphological, Geological, Soils, Natural hazard zonation Maps supplements a lot in the study of vulnerability assessment & Disaster Management

NATMO has experienced a technological shift from Traditional cartography to Digital cartography in late 90's. To keep pace with the technical advancement, to meet up the increasing demand of the different research area, NATMO with the support of proper training and infrastructural upgradation has gradually shifted from traditional time consuming, laborious traditional cartography to digital cartography.

NATMO is an organization which has experienced technological drift and managed to maintain the quality of its publication. Starting from scribing pen to sophisticated software tool, from positive-negative flim to explore to the third dimension, the journey took 60 years and organization contributes more than 2000 maps for the betterment of our nation. Users of NATMO maps are not only a particular section but it includes Students, Researchers, Policy Makers, Government Higher Officials, and Decision Makers of our country.

In this study a particular case study of Sikkim State has been taken into consideration for a detailed illustration of NATMO'S contribution in NATION BUILDING and Good Governance.

DISCUSSION & ANALYSIS

A Case Study of Sikkim

In this study the hilly state of Sikkim has been taken into account to analyze NATMO's contribution. Visualization of physical and socio-cultural setup provides an information base to cater the planning process. NATMO has prepared District Planning Maps for all the four districts of Sikkim – North, South, East, and West.

- NATMO has published a map of 'ADVENTURE TOURISM-SIKKIM & DARJEELING' to promote tourism in this hilly stretch. Especially for mountaineers, NATMO has identified the trekking routes, the mountain biking routes and river rafting routes with a guidance of well composed literature.
- Sikkim is blessed with plenty of natural resource reserve. NATMO has published 'Sikkim Natural Resource Atlas' highlighting its resource base.
- The urban nodes act as focal points of growth and development and urban area mapping is

Table1
List of NATMO Publications covering Mountainous Stretch

Serial no	Nature of Publication	Theme of Publication	Coverage	Publication	Scale	Remark
1	Map	Adventure Tourism	India	India – Adventure Tourism	1:6,000,000	
2	Map	Adventure Tourism	Ladakh&Zanskar	Adventure Tourism : Ladakh&Zanskar	1: 250,000	
3	Map	Adventure Tourism	Uttarakhand	Adventure Tourism – Uttarakhand	1:400,000	
4	Map	Tourism	Sikkim	Sikkim Tourism	1:150,000	
5	Map	Trekking & Tourism (H)	Uttarakhand	Trekking & Tourism (H)	1:1,000,000	In hindi
6	Map	Environment & Tourism	Northern India	Environment & Tourism – Northern India	1:2,000,000	
7	Map	Tourism Infrastructure	Northern India	Tourism Infrastructure – Northern India	1:2,000,000	
8	Map	DPMS: Arunachal Pradesh :- Lohit, West Siang, Tirap, Upper Siang, Lower Subansiri,DibangValley,Chang Lang, East Siang			1:250,000	District Planning Map Series Or DPMS Maps are single sheet maps with **district level** landuse with inset Maps (1:1M) Of associated themes. Specially prepared as an aid to District Level Planning.
9	Map	DPMS: Assam :- Barpeta, Cachhar, Dibrugarh, Hailakandi, Kamrup, Karimganj, Lakhimpur, Nalbari, Tinsukiya, Sibsagar, Jorhat, North Cachhar Hills			1:250,000	
10	Map	DPMS: Himachal Pradesh :- Kinnaur, Kullu, Lahaul&Spiti, Shimla, Sirmaur, Solan			1:250,000	
11	Map	DPMS:Jammu & Kashmir :- Kargil, Leh (Ladakh)			1:250,000	
12	Map	DPMS:Manipur :- Chandel, Senapati, Thoubal, Ukhrul			1:250,000	
13	Map	DPMS:Meghalaya :- East Khasi Hills, Jayantiya Hills, Ri-Bhoi			1:250,000	
14	Map	DPMS:Mizoram :- Chimtuipui, Lunglei			1:250,000	
15	Map	DPMS:Nagaland :- Mon, Tuensang,Mokokchung			1:250,000	
16	Map	DPMS:Uttaranchal :- PauriGarhwal, TehriGarhwal			1:250,000	
18	Map	DPMS: West Bengal :- Darjeeling,Jalpaiguri			1:250,000	
19	Map	GMS : Dharamsala, Itanagar&Naharlagun etc.			Scale varies from 1:5000 to 1:10000	Golden Map Service (GMS),ambitious project for urban nodes

required to ensure good governance, NATMO has also prepared 'GANGTOK- Golden Map Series Map'.

Sikkim at a glance

Spread below Kanchenjunga, world's third highest mountain, lies Sikkim – a mountainous state bounded by Tibet in the North, Bhutan in the East, Nepal in the West and West Bengal in the South. Sikkim is the 22nd State of India. The entire state is mountainous, with altitudes ranging from 300 to 8,586 metres from sea level. The opening of the Nathula Pass on July 6, 2006 connecting Lhasa, Tibet to India is expected to give a boost to the local economy, though the financial benefits will be slow to arrive. Sikkim has a very rugged topography and formidable physical features. The whole state is enclosed on three sides by lofty ranges and spurs of Greater Himalaya with varying heights on three sides. In the north, the Greater Himalaya is stretched in convex form while in the west, the Singalila range, which is a spur of great Himalaya, is extended from north to south and separates the state from Nepal. The Donkya range, forming the eastern boundary of Sikkim, is much segregated with only two gaps, Nathula and Jalepla, which provide trade routes between Sikkim and Tibet.

Map 2: Sikkim at a Glance

Kanchenjunga, the towering mountain God and protective deity of the Sikkimese forms a backdrop of immense proportions. The name Sikkim is an appellation of Nepalese origin meaning "new palace". The Tibetans called it "Denzong" or "the land of rice". It was known to the Lepchas, the original inhabitants of Sikkim as "Nye-maeel" or "heaven".Sikkim is drained by Tista River and its tributaries. Gangtok is one of the important tourist centre in North Eastern India. Gangtok has a great potentiality in the development of tourist industry not only in Gangtok itself but also in the northern and western part of Sikkim.

Sikkim offers the tourist a singular experience amidst the magnificent vistas of ice-clad peaks framed by dense tropical vegetation, forested slopes and ridges, fast flowing rivers and a tranquility visited on it by the Gods of its numerous legends and mythologies. Here in the mystique of the mountain mists, the flutter of prayer flags, in the swirling clouds that shroud its emerald valleys, in the warmth, hospitality and gentleness of its citizen's one gets a chance to glimpse the magic and mystery of an ancient culture, the life-style of a people.

Trekking is popular in Sikkim when the trekker gets an opportunity to see the unspoiled culture of the country and also the various types of flora specially orchids. Sikkim is also known as the 'land of orchids'. Besides the development of tourism, Agriculture is also an important occupation of the people. They belonging to a number of religion and sects has varied festivals along with colourful dances is an added attraction to the tourists besides Sikkim's rich natural beauty. Tourist industry has a tremendous possibility of development.

With the development of road and transport and expansion of power supply,all the natural and human endowments that the state is blessed which can make Sikkim into a prosperous unit of the Indian Republic. The land houses a continuous carpet of undisturbed forest mass. This is a place of space, tranquility and serene beauty for the refreshment of mind and body. There are 4 districts in Sikkim. Sikkim is situated in an ecological hotspot of the lower Himalayas, one of only three among the eco-regions of India. The flora of Sikkim includes the rhododendron, the state tree. The fauna includes the Snow Leopard, the Musk Deer, the Bhoral, the Himalayan Tahr, the Red Panda, and the Himalayan Black Bear etc. The state is gifted with abundant and natural resources. The resources can be grouped into biotic or abiotic, both of which can be renewable. Sikkim does not have any airports or rail heads because of its rough terrain. The closest airport, Bagdogra airport, is near the town of Siliguri, West Bengal. The airport is about 124 km away from Gangtok.

Present Conditions

The state of Sikkim is entirely dependent upon road transport as there is no air and rail links. The nearest railway station is New Jalpaiguri and airport at Bagdogra in West Bengal. The 41 km stretch of National Highway 31A runs through state from Rangpo to Gangtok. Besides, the Border Road

Organization is also constructing and maintaining roads particularly adjacent to China and Bhutan borders. Unfavourable physiographic and climatic conditions do not permit habitation in northern part of the state. Therefore, the population in this part is very sparsely distributed that too only in Lachen and Lachung valleys. The pace of urbanization is very slow in the state. Nevertheless, the National Atlas & Thematic Mapping Organisation (NATMO) is closely associated with this state in order to meet its cartographic requirements. "Natural Resources Atlas of Sikkim" is another milestone of such association. In this Atlas an attempt was made to depict the physical set up, resources, infrastructures and various socio-economic pattern, which should help depicting the environmental and development issues and consequently to make a strategy for development specific to this state. The planners, researchers and academicians will find a basis for carrying out new initiatives and researches for working out a strategy for balanced development/ Sikkim can become a model state and an example of how an economically backward state can take a leap forward.

NATMO Publications:

Table-2 Maps & Atlases of Sikkim

Serial no & type	Theme of Publications	Area	Coverage	Scale	Remark
1. Atlas	Resources Atlas	Natural Resources Atlas of Sikkim	State	1:400,000	Resource Management
2. Maps	DPMS	East Sikkim	District	1:100,000	For Planning
3. Maps	DPMS	West Sikkim	District	1:100,000	
4. Maps	DPMS	North Sikkim	District	1:150,000	
5. Maps	DPMS	South Sikkim	District	1:100,000	
6. Maps	GMS	Gangtok	city	1:8000	Urban
7. Maps	Tourism	Adventure Tourism Sikkim & Darjeeling	District	1:200,000	Tourism
8. Map	Administrative	Sikkim	State	1:150,000	General

Natural Resource Atlas of Sikkim

For spatial planning and economic development sound Information system on natural resources of state is required. This atlas will provide valuable system to define measures for regional inequality and spatial distribution of the resources. The atlas will also highlight the problems in a correct Spatio–Temporal frame works. The main objective of the atlas is to provide detail information of natural resources – their potentiality and constraints which determine the course of development in wider spatio – temporal frame work. The scale of the maps on Sikkim is 1:400,000 scale, while the maps on 4 districts of Sikkim is on1:300,000 & 1:180,000. This Atlas prepared in collaboration with Sikkim Government. It consists of 31 plates, out of which 9 plates are related to India on 1:12,000,000 scale. Those maps depict the different aspects such as Administrative, Physical, Geology, Climatic, Soil & Natural Vegetation. The rest 22 plates are related to Sikkim. They are Administrative, Physiography, Drainage, Natural vegetation, Soil, Rocks & Minerals, Forest Population, Land use, Industries, Tourism etc. Environmental aspects have been given due importance. Hence map on environmentally sensitive zones, natural hazards, wild life & wetland added in this atlas. Infrastructure is one of the important criteria to measure the socio-economic status of the state. So one map shows the National and State Highways while the other Road Network. The main source of information is satellite imagery.

DPMS Maps of Sikkim

This is a unique project with a minimum of ten most essential thematic inputs that serve as a ready reckoner for planners, administrators and for the general public as well. It receives much popularity and appreciation. The main map of DPMS North Sikkim (Scale 1:150,000), South Sikkim (Scale 1:100,000), East Sikkim (Scale 1:400,000), West Sikkim (Scale 1:100,000) have shown in different scale according to the size of the district. Apart from this 9

Map 3 : District Planning Map Series – South Sikkim

Inset maps i.e. Relief & Slope, Rocks & Minerals, Soils, Irrigation & Hydrogeology, General Land use& Cropping Pattern, Climatic Conditions, Industries, Population, Transport & Tourism are also shown in each District Map. In DPMS North Sikkim Map snow-field, Glaciers, Rocky Waste –this type of land features are also highlighted. The District map of Sikkim is a ready-reckoner to the researchers, students in respect of complete geographical, geological, geomorphological, demographic, cultural information and features along with administrative boundary, blocks, specialty, etc. of a particular district both in paper format and in digitized format.

Golden Map Service (GMS) – Gangtok

GMS is a promising venture to provide location based information or coordinate based information of any part of Gangtok to any user. It takes the advantage of electronic media to cater to the needs of the users. The scale of the main map is 1:8000. One inset map of "Core Zone" is also shown. GMS is a most ambitious project of NATMO, which has been designed to provide attached quarry oriented data base in integrated (spatial & attribute data) GIS environment for the Planners, Administrators, Researchers & common users. Hard and soft copies are its byproducts. GMS also provide Route maps between two points in the town. Administrative, Residential, Religious sites, Educational & Training Institute, Financial Institution, Services & Commercial, Health Sector, Food & Lodging, Landmarks, Museum, Government Building, Railway Stations, Bus Stations, Towers, Rivers, Lakes, Sports &Recreation Places, Forts, Castles, Libraries, Street Names and every possible Spatial and Non Spatial Information – all are shown in detail in Gangtok GMS map.

Utilities of GMS at a Glance

- Routes between two places or locations
- Movements and rescue operations during disasters
- Provision of Maps on mobile phones
- Circumvention Crimes

Different Aspects of GMS

It has to its credit of using high resolution satellite data to map in scale of 1:8000, Cartosat Imagery used here. It also aims to establish connectivity between two adjacent cities that further connects to other cities and finally to connect the nation within a single network.

- As a next phase, preparation has been initiated to process the data so as to make it intact for Web Publication, which is the core aim of the project.
- It is expected that the proposed goal will be fulfilled in a short time and users can get the advantage of the technology.
- Methodology
- Selection of Study Area
- Pre-field data collection
- Identification and marking of GCPs on imagery & toposheets
- Data acquisition of GCPs by GPS survey
- Rectification of imagery with reference to GPS data
- Detail land use survey
- Preparation of Land use Maps with the help of digitization
- Scrutiny of Land use Maps and Ground Verification
- Further Processing for web & Publishing Map
- Contribution of GMS in Planning & Development
- The continued economic growth of India is largely dependent on the development of her natural resources and Golden Map Service as modern geo-spatial techniques can play an important role for assessment and monitoring the resources for development.
- The faster, up to date, accurate and cost effective
- Derived data by this technique can also be useful
- For the planning of rural development and better planning monitoring, management and good governance of urban areas.
- In this way GOLDEN MAP SERVICE project of NATMO by providing faster, up to date and accurate data can play a solid role in the development of the country.

Adventure Tourism Map – Sikkim & Darjeeling

The scale of the main map is 1:200,000. Here all the General Information eg. Boundaries, Roads, River, Glacier, Forest and other amenities are shown. Apart from that Bird watching centre, home stay, Sightseeing route by Helicopter are also shown. These are the new things shown in the map. Besides the main map small Inset maps of River Rafting (Scale 1:2,66,000) and Mountain Biking (Scale1:4,50,000) are also highlighted. Popular Biking Routes are very helpful for the adventurers. Trek Routes proposed by Department of Tourism, Government of Sikkim are also highlighted on the map. In the back side of the map the following things are shown i.e. "About Sikkim, General Information, Action Prohibited in Wildlife Area, Bird Watching in Sikkim and Darjeeling, Mountaineering in Sikkim, homestays in Sikkim, Trekking in Sikkim and Darjeeling, Mountain Biking, list of Sacred Peaks, Caves, Rocks, Lakes, chortens, Hot Springs, and River Rafting". Sikkim is very popular for easy, moderate and high altitude

Table 3
Important Trekking Routes

Sl. No.	*Name of Important Trek*	*Places Covered*	*Suitable Month for Trek*
1.	Monastic Trek	Pemayantse-Sangacholing, Khedchopalri-Dubdi-Sinon-Tashiding-Ralong	March-May/Oct-Dec
2.	Rhododendron Trek	Naya Bazar-Hilley/Soreng ,Dentam-PemayangtseVarsey	March-May
3.	Khangchendzonga Trek	Yuksom-Bakhim-Tsokha-Dzongri-Lamune and Back	Mid March-Mid MayMid Oct to Mid Dec
4.	Coronation Trek	Rumtek-Sang-YangangRabangla-Tashiding-Yuksam	Oct-Dec
5.	Areylungchok-Dzongri Trek	Labdong-KasturiUrar-Chamrey-Thangsing-Lamune-Dzongri-Yuksom	Mid March-Mid MayMid Oct to Mid Dec
6.	YambongSingalila Trek	Nambu-Chongri-Yambong-Dzongri-Thangsing-Lamune-Dzongri-Yuksom	Mid March-Mid MayMid Oct to Mid Dec
7.	NarsingHimal Trek	Borong-Pokhri-Thumki-PhediUrar-Tin Devanay and Rani Taar	Mid March-Mid MayMid Oct to Mid Dec
8.	Tholung – Kishong Trek	Bay-Tholung-Tholpe-Dawathang-Shingo-Thepala-PachPokhri	Mid March-Mid MayMid Oct to Mid Dec

trekking. Sikkim has a number of popular challenging trek routes in West and North districts. All the trek routes are fairly reachable by jeep or car. There are three fields of interest in trekking e.g., trekking to peaks / mountains, glaciers and passes. Sikkim has more than 20 mountain peaks, a number of lakes

Map 4: Adventure Tourism –Sikkim & Darjeeling

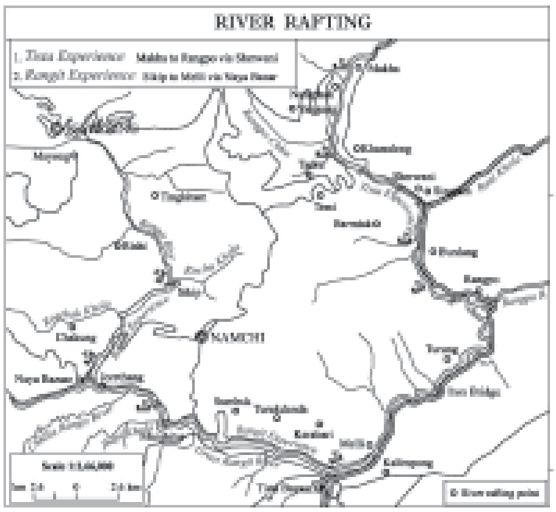
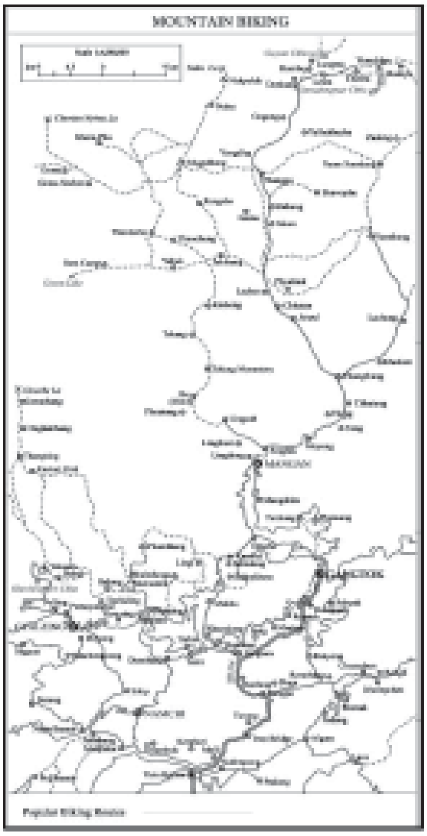


Fig 4 : Gurudongmar Lake, 17,500 ft, North Sikkim

Major River Rafting Routes in Sikkim

(On Tista) – Makha, Sherwani,Burdang,Rangpo

(On Rangit)- sikip, Jorethang,Manjhitar,Melli



Source: NATMO

Map 5 : Mountain Biking Routes

and passes to trek. The trek routes in Sikkim are :- Dzongri, HMI base camp at Chaunrikhiang, Rathongglacier, Goeche La / Samiti, GreenLake, Donkya La trek. The jeepable road head in this trek is Gurudongmar. Mountain Biking is another adventure sports which is also very popular in Sikkim. A number of popular biking routes nearly all over the state prevail through out Sikkim.Some routes may be found interesting as adventure experience, while others are easy biking routes through remarkable landscape. All the important trekking routes are shown in the map.So this map is very helpful for Mountaineers and Trekkers.Adventure Tourism Maps are among the recent Publication of NATMO. It is very popularly used by the Trekkers, Mountain Bikers & Tourists. On the other hand Tourist agencies & Government Tourist departments also refer the same as a good resource to promote tourism in Sikkim. Map furnish important details related to Trekking Routes and it seems to be very resourceful for Mountaineers and tourists.

Future Prospects

This study shows how successfully NATMO has contributed to achieve Government's endeavors. For

Fig 5 : The Topography of North Sikkim

the development of the economy of Sikkim proper planning is necessary and NATMO supports in all respects. The village level mapping is required and emphasized to formulate proper risk management plan. A detailed database of rural settlement and villages are the need of the hour. In future NATMO can work in this aspect with a collaboration of the local bodies of state as well as district level. With the light of mountain cartography NATMO has established itself as a blessing to Sikkim's fortune and with a hope it may be concluded that as a thematic mapping organization NATMO will always stand beside the people, and will act as a positive catalyst to build our nation in an optimistic way. NATMO is dedicated towards —Geo-spatial thinking, Information and communication technology and Planning for governance. NATMO, since its inception, sticks to the core idea of educating the people with geo-spatial knowledge with the help of maps & atlases. There is no better tool than a thematic map to show the gradual changes that includes administrative, agriculture, industrial, political, social etc. in a accurate way. Use of geo-spatial technology is the most effective tool for the disaster management. NATMO can do different maps for micro, macro and meso –level mapping for proper planning of the country.

Note

1. Neocartography Commission of the International Cartographic Association (ICA)

BIBLIOGRAPHY

1. Different Maps of Sikkim published by NATMO, Government of India
2. Mallet, F.R. (1974) Geology of the Darjeeling District and Western Duars. Memovis, G.S.I, Vol.2, Part I.
3. Natural Resources Atlas of Sikkim, published by NATMO, 2009

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COMPARATIVE STUDY OF SATELLITE BASED ESTIMATED RAINFALL DATA WITH RAIN GAUGE DATA OVER HIMALAYAN RIVER BASIN OF INDIA

Anoop Kumar SHUKLA[1], C.S.P. OJHA[2] & R.D. GARG[2]

ABSTRACT

Research has been conducted to compare monthly and monsoon season precipitation rates derived from Tropical Rainfall Measuring Mission (TRMM) multi-satellite precipitation analysis (TMPA) and rain gauge analysis from January 1998 to December 2012. The TRMM 3B43 V7 derived high resolution satellite product is used to provide the best precipitation estimate on every 0.25°x 0.25° grid. TRMM 3B43 V7 has level-3 monthly rainfall products. It is a combined product of rainfall related information provided from TRMM Microwave Imager (TMI), Precipitation Radar (PR) and gauge data of ground validation (GV) sites across the world. TMI sensor provides information on monthly rainfall, rain rate, rain frequency, and freezing height. PR sensor provides information on monthly total surface rain, snow ice layer, surface rain rate, rain profile at varying altitudes of 2, 4, 6, 10 and 15 km, fractional rain, storm height histogram, and path attenuation. Rainfall data from GV sites provide rain maps and 3-D maps. Hence, the final combined outputs are the generation of global gridded rainfall data and calibration of the combined instruments. Rainfall of four rain gauge stations viz. Rudraprayag, Tehri Garhwal, Chamoli and Uttarkashi in the Himalayan river basin is studied. Statistical analysis was done to study the relationship of the TMPA product with the rain gauge station data. Resulting statistical measures consisted of the linear correlation coefficient (r), Mean Square Error (MSE), Root Mean Square Error (RMSE) and Average Percentage Error (avg. % error). The results of these analyses indicate that satellite data have lower values than the gauge estimation values. The validation analysis showed a very good relationship with the rain gauge data on monthly as well as monsoon season time scales. The correlation coefficient (r) of four rain gauges for the monthly rainfall and for the monsoon season was found 0.99. The average % error estimate of 6.84, 6.82, 5.47, and 6.16 was observed for Rudraprayag, Tehri Garhwal, Chamoli and Uttarkashi rain stations respectively. The isohyets, prepared using gauge rainfall data matched well with the spatially distributed rainfall surface generated by TRMM satellite data for the study area. From the averaged spatial-temporal comparisons it was observed that the TRMM 3B43 rainfall estimates were much closer to the rain gauge data, with minimal biases for a period of January 1998 to December 2012. The results of the study show that the precipitation estimates from TRMM 3B43 can effectively be applied in the interpolation of missing gauge data, and in the verification of precipitation uncertainties at the basin scales with minor adjustments, depending on the timescales considered. In general, the data from TMPA have potential to replace rain gauge data, especially to replace the monthly data, if inconsistencies and errors are taken into account.

Keywords: *Rainfall, Rain Gauge, River Basin, Satellite Data, TRMM TMPA.*

INTRODUCTION

Rain is an important climatic variable with regard to many areas of study, e.g. environmental science, hydrology, drainage basin response and soil applications (Huang et al., 2011). In these studies, spatial and temporal variation characteristics of precipitation are needed. However, precipitation estimation is a challenge in a large part, especially in areas with complex hilly terrain or remote areas and without rain gauge stations (Gottardi et al., 2012). The accurate rainfall estimation is a key factor in the context of water resource develop-ments to develop a run-off model, flood forecasting, ground water recharge for agriculture purposes, design and operate the civil infrastructures (reser-voir, dam, bridge, etc.) and also to detect and solve environmental problems related to water like pollution, flooding and drought etc. The rain-fall is highly dynamic and variable in the form of quantity and intensity over a given area. The traditional method of recording rainfall is through instruments, which records accurate rainfall amount that passes over it, but determination of its spatial distribution is nevertheless a major restriction. To address the same, remote sensing techniques can be employed for accurate rainfall estimation by radiometer observation from the satellite. The Tropical Rainfall Measuring Mission (TRMM) is one of the most useful missions for calculating rainfall over the earth. Remote sensing and geographical information system can provide spatial precipitation patterns (Alamgir, Bernier, and Racine, 2004; Cristobal, Ninyerola, and Pons, 2008; Takayabu and

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Hikosaka, 2009). Moreover, satellite remote sensing is a better source of spatial precipitation data (Gebremichael et al., 2008; Moazami et al., 2013). Such data are generally available over longer periods and cover large areas. In this study, we used blended data products for the Tropical Rainfall Measuring Mission (TRMM). It produces three hourly rainfall data at 0.25°×0.25° spatial resolutions. In this research work the 3B43 V7 product of TRMM data is utilized for determination of the rainfall variations.

OBJECTIVES

The specific objectives of this study are:

(1) The objectives of this study are to evaluate the reliability of Tropical Rainfall Measuring Mission (TRMM) 3B43V7 algorithm to study the annual rainfall in Upper Ganga river basin and to analyze the annual rainfall distribution.

(2) Tropical Rainfall Measuring Mission (TRMM) satellite data has been used to derive annual rainfall amount and compare with gauge station's rainfall data over Upper Ganga river basin.

STUDY AREA

The Ganga river is the longest river of India and ranks among the world's top 20 rivers by the amount of water discharge. The Ganga begins at the meeting of the Bhagirathi and Alaknanda rivers, which meet at Dev Prayag in Tehri Garhwal district of Uttarakhand State of India within the mountains range of the Himalayas. The Bhagirathi river has been con-sidered as a true source of the Ganga which rises at the foot of the Gangotri Glacier, at Gaumukh. The Ganga River is divided into three zones, viz. Upper Ganga basin, Middle Ganga basin and Lower Ganga basin. The study area, Upper Ganga basin is located in Northern India which covers an area of around 22,580 km^2. The altitude ranges from 7400 m in the Himalayan mountain peaks to 90 m in the plains. Approximately 433 km^2 of the entire area of the watershed is under glacier landscape and 288 km^2 is under fluvial landscape. The Ganga river basin is situated in Uttarakhand state, India within geographical coordinates $30^0 38'$ to $31^0 24'$ N latitude and $78^0 29'$ to $79^0 22'$ E longitude with area of 4495.52 km^2 up to Uttarkashi.

The annual average rainfall in the Upper Ganga basin ranges between 550 and 2500 mm (Bharati and Jayakody, 2010), and a major part of the rains are due to the south-westerly monsoon that prevails from July to late September. The geographical location and other details of the study area Upper Ganga river basin are given in Fig. 1.

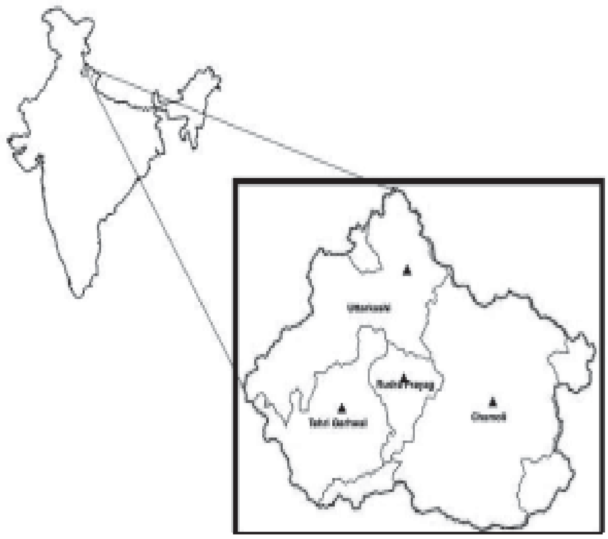


Fig.1: Study Area Location and Location of the Rain Gauge Stations Used for Validation.

DATA COLLECTIONS

Tropical Rainfall Measuring Mission

In this study, the TRMM 3B43 V7 products are used. TRMM 3B43 V7 data were downloaded from The NASA Goddard Earth Sciences Data and Information Services Center website (http://mirador.gsfc.nasa.gov/). These data provide global coverage of precipitation within the global latitude belt from 50° S to 50° N, at 0.25° × 0.25°spatial resolution and 3-hour temporal resolution. The monthly precipitation was obtained directly from TRMM 3B43 V7 data that are at the monthly temporal scale, and the annual precipitation from January 1998 to December 2012 was calculated by accumulating the monthly TRMM 3B43 V7 precipitation data for each month of each year. Moreover, the original TRMM 3B43 V7 precipitation data were calibrated based on the relationship between the original TRMM 3B43 V7 and data from four rain gauge stations.

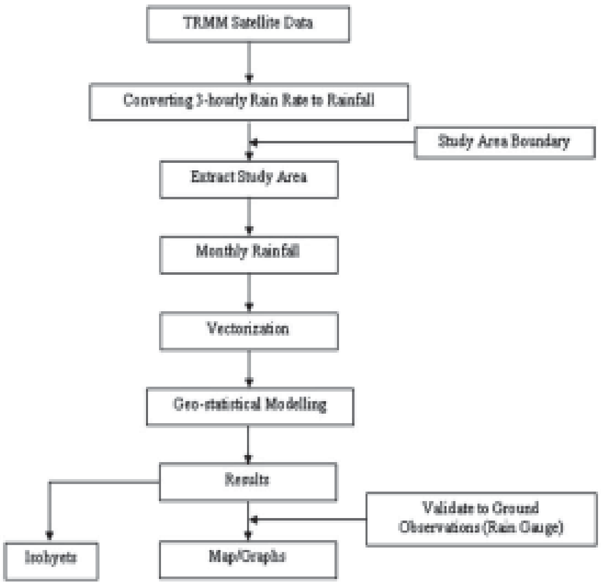
Rain gauge stations

Rainfall observations were obtained from rain gauge stations, and only four rain gauge stations were used in this study area for validation (Fig. 1). Monthly rainfall data from January 1998 to December 2012 were used in this study.

METHODOLOGY

In this research paper monthly rainfall TRMM 3B43 V7 data were downloaded from Giovanni, TRMM Online Visualization and Analysis System (TOVAS) of Goddard Earth Sciences, Data and Information Services Center (GES DISC), NASA. TRMM 3B43 V7 has Level-3 monthly rainfall products. For this study

Lat-Lon based, time averaged monthly rainfall data was used. The parameters available for download, with the TRMM 3B43 V7 rainfall data are: rain rate, accumulated rain, and relative error. The monthly gauge (observed) rainfall data were collected from Indian Meteorological Department (IMD). The detailed flow chart of methodology is expressed as below in Fig. 2.



Fig, 2: Flow Chart of Methodology

Validation

Statistical indices can be used to evaluate, compare and validate satellite rainfall data with respect to gauge rainfall data. They help to understand the existing co-relationships, trends and error propagations between the two types of datasets. In this study, the following four statistical indices are used: (1) Correlation Coefficient (r), (2) Mean Square Error (MSE, equation (1)) (3) Root Mean Square Error (RMSE, equation (2)) and Average Percentage Error (Avg. % Error equation (3)).

$$MSE = \sum_{i=1}^{N} \frac{(Obs - TRMM)^2}{N} \quad (1)$$

$$RMSE = \sqrt{MSE} \quad (2)$$

$$Avg.\%\,Error = \sum_{i=1}^{N} \frac{100 * Abs\left(\frac{Obs - TRMM}{Obs}\right)}{N} \quad (3)$$

First, the co-relation coefficients (r) were calculated between the rain gauge rainfall data and TRMM satellite data. A value of 1 corresponds to a perfect correlation and a value of zero indicates that the station data and the rainfall product are uncorrelated. The Avg. % Error provides a percentage measurement of the difference between the estimated versus the observed data. The validation is considered to be excellent when the Avg. % Error is <10%, good if the Avg. % Error is between 10% and 20%, acceptable if the Avg. % Error is between 20% and 30%, and poor if >30% (Campi, Palumbo, and Mastrorilli 2012). The Avg. % Error test provides a value for the prediction model error rate by placing emphasis on a high level of errors. Lastly, for the RMSE, lower values indicate better performance.

RESULTS AND DISCUSSION

TRMM satellite derived monthly rainfall data over the period of January 1998 to December 2012 is compared with the gauge rainfall data of four rain stations Rudraprayag, Tehri Garhwal, Chamoli and Uttarkashi across the Upper Ganga river basin lying in Uttarakhand state, India. Statistical indices viz. Correlation Coefficient (r), Mean Square Error (MSE), Root Mean Square Error (RMSE), and Average Percentage Error (Avg. % Error) estimated for all four stations are summarized in Table-1. It can be seen from Table-1 that at all the stations, TRMM 3B43V7 monthly rainfall data is significantly correlated with gauge rainfall data. The correlation coefficient of 0.99 is found at all four stations viz. Rudraprayag, Tehri Garhwal, Chamoli and Uttarkashi. A maximum average % error of 6.84 % is observed for Rudraprayag rain gauge station. Hence, a clear spatial trend is not observed with respect to the correlation coefficient and average % error in the study area. However, the coefficient seems to increase with the total rainfall. The magnitudes of MSE and RMSE are directly related with each other. A general observation for all the rain stations is that both the correlation coefficient and the average % error increase with total rainfall. The monthly statistical indices are estimated for rainy season in Upper Ganga river basin Uttarakhand state. The rainy season in Upper Ganga river basin covers the months of June, July, August, September and October. It can be seen from Table-2 that again maximum correlation coefficient of 0.9 is observed for all four stations during rainy season (Fig.3). A maximum average % error of 5.3%, 5.5%, 4.5% and 5.5% is observed for four rain stations respectively. Therefore, it is evident from Table-2 that during rainy season a very high agreement exists between the TRMM based satellite rainfall data and gauge rainfall data. To validate the TRMM rainfall data with gauge rainfall data, a study of the existing relationship between them is required. A good relationship is observed between the two types of rainfall datasets (Figure-4). For further validation and to have a better representation of the relationship GIS based analysis is used.

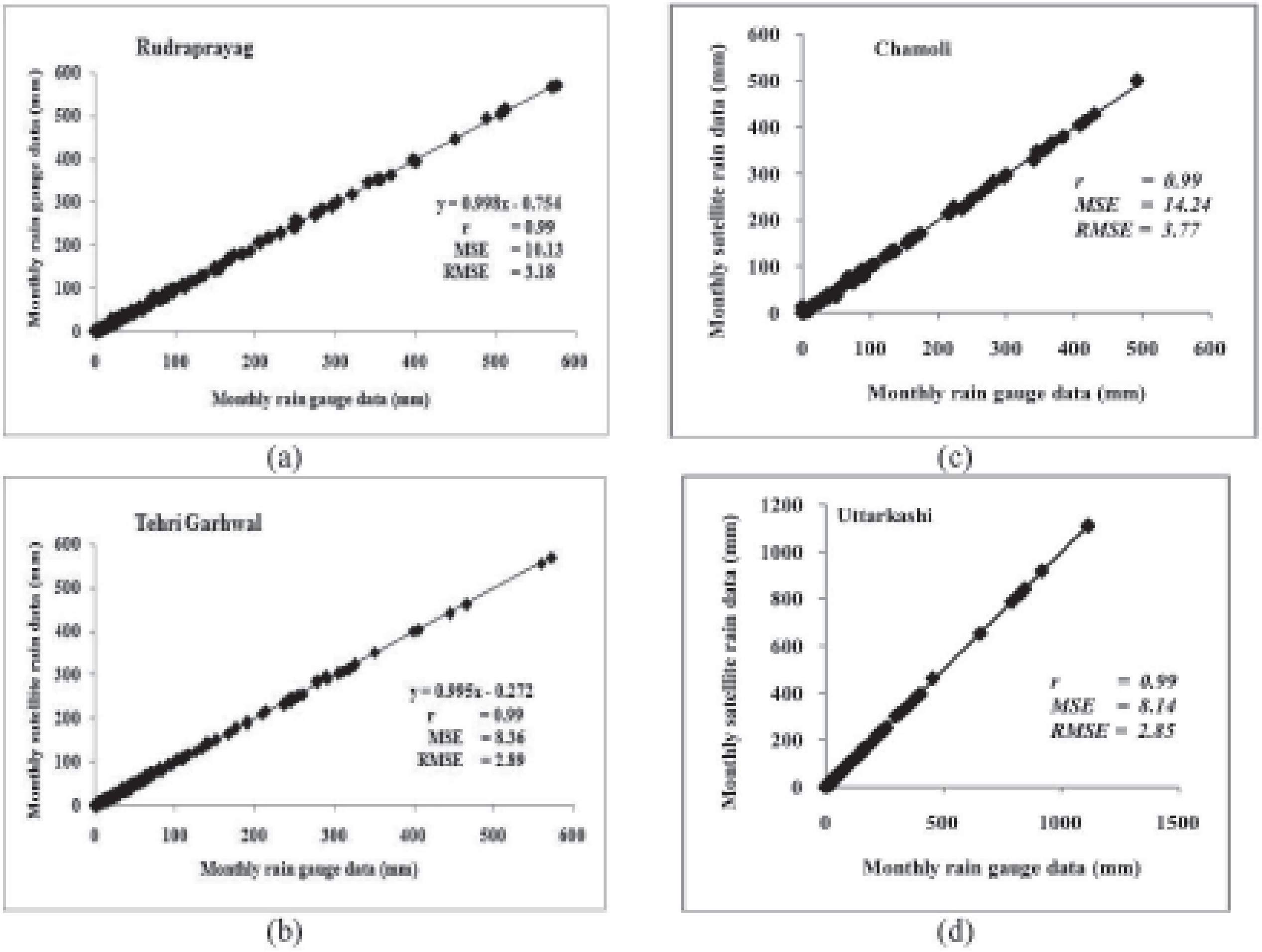


Fig. 3: Co-Relationship between TRMM Monthly Data and Ground Data for Stations Located in Upper Ganga River Basin (a) Rudraprayag Rain Gauge Station (b) Tehri Garhwal Rain Gauge Station (c) Chamoli Rain Gauge Station (d) Uttarkashi Rain Gauge Station

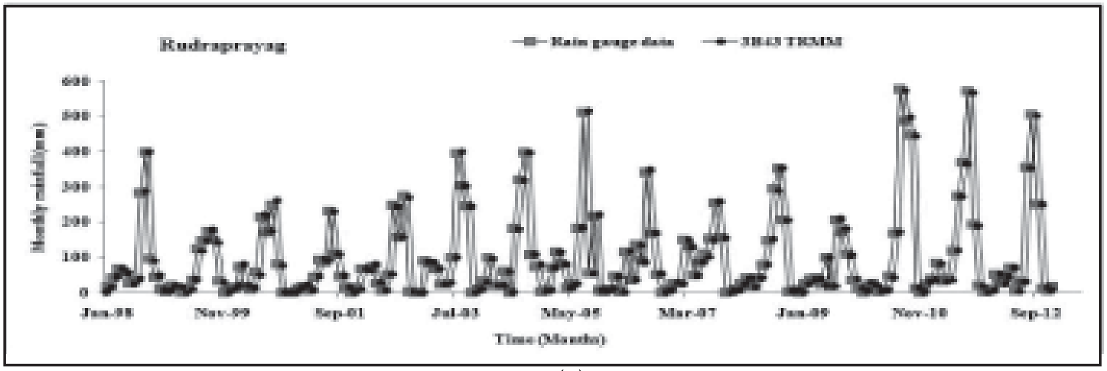
Table 1
Locations of the Rain Stations and Satellite Data Validation Parameters for Monthly Rainfall from the Period from January 1998 to December 2012

Stations	*Long.*	*Lat.*	*r*	*MSE*	*RMSE*	*Average % Error*
Rudraprayag	30.32	78.97	0.99	10.13	3.18	6.84
Tehri Garhwal	30.38	78.50	0.99	8.36	2.89	6.82
Chamoli	30.40	79.33	0.99	14.24	3.77	5.47
Uttarkashi	30.73	78.45	0.99	8.14	2.85	6.16

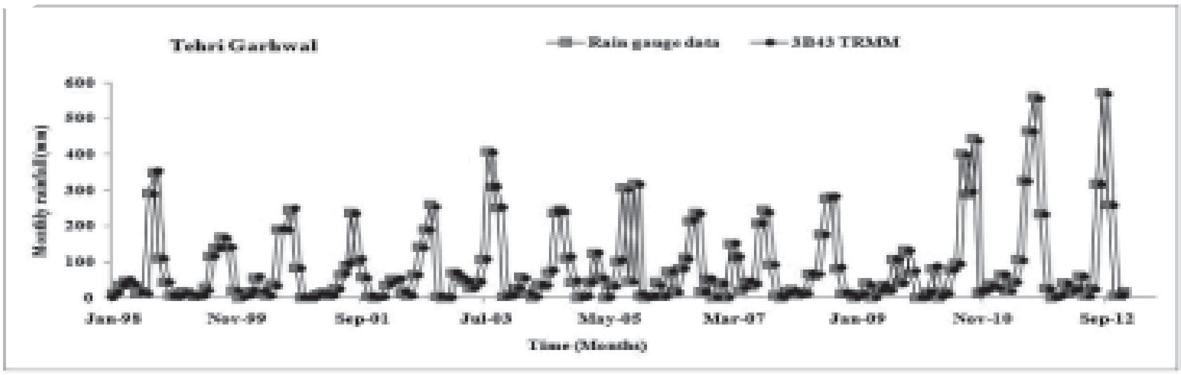
Table 2
Statistical Indices for Validation of the TRMM Monthly Satellite Data With Respect To Gauge Rainfall for the Rainy Season in Upper Ganga River Basin

Stations	*June*				*July*				*August*				*September*				*October*			
	a	**b**	**c**	**d**	**a**	**b**	**c**	**d**	**a**	**b**	**c**	**d**	**a**	**b**	**c**	**d**	**a**	**b**	**c**	**d**
Rudra-prayag	0.9	16.7	4.0	4.0	0.9	18.2	4.2	1.3	0.9	19.0	4.3	1.6	0.9	14.2	3.7	2.4	0.9	4.0	2.0	5.3
Tehri Garhwal	0.9	11.8	3.4	5.2	0.9	7.84	2.8	0.9	0.9	17.1	4.1	2.0	0.9	11.1	3.3	3.2	0.9	3.3	1.8	5.5
Chamoli	0.9	11.1	3.3	2.9	0.9	22.8	4.8	1.3	0.9	12.9	3.6	1.2	0.9	24.7	4.9	3.5	0.9	2.6	1.6	4.5
Uttarkashi	0.9	9.2	3.0	3.2	0.9	20.0	4.5	1.3	0.9	12.5	3.5	0.8	0.9	12.3	3.5	1.9	0.9	3.4	1.9	5.5

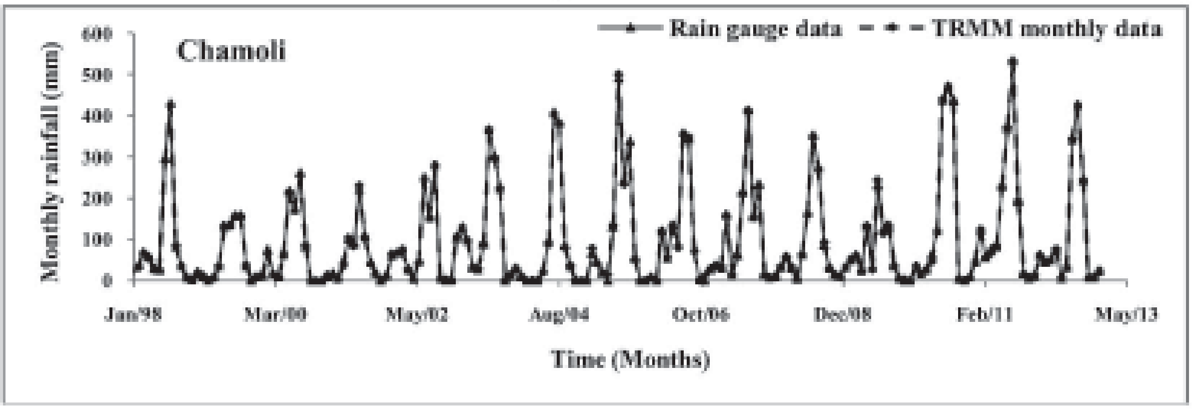
Where, a= r, b= MSE, c= RMSE, d= Average % Error



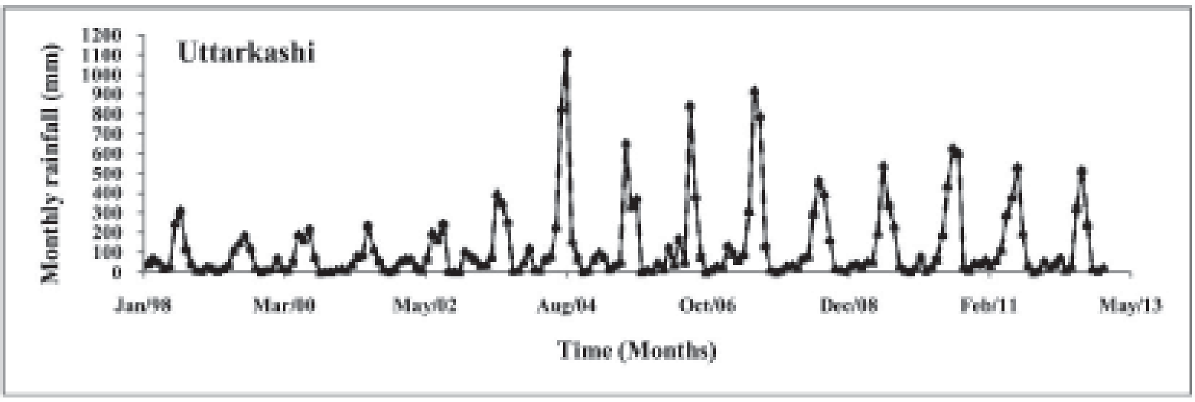
(a)



(b)



(c)



(d)

Fig.4: Time Series Monthly TRMM and Gauge Data for Stations Located in Upper Ganga River Basin (a) Rudraprayag Rain Gauge Station (b) Tehri Garhwal Rain Gauge Station (c) Chamoli Rain Gauge Station (d) Uttarkashi Rain Gauge Station

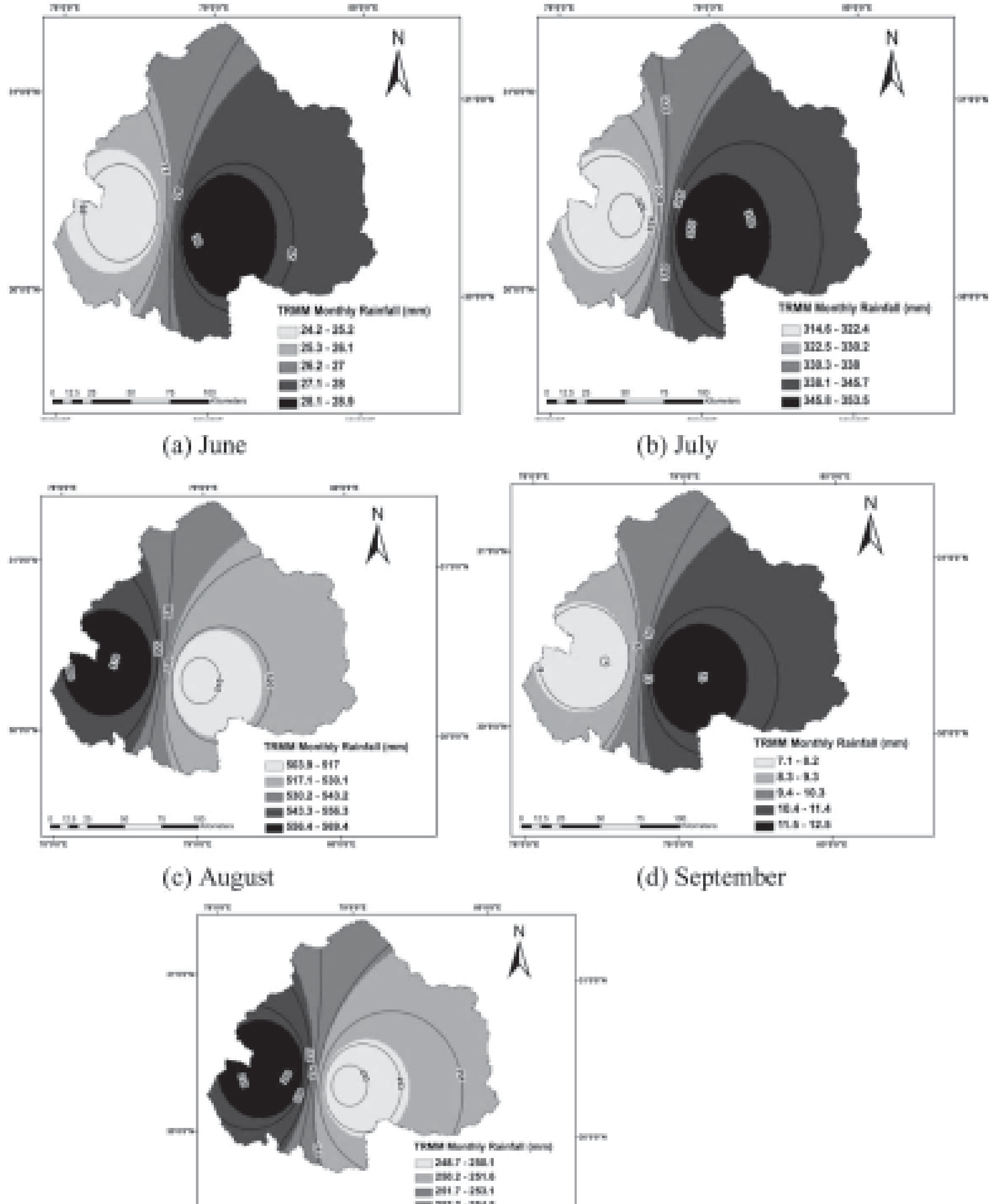


Fig. 5: Comparison of the Spatial Distribution of TRMM Monthly Rainfall Data with Gauge Monthly Rainfall Data (Isohyets) for the Following Months: (a) June, (b) July, (c) August, (d) September, and (e) October

A comparison of the spatial distribution of TRMM monthly rainfall data with gauge monthly rainfall data (isohyets) is done for the following months: (a) June, (b) July, (c) August, (d) September, and (e) October (Figure-5). In these figure isohyets lines represent the gauge rainfall datasets for months of the rainy season.

On the other hand spatially distributed rainfall surface is generated from TRMM satellite datasets of months of the rainy season. Then both isohyets and spatially distributed rainfall surface are overlaid to see the matching or agreement between the data. The results illustrate a very good matching between the satellite and gauge rainfall datasets. Hence, validation of TRMM satellite data with gauge rainfall data shows a very good overall agreement.

CONCLUSIONS

This study employed four statistical indices viz. Correlation Coefficient (r), Mean Square Error (MSE), Root Mean Square Error (RMSE), and Average Percentage Error (Avg. % Error). They were used to compare and validate the TRMM satellite derived rainfall data with gauge rainfall data of Upper Ganga river basin Uttarakhand, India which falls under sub-tropical zone. For four stations, the correlation coefficient of 0.99 is estimated and the maximum average % error estimated is 6.84% for Rudraprayag station. The isohyets, prepared using gauge rainfall data matched well with and the spatially distributed rainfall surface prepared by TRMM satellite data for months in the rainy season of the study area. As all the selected stations fall in the sub-tropical zone, a similar trend is observed in their comparison graphs. The correlation coefficient seems to increase with the total rainfall in the region.

A good agreement and relationship is observed on comparing the monthly TRMM satellite rainfall data with gauge rainfall data. The variation in satellite based rainfall and gauge rainfall may be due to the limited spatio-temporal coverage of TRMM satellite over a particular region. The satellite may miss few rainfall events. Other reasons can be the uncertainty and errors while sensing the rainfall parameters from satellite and during the raw satellite parameters processing using algorithms. These errors may affect the final rainfall products. Geospatial technologies such as remote sensing and GIS are promising tools for satellite based rainfall estimation. TRMM product used in this study has shown that satellite-derived rainfall can be used to complement ground-based measurements. In cases where ground measurements are not available and it is strongly recommended that the TRMM rainfall data did not perfectly match with the ground measurements but it can be used to supplement ground measurements of estimating rainfalls in un-gauged basins. They can provide spatial distribution of rainfall data which is not possible with simple ground based rainfall measurements. TRMM rainfall data can be used well as inputs to the hydrological models for various watershed developmental related activities. The results also suggest that TRMM derived rainfall data could be used for the runoff simulation to the catchments where there is no gauge station for early investigations.

Acknowledgements

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REFERENCES

1. Alamgir, S., Bernier, M. and Racine. M. J., (2004): "Performance of TRMM Satellite Data over the Rain Gauge Observations in Bangladesh". *Proceedings of SPIE 5568*: pp.179-188. doi: 10.1117/12.565815.
2. Bharati, L. and Jayakody, P., (2010): "A Report on Hydrology of the Upper Ganga River Basin". International Water-Management Institute. Project report no: H043412. Available online at: http://publications.iwmi.org/pdf/H043412.pdf. Accessed on: June 01, 2014.
3. Campi, P., Palumbo, A. D. and Mastrorilli. M., (2012): "Evapotranspiration Estimation of Crops Protected by Windbreak in a Mediterranean Region". *Agricultural Water Management*, Vol. 04, pp. 153-162. doi:10.1016/j.agwat.2011.12.010.
4. Cristobal, J., Ninyerola, M. and Pons. X., (2008): "Modeling Air Temperature through a Combination of Remote Sensing and GIS Data". *Journal of Geophysical Research*, 113: D13106. doi: 10.1029/2007jd009318.
5. Gebremichael, M., Krajewski, W. F., over, T. M., Takayabu, Y. N., Arkin, P. and Katayama. M., (2008): "Scaling of Tropical Rainfall as Observed by TRMM Precipitation Radar". *Atmospheric Research*, Vol. 88, pp. 337-354. doi:10.1016/j.atmosres.2007.11.028.
6. Gottardi, F., Obled, C., Gailhard, J. and Paquet. E., (2012): "Statistical Reanalysis of Precipitation Fields based on Ground Network Data and Weather Patterns: Application over French Mountains". *Journal of Hydrology*, Vol. 432-433, pp. 154-167. doi:10.1016/j.jhydrol.2012.02.014.
7. Huang, J., Zhang, J. C., Zhang, Z. X., Xu, C. Y., Wang, B. L. and Yao. J., (2011): "Estimation of Future Precipitation Change in the Yangtze River Basin by using Statistical Downscaling Method". *Stochastic Environmental Research and Risk Assessment*, Vol. 25, pp. 781-792. doi: 10.1007/s00477-010-0441-9.
8. Moazami, S., Golian, S., Kavianpour, M. R. and Hong. Y., (2013): "Comparison of PERSIANN and V7 TRMM Multi-satellite Precipitation Analysis (TMPA) Products with Rain Gauge Data over Iran". *International Journal of Remote Sensing*, Vol. 34, 8156-8171. doi:10.1080/01431161.2013.833360.
9. Takayabu, Y. N. and Hikosaka. K., (2009): "Statistical Analysis of Oceanic Rainfall Characteristics in the Baiu Season Utilizing TRMM PR data". *Journal of the Meteorological Society of Japan*, Vol. 87, pp. 339-352. doi:10.2151/jmsj.87A.339.

PARADIGM SHIFT IN MAPPING SCIENCES : CAUSES AND CONSEQUENCES

Jawahar Lal JAIN[1]

ABSTRACT

The paper focuses on the volley of technological advances bearing on the whole range of spatial sciences in the late 20th century. They have particularly pulverized mapping, navigational and communication fields. This paper concerns mappings sciences, particularly Cartography – with an insight into the causative factors and consequences of the radical changes. Post WW II researches in these fields, particularly in electronics, computers graphics, avionics, space science, telemetry, signal processing, superconductivity and semiconductors, etc. have paved way for developments in the very practical fields of space application technology, graphical and thematic data base management, spatial decision making, positioning and navigation among others.

If map was the only form of representing geographic information, today there are many other forms to parallel or complement it. Thus GI today is a much extended and augmented connotation than the map of yore. Modern map or image map is a much more real-time and complete geographic picture, even interactive and editable. This has changed map design parameters. On Internet map has become a two-way communication as a map user can upload one's own data on map. So too, data and maps from two different sources can be turned into new thematic maps as map mashups. Maps and satellite images on free geoportals and mobile mapping devices have enabled people to update local maps with portable, GPS-enabled devices. Digital maps and thematic data handling S/Ws, conjoined with free image maps, have boosted GIS, which in turn has pulverized cartographic practice and profession as well as GI application. Finally, cloud computing will potentially transform map and GI production. This is all changing our attitude and ethos as regards GI applications.

If geographers traditionally have had an intimate interface with maps and Cartography, their profession and practice also stands radically transformed. Actually the entire ICT has changed the very life style at the societal plane. Bold prognostications of the great futuristic sociologist, Marshal McLuhan and others of his genre, are turning starkly true. Thus these most happening decades in these fields present a saga of Cartography first loosing a bit of its sheen and then transforming and augmenting into multifarious Geospatial Science, even though the two are not exactly the same. In the Geospatial Science the distinction between Cartography and mapping sciences gets further blurred. The causes and consequences of this change are often intermingled, they are attempted to collate and relate in a separate table.

***Keywords**: Image Map, Map Design, Geoportal, WEB-map, Map Mashups, Neocartography, Cloud Mapping.*

Mapping Sciences Stand Pulverized - Entire spectrum of mapping endeavors has changed, rather drastically, over the last few decades. Very ethos of mapping professionals and map users has changed as well. As Peterson concludes, 'We live in an amazing time for mapping. Within a matter of 20 years, from 1970s to 1990s, maps changed from static objects on paper to interactive presentations delivered through an electronic network. In the years since then, maps have become even more interactive in the sense of being able to add more information – both thematic information through mash-ups and the editing of the underlying base map'.[1]This quantum change in the mapping profession and practice in its larger connotation actually amounts to a definite paradigm shift. And this change of mindset, of attitudes and expectations, both among producers and users of map, and an insight into its causative factors and resultant consequences warrant an articulated elaboration and elucidation, which is attempted in following paragraphs. Though the focus is essentially on Cartography, the related aspects of other mapping sciences are also considered briefly.

Recent geospatial revolutions have greatly boosted, facilitated and diversified the use of maps and other forms of GI in the working of umpteen institutions and daily life of individuals. In India where the access and circulation of maps among common public was much suppressed till not long ago, the freedom and access to maps or image maps on free geoportals and the like brings a thrill to the common man; and this comes much as a sea change. As such, this articulation stands all the more relevant in India. Though causative factors and consequences are intricately intermingled, a table collates and correlates them in these categories.

Cartography vs. Mapping – Though the two terms are popularly deemed synonymous and often used interchangeably, Mapping is actually a much larger

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connotation than Cartography. Mapping entails the entire endeavor of acquiring locational information of places, features, and locales. It thus principally involves metrical profession of Surveying, and, for larger areas, map projection and geodetic aspects of the profession. After measurements, calculations/ adjustments, coordinates-cum-projection system, and plotting comes the role of representational science of Cartography, which actually defines the look, format and communicativeness of maps, and which in turn is topped with considerations of printing technology. Plotting constitutes the threshold role between Surveying and Cartography. The latter is the skilled profession and acumen of turning the plotted information into effective and appealing spatial representation called map.

In historic times, explorers endeavored to locate the new places or features they discovered with rudimentary observations and measurements; they would add this to the extant information, and compile fresh maps. Later in more settled areas it evolved intocountrywide Survey projects by premier national agencies to triangulate and traverse thecountry with a network of reference points, and then fill the surrounding local details with other piecemeal local surveys with rather simple equipment like plane table and alidade. However, in most areas today mapping amounts to adding new themes onto the base map, or simply updating the old maps. Their effective representation remains the core activity of Cartography. In some cases mapping may also involve harmonizing their specific old projection and geodetic parameters to modern ones. Modern mapping throughaerospace Remote Sensing has largely blurred the distinction among Surveying, Cartography, Thematic Mapping, etc. Most premier national mapping institutions are umbrella organizations with specific wings catering to various aspects of national mapping programme. In India the Survey of India discharges all these functions of topographic mapping and of ensuring security of the sensitive information.

Map Connotation Augmented - Map, or rather GI today, carries a much different and far larger, multi-dimensional connotation than it did in yester years. Likewise, Cartographic practice and profession has lately come to involve a far larger and multifarious gamut of skills. In fact GI today entails not simply a mapper or cartographer but a spectrum of modern Geospatial technologists as well. Modern map is mostly based on aerial or satellite Photogrammetric techniques, may combine map as well as image elements; it may even combine DEM with image draped upon it, with scope, on an electronic display, for viewing it kinematically from any height and bearing (virtual fly-through). Such image-map may be augmented with light, sound and animation elements, as well as field photos or videos of noteworthy spots tagged to them, which can immerse the viewers in total experience of actually getting across the focused area or around the feature. If so, modern GI may introduce perspective viewpoint to the orthogonal view of maps.

Map Mutates to Transient, Small-Time Product - In the paper-print era, map was a much perfected product – immaculately and patiently finished and garnished, with utmost visual appeal, and maximum possible detail at the given scale. And once printed, it was not possible to modify it. A map was thus deemed to serve as a spatial reference document for geographic visualization for a good long time – much like Keats's 'a thing of beauty is a joy for ever' - as revision of a map would entail repeat of much of the tedious effort over again. Though a color map is a co-registered superimposition of half a dozen plates or more, each in preselected different color, there is no way of extracting any information layer except through manually tracing it from the map.

In the computer environment map data is organized into several theme layers, which can each be lifted or superimposed easily. The print maps were most difficult and ticklish GI to combine with a computer system or a GIS. Little wonder that adopting GIS entailed the formidable drudgery ofinputting the printed maps through tedious digitization. Once Cartographic process and procedure became digital or computerized end-to-end, maps can be readily inputted in a GIS, and can be easily revised/ updated also. Today maps are ad-hoc artifacts tailoredto specific context and needs (Gartner, 2015)[2]. In the computer or GIS environment maps are essentially reduced to cartographic or geographic data bases, and can be easily updated with fresh inputs like recent RS data, new departmental surveys, etc.

Consequent Changes in Map Design - If print map was formerly a product of long and tedious work and was meant to serve for a long time, map today, particularly the GIS map or the Web map, is a transient, functional product meant for a particular purpose, and is treated as such. It is deemed preserved as long as its spatial and thematic database is preserved. Map used to be a valuable thing not available everywhere, nor was it reproducible easily. Except for atlas maps, they were often large-format graphics, rather unwieldy to handle. These factors besides, printing constrictions, designated purpose/ emphases of the map, along with need for balance between maximum information and visual clarity, largely governed the map design. Atlas maps, as part of a large bound volume of numerous maps and related information under a unitary scheme, were controlled by certain other factors of Atlas Cartography as well. Progress of cartographic production has moved in tandem with the progress of printing technology.

Now modern technologies have radically changes these governing factors of map design. Today map on a digital electronic screen comes alive at the flick of the finger. Electronic atlas or geoportal map is a single global or regional map, which can be zoomed and scrolled. And we generally look at the areas of interest, rather than the whole large map at a time. Today World electronic or digital atlases on a single CD or DVD, such as 'Encarta Virtual Globe' present global coverage on up to 1: ¼ million scale for general areas, and even larger scales for major urban areas. Whereas paper print maps had rather strict limitations in combining maps elements with satellite image elements, the electronic maps can better combine them as image maps.

Actually the visual potentials and limitations of print and the electronic display are radically different. Their symbology also differs accordingly, as place and feature symbols and names on electronic media can not come up as fine as on the print map after the final reduction. Generally therefore, electronic maps have much fewer place or feature names, etc. Moreover, electronic maps often have multiple representation capability also. This opens a different world of information at each distinct level of representation – each with its own level of detail and generalization, and its own symbology.Zooming functionality of digital maps provides for close-up or panoramic views of areas with appropriate details at several steps of scale range.

The zooming, scroll, and multiple scale portrayal comprise a major milestone in the evolution of electronic map. Multiple scale representation opens a new world of map details. Thus in a single map one can view panoramic views of continents and countries and zoom up to topographic and urban scale information with commensurate details and appropriate symbology. And this detailed map can be scrolled seamlessly. Obviously, these maps become S/W-wise immensely intensive.

The huge section of place and feature name index on print maps and atlases is neatly dispensed with; instead, there is a search functionality in supporting S/W of the electronic atlas and geoportals, which brings on display the areas containing the place or feature being searched from the database and highlights the same with a marker. And free geoportals like Google Earth and Google Maps have made even these digital atlases rather redundant, as these geoportals present even more elaborate and up-to-date details as image maps. Today's digital maps on electronic display screens have virtually freed map design from printing constrictions, as one would rarely need it in print form.

Google's Stamp onMap - The geo-WEB has made maps interactive and enabled freelance enthusiasts to upload their contents or photos and videos at pertinent locations in the geoportal maps. Clicking the photo/video icon at the chosen location, one gets ground views of those spots and features – providing for a virtual home tourism. Google has itself added 'ground views' and 'street views' of myriad locations on its Google Earth and Google Maps. Google Earth has also added myriads of 3-D views of townscapes and other man-made features to its images maps. Its Trekker Camera can be brought to zoom in on any wild location. In this series it has lately simulated the perceptual experience of rapidly sinking through the canopy of Amazonia in a remote location in Brazil[3]. However, Google's valiant endeavors - of capturing the ground views of ascent to the Mt. Everest – the highest in the world - were tragically foiled when its veteran mountaineer-cum-photographer Dan Fredinburg died with others climbers in the major avalanches in the Mt. Everest area accompanying the extremely violent earthquake on April 25, 2015 in Nepal. Free geoportals like Google Earth, Google Maps, and others have forestalled even electronic atlases.

Early maps would often show ground views of some cardinal features – of course at the cost of map details of some adjoining areas in the maps, for instance Vincent's Map of Benaras – modern maps or image maps can include it in the form of tiny clickable icons at pertinent locations. Clicking the icons brings alive a thumbnail of photos and video of the feature or landscape. Multimedia elements can as well be added to them. Moreover, image-wrapped DEM's perceivable from any bearing and elevation infuses some perspective elements in essentially orthogonal visuals of landscapes, as maps by definition are.

Thus, today maps rarely stand alone as nearly self-sufficient spatial portrayal of areas; they are often accompanied or combined with many other elements like image, DEM, animation, multimedia, fly-throughs, etc. Even basic acquisition of spatial/locational information is readily accomplished with GPS-enabled total stations and hand-held mobile mapping systems. As such, they can be readily updated with Remote Sensing and newer departmental information, and further enriched with newer VGI.

Interactive Maps in Geo-Web Age - Electronic maps are dynamic and interactive on proper Internet-enabled platforms. Geo-WEB has rendered mapping and map use through free-lance map inputs a two-way process, where both the map producer and map user are exchanging mappable information on the displayed maps; and the user-contributed information is called VGI. This new source or mode of generating map information is lately designated as Neocartography, on which the ICA created a new Commission in 2011. Again some enthusiast amateurs or corporate houses are harnessing API tools to combine specific data from one source with a current map form another source, and thus launching a new type of map, e.g. map-mash up. Thus vast new, diversified information is becoming available for public at large in map form. Clearly, VGI and map mashups are going to facilitate as well as dominate the world of quick GI becoming readily available to one and all.

Surely, all these developments and innovations are taking place rapidly in the boiling cauldron of Cartographic, or rather Geospatial, revolutions; and the final shape of things to emerge and stabilize is yet to crystalize. Nevertheless, a sea change has taken place, and cartographic process, products and use procedures stand radically transformed to warrant a recognition and designation as Paradigm Shift in Cartography, nay, in the larger gamut of mapping and map use process, practice and profession – in the very ethos of expanding mapping and map use circles.

Cartography Takes off to Cloud - Latest geospatial wave to hit Cartography is the cloud computing. Like invisible global web of Internet, cloud connotes pooled-up massive computing resources, which can be hired for massive and/or high-end computer-tasks like Cartographic applications. Provision of computer services and infrastructure has now opened new commercial vistas for big corporate houses in the fields such as management of huge databases. This implies that even a small company with up-end technical resources but little infrastructure can also venture big mapping/cartographic projects through cloud computing resources (H/W, S/W, protocols, etc.), undermining the monopolistic predominance of just the handful leading cartographic houses.

Changed Attitude to Maps - With all these technological changes, the cartographic ethos and attitude towards maps and other GI has also gradually and imperceptibly changed. Maps and other GI today are perceived to be small-format visuals, enriched with image and multimedia elements, tuned to the computer, even smartphone, display, which can be zoomed and scrolled seamlessly, and can be interacted with. Rather than the map itself, it is the pertinent databases that are kept updated; and the GIS/Carto. S/W facilitates transforming them into appropriate maps as per need. Maps repository is no longer viewed as huge and numerous drawer-like cabinets stashed in a super size storehouse. Accept for printing facility, a cartographic office or lab is essentially a computer system with dedicated H/W and S/W, or a more organized configuration like DMC. Maps will soon be used much like umpteen other apps from smart gazettes.

As the map becomes readily available and manipulable, peoples' attitude to map and other GI will change as well. They no longer crave and scramble to lay their hand on or preserve an old, dilapidated, outdated map and make do things with it – i.e. the 'Treasure Island' syndrome to maps is now a gone thing. Like GPS, maps are becoming integrated with utilities of daily life, and as apps they are transforming into multi-utility items. Only, the imperative of a sizeable hardware screen for map display remains the alluding problem.

Academic Cartography on Downturn - Inmodern age formal academic aspects of very many disciplines and professions are on a downtrend; and newer, more vocational, computer-based segments or aspects are taking precedence in the Internet age. So also, in mapping sciences academic Cartography, which was much developed in the early and middle decades of 20th Century, particularly in European-American-Australian world, was much pulverized and confronted with existential challenges around the turn of the 21st Century. Particularly in the US, many Cartography departments, often fostered by Geography departments at their respective universities, mostly lost their struggle against the succession of Geospatial revolutions. However, they have better survived the Geospatial surge where Geography had retained its science-tech. moorings.

Like many University Departments of Geography in US, several University Departments of Geography in India also started special programmes in Cartography like optional PG paper or even one-year PG diploma course, which however didn't run well for long. Even more surprisingly, no Department requisitioned any faculty position like professor in Cartography. Cartographic education in academic institutions thus looks like half-cooked and half heartedly done feature, and thus failed to make substantial progress. Only some few of them that adapted to Geospatial Science are carrying on well.

Cartography Digresses form Geography –Academic downturn of Cartography has moved parallel with divergent progression of Geography and Cartography. The two sister disciplines later parted their ways – Geography leaning towards social concerns, whereas Cartography moved progressively to geospatial technologies. Thus, Geographic tutelage of academic Cartography is a gone thing. The few surviving departments of Cartography are those that have successfully transmuted into essentially Geospatial departments, adopting many newer technologies to the old stump. Formal academic societies like ICA have long divorced from IGU and aligned with the newly emerging Geospatial societies. In our country too, INCA has moved away from its childhood companion, e.g. Geography, and feels better at home with several geotechnical institutions. These developments clearly manifest a strong paradigm shift in not only Cartography but in the much larger gamut of mapping sciences. If academic Cartography is struggling for survival, it is being replaced with Geospatial Science or its equivalent. Thus new version of old Cartography is actually proliferating in many new academic and professional institutions, now not necessarily in Geography departments.

Mutation in Other Mapping Sciences - Yes, commensurate changes have occurred in other mapping sciences like geodesy, surveying, photogrammetry etc. The fundamental instrument of Surveying, e.g. the theodolite, has transformed from essentially triangulating device to direct distance measuring instrument as well; and thus eliminated much of calculation work. GPS has brought a satellite-based all-weather technology of getting locations in terms of a predefined or presumed global coordinate and geodetic system. Their accuracy has been further augmented by similar regional systems in certain parts of the world. The Electronic theodolites are now fitted with GPS. Rigorous application of higher mathematics in Geodesy is also replaced with ready transforms built into pertinent S/W's.

Beside this fundamental function of GPS, many very practical applications/devices have been developed upon them such as car navigation system. Mobile mapping system is again a very handy, practical device for directly marking new locations on pre-fed map on a mobile computer. Thus the drudgery, patience and perseverance of months of field work and many more months of calculations and adjustments in the office are now history. Similarly, aerial photogrammetry has also become a digital technology; and was soon further boosted with satellite photogrammetry. Actually satellite remote sensing, particularly high resolution remote sensing, has greatly helped monitoring and mapping of topographic and man-made features as well as their many inferential aspects. Clearly, if map and map use have seen a sea change, the pertinent preceding endeavors of acquiring exact spatial information for map compilation or updating have also changed commensurately.

Map Use Stands Changed As Well – If map-making sciences have changed radically; the map usage has changed quite as well. In the computer milieu, all sorts of data are used in the soft or digital form. Graphics was a hard thing to be harnessed and handled on computer. Maps are a special type of graphic data drawn to a constant scale, with relative locations defined in terms of a coordinate system. It is essentially a point-and-line drawn vector data, which is basically not compatible to the pixel-based raster handling by computers. Therefore, it took some time to efficiently handle large-size vector graphic data on computers, and harmonize it with other raster graphic data like remote sensed digital images. However, once achieved, this paved way to handle alphanumeric as well as graphical data on computer, and large S/W suits were developed to use maps and tabular/departmental data together, and analyze them for given application; and this came to be called the GIS, which essentially handles maps as spatial and thematic data bases; and this allows maps and other GI to be easily modified and analyzed. GIS applicability is pervading all spheres of life, and has taken the world by whirlwind. Now maps are hardly used in the conventional way; they are mostly used in a computerized form and often in a GIS.Up coming map apps on smartphones and wearable gazettes will soon blur boundaries between map use and many an app of daily utility.

While the map, or rather the GI, production and use have changed in a big way; the computer and Internet revolutions have changed the use of alphanumeric departmental data as well. Both are now, or will soon be, accessed via Internet through national Geoportals. Now researchers hardly need run about various departments personally for culling out pertinent data, as national geoportals act as the single gateway and clearinghouse to all national data, including GI. Though it is taking much too long to come up fully functional, NSDI is bracing up to be the national geoportal of India. Ideally, it should be possible to access all departmental information and pertinent GI from one's office.

Augmented Geographic Information –In recent geospatial literature Augmented Reality and Augmented Map have acquired special technical connotation. As Schmalsteig&Reitmyr (2007)[4] elucidate, the **Virtual Reality**, acts as an interface between the GI user and the objective world, and supplements the user's objective world with additional geographic information that the virtual sources (computer, Web, cloud, etc.) furnish through, say, wearable gazettes. This gazette may be in the form of half-eye glasses, which presents GI in 3-D while the objective world may be seen directly by the person in the field. This combination of instant GI and the direct field perception greatly enhances, for example, the efficiency of field team leaders in supervising disaster management operations. **Augmented Map** presents a superimposition of rich graphic and toponymic information of traditional maps,and of the real world situation as recorded, say, by satellite imaging. It thus becomes an enhanced,

Table 1
Radical Transformation in Mapping Sciences : Causes and Consequences

Motive Developments	Pertinent Consequences
1. Advances in Surveying instruments; Printing technology; and color reprographics. Early 20th C.	**A.** Improving precision and ease of Surveying, plotting and printing.
2. Photogrammetry and Photo Interpretation - II Quarter of the Century.	**B.** Rapid Carto. coverage of inaccessible areas. Umpteen applications of photo-Interpretation. Minimal field work in mapping. 3-D views. Verification of map portrayal & interpretation.
3. Extension of photography into infra-red and color photography. Mid-20th C. - III Quarter of the Century.	**C.** Camouflage detection and umpteen other uses of infra-Red photography and mapping applications.
4. Further researches in imaging and avionics, and in computers – culminating togetherin Space Remote Sensing).Manned and unmanned space flights; multispectral scanners for earth imaging from satellites continuously and on a regular basis -1960's through 1980's.	**D.** Global imaging and mapping without any material cost in digital, raster mode compatible with computers. Opened a new era of thematic mapping and monitoring that boosted digital transformation of Carto. practice& procedures. Initial vector plotters soon replaced with raster plotters. – 1970's-80's. Incorporation of Infra-Red data as FCC imagery. Digital revolution in Cartography.
5. Improved push broom scanners, along-track stereo HR imaging. Satellite based GPS. DBMS; Spatial data handling with major GIS S/W's. Intel chip on miniaturized computers - even on laptops and handheld devices. DMC's. Electronic theodolites and total stations; Multilevel Carto. representation on electronic media. Techniques for Conversion of basic spatial data into DCDB's or print maps. Digitization of maps – 1990's.	**E.** Radical changes in Surveying methodology from triangulation to trilateration and direct coordinate acquisition; position of remote objects with bearing and distance from master stations. Analogue Carto. equipment gradually replaced with digital ones – integrated end-to-end map production from DBCB's. Digital/electronic maps and atlases on CD/DVD and from geoportals. Incorporation of map vectors into imagery as image maps. Direct urban and cadastral scale mapping feasible from HR Sat. imagery. Digital Carto. comes of age -1990's.
6. Advent of Internet and its all-pervasive impact on communication of and access to all sorts of info. – DEM, via virtual fly-throughs and perspective geovisualization – turn of 21st Century.	**F.** Like computers, WEB Internet was also soon able to handle graphic info. including maps and images, and disseminate them worldwide. Electronic and geoportal maps or image maps are dynamic, i.e. interactive. Also, one can fly over DEM draped with pertinent image map from any height and direction, which infused perspective elements to the orthogonal map view.Multimedia and animation further enriched maps.
7. Advent of Geo-WEB and Cloud Computing -Turn of the II decade of the 21st C.	**G.** Now map users are not simply map viewers – they can add their own info. to the map/image map as VGI on sites like 'openstreetmap' or 'wikimapia'; and individuals or corporate houses can mix up map from one source and some information from another source as map mashups through API tools. It is also feasible to tag some spot photos, videos, or info. boxes of locales or features as icons, which can be opened by just clicking at the icons, facilitating home tourism. Cloud, i.e. massive computing resources and services for hire,enable even small companies to take up large projects, like major world atlases, and challenge monopoly of giants of the field.
8. Augmented Virtual Reality and Augmented Map with wearable computer gazettes. Map turning into an App on smart gazettes – Currently in progress.	**H.** Recent GI like map or image map brought to view from GIS or Web through wearable gazettes can be matched with the real world situation in the field. Or rich graphic and toponymic map information of the map can be seen on the satellite image as back ground. Maps turning into Apps and being integrated into multi-utility items of daily life.

annotated image-map. Both the components of the image-map on the computer are perceived through a set of tangible tools.Concepts like Internet of Things, and Mobile Augmented Reality will likely facilitate this development.

Many and varied are the causative factors and consequent developments in the mapping field, and they are often intermingled rather intricately; however, an attempt is made to collate and relate them explicitly as a table below (Table 1).

Enhanced Cartographic Capabilities of GIS - Lately, major GIS S/W producers have tweaked up their GIS S/W or have developed cartographic finish components that can impart cartographic quality and finish to the map products from CDBS or GIS data. MAPublisher, for example, is an add-on plug-in for Adobe Illustrator and Xtras for Macromedia Freehand. In India NATMO has been trying to adopt this suit of GIS components for sometime for final touch ups for its map publication projects.

If this practice comes in vogue, I must modify my long-held conviction that GIS produces only functional, ad-hoc maps for practical purposes. No, they can now produce maps true to the core – as there have come about Cartographic S/W or components of GIS S/W that produce quality maps. Only it takes a relatively long, patient learning perseverance to efficiently use these specific tools. However, many of the cartographic procedures and processes do take good deal perseverance on the part of learners and even operators to carry them out with good results. Once these specific components of GIS S/W's become commonplace in operation and access, GIS will have truly replaced conventional cartography or become its indispensible ally, i.e. the GIS Cartography will have truly come of age. One more fall out of this S/W-based Cartography will be minimization of subtle subjective elements of Cartography.

Cartography vs. Geospatial Science Enigma - The enigmatic question still remains as eluding: Will Cartography survive or simply pass off into oblivion, 'yielding place to new', i.e. Geospatial Science to function as Cartography much augmented? The image of cartographic practice and profession vs. that of Geospatial Sciences, and the prospects of the latter eventually pushing out the former are distinctly influenced, among other things, by one's orientation and perception. For the old veterans, who have essentially seen only print maps in their formative years,Cartography is Cartography which cannot be replaced by anything –not even by the technological gamut called Geospatial Science, though the latter can better perform many functions of Cartography. And for the young sophomores, who have grown essentially with the digital maps or image maps on the electronic media, Cartography is a classical profession - of great diligence and acumen – that has seen its days.

Perhaps, geospatial technologies add many novel elements to map, and augment it with much new functionality. Nevertheless, creating a finished map per se remains the basic function of Cartography – be it analogue, digital, or even GIS/Geospatially-enabled. It implies that 1. Scrambling to edge out each other is a futile and self-defeative impulse; 2. Instead, moving together, the two streams enrich each other.

Epilogue – If detailed, real-time maps or image maps are a reality, as envisioned in the New Map Policy of the Govt. of India, the topographic, cadastral and even urban maps may be combined and kept updated, as cadastral record and urban land use records are updated. This actually stands warranted as the NMP envisages urban scale maps at 1: 10K and larger scale[5]. The built-in hiatus between topographic, cadastral and urban maps no longer stands viable.

The paradigm shift in Cartography will go a long way to help realize the ambitious dreams of the country like Digital India, and Smart Cities & Villages, E-Governance, and also in disaster mitigation and management. Modern GI, ITC and augmented reality through wearable computers gazettes with people out in the field can help manage things with incredible efficiency. However, for this fond scenario to be realized, an unflinching power supply and Internet at reasonable speed are the crucial bottom line.

REFERENCES

1. Peterson MP, 'Web and Mobile Mapping' in Tyner JA (Ed.) '*World of Maps: Map Reading and Interpretation for the 21st Century*', Guilford Press, 2014.

http://www.guilford.com/books/The-World-of-Maps/

2. Gartner G., 'The Future of the Map – Map of the Future', '*Coordinates*'Nov. 2015

http://www.mycoordinates.org/the-future-of-the-map-the-map-of-the-future

3. Liedtke M, 'Next Google Maps Adventure: Soaring through Amazon Jungle'.

http://www.google.com/map/views/streetview

4. Schmalsteig D. &ReitmyrG., 'Augmented Reality as a Medium for Cartography' Chapter 19, pp. 267-281 in Cartwright W., Peterson M.P. &Gartner G. (Eds.), '*Multimedia Cartography*', II Ed., 2007, Springer.

5. Survey of India, 'Guidelines for Implementing National Map Policy', Govt. of India, (2006).

Mapping Social Exclusion and Discrimination

TRACING THE GEOGRAPHIES OF STIFLED SPACES OF CHRISTIAN DALITS IN KERALA

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ABSTRACT

Space is not merely an avenue of performance and existence; it is an arena of conflict and struggle. Not only it wields power but also delegates power. Although with the march of time a particular space loses its sheen yet it denies rendering itself into a complete oblivion as it produces forth other spaces, laced with more/less power and wider/constrained scope. Everyone in the society does not share the same level of synergy of these spaces. This leads towards the appropriation of space by various strata of the society. The resultant occupancy of space is mostly attributed to a specific culture of a community. But this does not always hold water as this very culture of this community might be an offshoot of an imposition of another culture. The Longer this imposition of culture continues, the longer it takes for a certain community to carve out a holistic socio-economic space. In Kerala, geographies of space are highly asymmetrical and implicated with power. These asymmetries of geographical space and implicated power have given rise to explicit and implicit forms of social exclusion and discrimination. Tracing out these asymmetries of geographical space implies balanced spatial development and better local governance. This paper explores the inextricable link between physical, social and economic spaces and endeavours to expound that how the culture of two communities namely, Syrian Christians (Christians converted from the upper echelon of the Hindu society) and Dalit Christians (Christians converted from the lowermost rung of the Hindu society) in Kerala, the most advanced state of India, give rise to a chameleonic and stifled socio-economic space and thereby, various strands of social exclusion and discrimination.

Keywords*: Space, Power, Culture, Social Exclusion, Discrimination*

INTRODUCTION

Space is not a linear narrative. At the same time, its conception has been very fluid from the beginning itself. Some thought it to be an absolute space, which was identified with emptiness (Reichenbach, 1957)[1]. It was considered as container and not as contained. Relative space and relational space were two another important explanations of the space discourse. Harvey (1973)[2] also strives to pull together all these three versions of space and tries to put forward the relational space as the geographical space. The credit of the most important explanation of space goes to Lefebvre (1991)[3] who portrayed space as a social construct. Soja (1989)[4] also goes for a space which is socially produced. Foucault (1980; 1986)[5] links space with the notion of power. So, there has been various strands of this discourse on space. But Raju (2011)[6], summarizes it beautifully. She says,

The traditional conceptualization of spaces as territorially bound and self-enclosed pre-constituted autonomous containers has become highly problematic. The more recent construct does not see space as a passive locus or container, but as contained"full of meanings, both metaphoric and grounded. The binary constructs of space as non-real and real no longer hold the currency the way it did earlier as the two are increasingly being seen as dialectic, and mutually constitutive. Spaces and places are socially produced and power asymmetries are implicated in their production [and maintenance].

Basic idea of this study in regard to space is to consider it as relational one where one section of the society interacts with the other sections' spaces and register its presence or find itself in oblivion or avoidance or stifled. This study puts in an effort to decipher these inextricably linked spaces of Christian Dalits, Syrian Christians and Hindu Dalits and how do they orient themselves when it comes to a production of a common space. This study also focuses on the dimension of implicated power in the emergence and maintenance of social and economic spaces.

OBJECTIVES

In the present geographical and larger social science literature space is being treated as power. This power does not only decide the present access to the available space but also depicts how this produce other forms of stifled space. This study endeavors to document the power asymmetries inextricably linked with the space. This study also brings out the systemic relationship between physical space, social space and economic space. It finally exposes the hoax that Christian dalits are now empowered, very similar to the other Christians and that is why reservation benefits should not be extended to them as to the other dalits hailing from other religion.

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DATABASE AND METHODOLOGY

This study has been carried out in Kerala. Further the study is filtered down to the two districts showing the substantial percentage of Christian population as well as substantial SC (Scheduled caste) population.

At district level, data on SC Christians and non-SC Christians (NCDs) is not available either in Census or in NSSO (Though one can extract the district level data in NSSO but that would be insignificant and unstable due to the very small sample size). So, in order to deal with this limitation, this study takes into consideration those districts having higher percentages of Christian population as well as SC population. Census of India, 2001 provides information in this regard. Keeping this in mind, Kottayam and Pathanamthitta districts in Kerala have been selected for the study. These districts have the higher percentage of Christians (44.6% and 39.03 respectively) and substantial Scheduled caste persons (7.7% and 13.2% respectively).

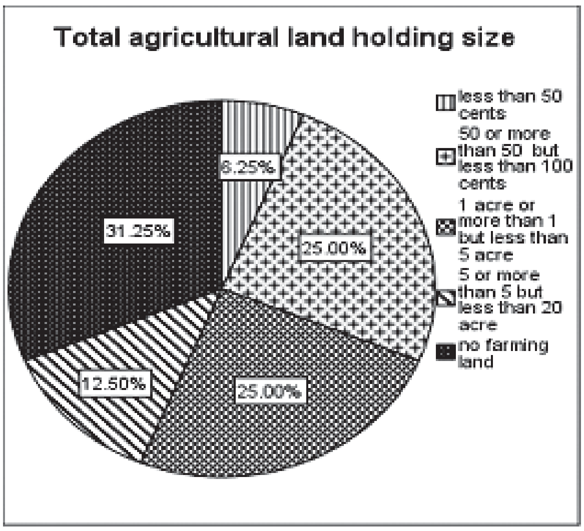
This study uses the combination of stratified-purposive and random methods of sampling. Up to village and urban area level, it involves stratified sampling but at household level this study employs purposive and random sampling.

This study takes into consideration two villages, two urban areas and two communities, that is Christian Dalits (Christians converted from the lowermost rung of the Hindu society) and So-called Syrian Christians (Christians converted from the upper echelon of the Hindu society and who follow Syriac liturgy). Total three hundred fifty households from two villages and two urban areas have been interviewed to collect the primary information on issues important for the present study. Apart from personal interviews, this study involves focused group discussion and observation methods of data collection.

DISCUSSION AND ANALYSIS

As mentioned earlier, this study focuses on the inextricable link between physical space, social space and economic space. From the very beginning of any culture physical space has been foundational. In ancient times and up to a greater extent even now, it extends an 'honour' or 'prominence' to the one who possess it. In fact, there was a time and even today in agricultural societies, marital relations were dependent on the possession of the physical land. Thus, it has a bearing on social space. Possession of land brought material prosperity too. This prosperity provided a thrust to the social as well as economic space of a person who possess a great deal of physical space. Once a family got a good head start because of this physical space, they seldom suffered poverty or a blow to their economic space. Social space can be possessed by physical space up to a limited extent especially in India. Because in India social space is decided by one more crucial factor that is one's caste. So, one can imagine the condition of a particular community which is deprived of both the physical land and the higher rank in the caste hierarchy. Physical land or agricultural land possession by Christian Dalits (CDs) and Syrian Christians i.e. non-christian dalits (NCDs) is depicted in Figure 1 and 2.

Figure 2 when compared to Figure 1, documents very succinctly that around 90 per cent of the CDs do not possess any agricultural land. But on the other hand around 70 percent of the NCDs possess agricultural lands of various land holding sizes. In terms of the



Source: calculated from primary survey data

Fig. 1 Agricultural Land Possessed by NCDs

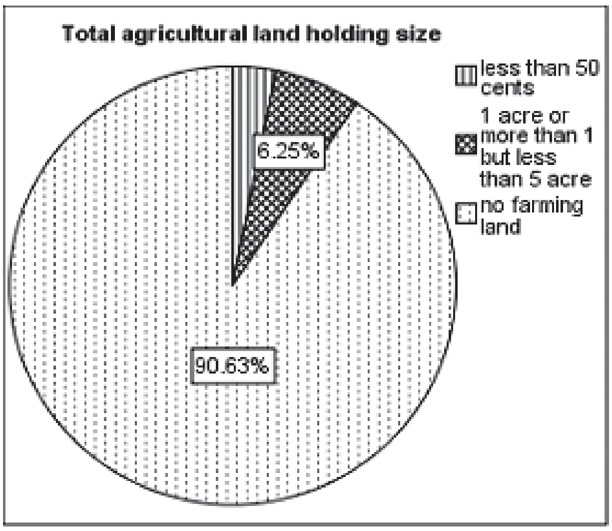


Fig. 2 Agricultural Land Possessed by CDs

appropriation of space, this dispossession has been catastrophic for CDs. In fact, this has been one of the primary reason for their agrestic slavery (Mohan, 2007)[7]. This deprivation of physical land has stunted their growth in other spaces too. Because they could not possess this physical space, they worked as agriculture labourer which did not allow them earn enough for a good education of their wards. Consequently, almost whole of their next generation also could not redeem this space.

Similarly, when we compare the physical land available for house construction across these two communities, picture is not much encouraging. Most of the CDs' houses are single room houses. And most often they four to seven people inhabit a physical space of thirty square meters. This leaves every one of them to live a suffocated life. Married couple are irritated because they cannot express themselves whenever they want; children do not get separate space to study as all of them are watching TV in the same room; many of them are sick often because of unhealthy environment. On the contrary, NCDs have enough physical space available for them. In most of their houses, they have separate rooms for their children. So that they can study properly.

Even the locale of the house plays a vital role in appropriation of the other spaces as well as in showing the power of the space. In urban as well as in rural areas CDs have their localities at a segregated place which is away from the center of the city or village. In urban areas they have houses along or near the waste water drains which is unhealthy. Sometimes they are located near cemeteries where foul smell engulfs the surrounding because of faulty burial place and thus posing serious health threat. These segregated locales constrict CDs' social interaction. This results in stifled social space. This in turn has a bearing on their psychological development. And have an ultimate reflection on economic space too. Table 1 shows the international mobility of CDs and NCDs. It has a subtle clue to the stifled social as well as economic space.

Table 1
Occupation Levels at Abroad

Response	*NCDs (In Percent)*	*CDs (In Percent)*
Yes	81.3	25.0
No	18.8	75.0
Total	100.0	100.0

Source: calculated from primary survey data.

Kottayam as well as Pathanamthitta share almost similar story presented in table 1. NCDs global mobility is an evidence of their successful appropriation of their economic space. But in case of CDs, it reflects their stifled economic as well as social space. NCDs have gone out to many countries in search of jobs and have settled there. Now it has become for the current generation to go abroad and find a job because they have got already someone from their community or extended family who will facilitate everything for them. But for CDs it is a hard struggle because their economic space has been very fragile and that is why their social space has been very limited which explains why we have very less population of CDs working outside India and that too, when explored further it is revealed that most of them are working as laborers and limited to only

Table 2
Occupation

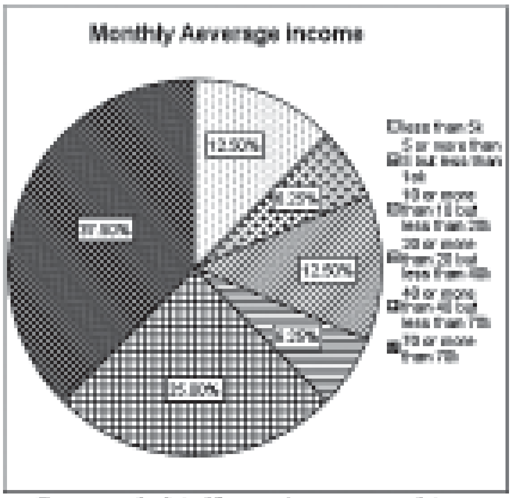
	(NCDs) (in Percent)	*(CDs) (in Percent)*
daily wage labour	0	12.3
daily wage labourer in agriculture	0	1.4
monthly wager	2.7	8.2
primary and middle school teacher	1	3.2
secondary and upper secondary teacher	1.3	0.7
UG and PG lecturer	8.0	1.4
Doctor	2.7	1.4
Engineer	9.3	2.2
Evangelist	1.3	4
Priest	5.2	1.4
homemaker	18.7	24
artist (musician, actor, actress, etc)	2.7	0
political activist and social worker	1.3	0
govt. service	1.3	1
retd. from govt. service	1.3	4
pvt service	4.0	3.4
no occupation	1.3	3
Counselor	1.3	0
big businessman	4.0	0
small businessman	1.3	0
MNC administration	10.7	0
architecture	1.3	0
Self-employment	2.7	1.6

Source: calculated from primary survey data middle-eastern countries. While on the other hand NCDs are everywhere on the globe and a significant chunk of their population is absorbed in skilled to highly skilled jobs.

Occupational structure of CD population and NCD population in both the districts provide us clearer picture. Table 2 brings this idea home.

According to Table 2, there are around 25 per cent CDs who are working as daily and monthly wage labourer. They are in informal sector. They may get job in the morning but not in the evening. They may get job every day of the month and they may get job only ten days a month. That is how precarious their economic space is.

Monthly average income is another stronger indicator signifying their participation in larger economic space. Figure 3 and 4 present the economic space of NCDs and CDs respectively



Source: calculated from primary survey data

Fig. 3 Monthly Average Income of NCDs

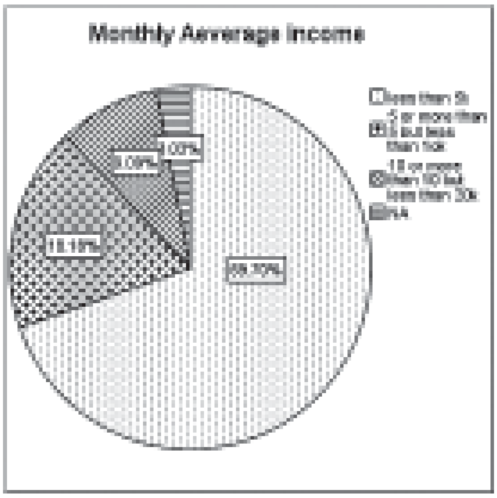


Fig. 4 Monthly Average Income of CDs

As per figure 3 and 4, CDs' economic vulnerability is crystal clear. Around 70 per cent of them earn less than five thousand or around it a month. Interestingly no person was found to be earning around fifty thousand a month. But in case of NCDs, around 50 percent of the population earns around 50 thousand a month. This enables them to appropriate almost all the economic space available for Christians and Christian dalits are left with the minimal. Unfortunately this economic space aggravates the severity of vicious cycle of stifled spaces.

CONCLUSIONS

In no way this study implies that non-Christians are the main culprit who are behind the stifled spaces of Christian dalits. Caste Hindus and others are also responsible for the deplorable plight of Christian Dalits as the physical, social and economic spaces of Christian dalits did not emerge yesterday only. They have a historical underpinning. Hindu Brahmins and Nairs and other caste oppressed them. They snatched away their physical space in ancient times which could not be procured even today. This seems very petty issue today as land no more holds an immense value. But the question is, where did it all start? Of course, for others might be many other starting point. But for dalits it was physical land which eclipsed their social and economic space. It was all done in the name of their caste. Larger society innocently assumes that there is no caste in Christianity and which is very true that Christianity do not approve any discrimination on the basis of caste. But we must remember that we are talking about Indian Christianity which consists of Indian people, most of whom were at some point of time Hindus or at least considered Hindus. Many of these people embraced Christianity but could not do away with the caste. For name's sake they are Christians. But in practice they have separate churches for people who trace their origin in the so called lower castes of Hinduism but later on embraced Christianity. Apart from physical space, caste is one of the major factor which does not allow Christian dalits to break the vicious cycle of stifled spaces. Nowhere during the primary survey it was observed and later on substantiated by the data that Christian dalits have risen to the socio-economic status similar to that of the other Christians. That is why it would be unwise to throw the baby with the bath water. For the rightful appropriation of their physical, social and economic spaces within and without Christianity, benefits of affirmative action is inevitable for Christian Dalits. It will facilitate the fixing of the asymmetries of spatial power between these two communities.

REFERENCES

1. Reichenbach, H. (1957). *The Philosophy of Space and Time*. New York. Dover.
2. Harvey, D. (1973). *Social Justice and the City*. London. Edward Arnold.
3. LeFebvre, H. (1991). *The Production of Space*. Blackwell. Oxford.
4. Soja, E.W. (1989). Postmodern Geographies: The Reassertion of Space in Critical Social Theory. London. Verso.
5. Foucault, M. (1980). Questions on Geography: Interviewers. The Editors of the Journal Hérodote. In C. Gordon (Ed.) Michel Foucault. Power/ Knowledge. Selected Interviews and Other Writings, 1972–1977. Brighton. UK, Harvester Press. [trans., orig. 1976]. -(1986).Of Other Spaces. *Diacritics*. Spring, 22–27.
6. Raju, S. (ed.) (2011). Gendered Geographies: Space and Place in South Asia. New Delhi. Oxford University Press.
7. Mohan S. (2007). Imagining equality: Modernity and Social Transformation of Lower Castes in Colonial Kerala. Unpublished Thesis. MG University, Kottayam.

SPATIAL ANALYSIS OF HOMELESS POPULATION IN INDIA

Chetana NASKAR[1]

ABSTRACT

Homelessness is one of the major problems that humankind is experiencing for long, and India is no exception. The country has more than 20 million homeless people living in sub human conditions and the phenomena is argued to be the repercussion of the third world urbanization process which thrusts many in to the streets. Another important factor associated with this phenomenon is the presence of women at a significant level. Falsifying the argument made by previous literatures, new studies and also various contemporary data strengthens the presence of women in the homelessness phenomenon. Using the 2001 and 2011 Census data, the present study thus portrays the scenario of homeless population in the country. Their distribution across districts the growth rate and the gender differential in their concentration has been calculated and mapped.

Keyword(s): *Homelessness, Distribution, Disparity, Women Homeless*

INTRODUCTION

Homelessness represents the most obvious and severe manifestation of the unfulfillment of the human right to adequate housing. While estimates on a scale of homelessness are invariably difficult to ascertain with precision, it is generally mentioned in the relevant United Nations documents that there are about 100 million homeless persons in the world. Few, if any, countries have entirely eliminated homelessness and in many nations this phenomenon is clearly increasing rather than declining, and further action is clearly required to eradicate homelessness (UNCHS, 1999d cited in UNCHS, 2000:02).

The above declaration by the United Nations Organization gave recognition to the phenomenon of homelessness and thus homeless people in the world where their existence otherwise goes unnoticed; and apprehensively, the phenomenon has increased and is continuing to increase at an alarming rate (Cloke *et al*, 2010). Even the most developed countries are not spared from experiencing this problem and the developing countries where economic and housing policies remain inadequate, the phenomenon is apparent.

Homelessness is the repercussion of the structural changes that are-loss of/or unstable job, increase in the housing cost, inability of the government to secure its population with minimum cost housing, decreasing the allocation of budget for public housing projects deliberately, continued gentrification of the urban spaces-that these 'high-income industrialists' countries had gone through since 1980s (UNCHS, 2000; Banerjee-Guha, 2011). In Europe - Germany, France, and the United Kingdom counts for maximum homeless population, where on an average 4 to 12 per thousand population is estimated to be homeless; rest of the countries have numbers lower than 4 or equivalent to 2 per thousand population. The overall homeless population in the entire continent is estimated to be around 3 million (RAIS, 2010). The problem is also widely situated in the United States and Canada, the countries where the phenomenon got its recognition as a serious social problem, way before other countries. There are about 200,000 homeless people in Canada and the estimated numbers of homeless people range from 600,000 to 2.5 million in the U.S.[1] Among the developing countries (like Bangladesh, China and India) India remains worst affected by this phenomenon (UNCHS, 2000). Homelessness is one of the major problems that humankind is experiencing for long, and India is no exception. The country has more than 20 million homeless people living in sub human conditions and the phenomena is argued to be the repercussion of the third world urbanization process which thrusts many in to the streets (*ibid*). The phenomenon has been an intrinsic problem of Indian cities with the problem being more consolidated in the large metropolitans. The present study therefore looks into spatial distribution of the homeless population in the country over a decade (2001-2011), alongside the gender disparity in the spatial distribution. Census 2001 and 2011 data is used for carrying out the study. Data from various reports published by non-governmental sources are also included in the study. Simple statistical and cartographic tools have been used in this study which includes compound growth rates, Sopher's modified disparity index, differentials, proportions and ratios.

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(a) Compound Growth Rate

The compound annual growth rate is calculated by taking the nth root of the total percentage growth rate where n is the number of years in the period being considered.

N= (end year-beginning year)

Compound growth rate= (value of end year/ value of beginning year)$^{(1/n)}$ -1

In the present study,compound annual growth rate have been calculated to show the growth rate of homeless population in Delhi between two points of time (2001 – 2011).

(b) Sopher's Modified Disparity Index

Disparity between the two gender across the homeless populationhavebeencalculated by using the disparity index.The index was primarilydevised by Sopher and later modified by Kundu and Rao (1985). The index uses the following formula:

$DS=log(X_1/X_2) +log (200-X_1)/ (200-X_2)$

Where, $X_2>=X_1$.

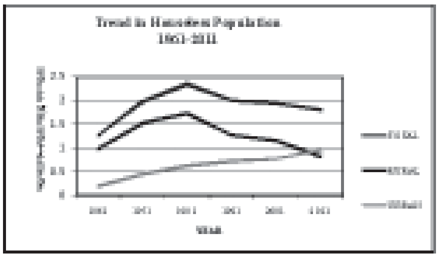
Larger the value greater is the disparity and vice versa. In case of homeless population, the reference category is male.

DISCUSSION AND ANALYSIS

Homeless Population in India

Homelessness has been a persistent feature in the country and 'in rapidly urbanizing India homelessness in urban spaces has been a growing concern (SSC, 2011:03)[2]. Presently about 17 per cent of the world's slum dwellers reside in three mega cities of Mumbai, Delhi and Kolkata. The socio-economic imbalance and extreme rural poverty forces people to out migrate from their native place to these mega cities, most of whom 'get lost in the city-life and end up' on the streets (GNTCD-UNDP, 2010). The Census of India defined them as '*houseless population*' and recognized them as those living in places unfit for human habitation such as – roadsides, pavements, hume pipes, temples, under staircases and the like (Census, 1991: 64).

The diagram 1 provides a glimpse to the changes in the absolute homeless population in the last six censuses. The urban homeless population has increased over the time with no break in between, however there has been a decrease in homeless population in rural India contrary to the urban experiences. This is mainly due to the increased migration of the rural poor to the urban regions for



Source: Census of India 2011; from 1961 - 2001 retrieved from Shelterless Persons in Delhi: Challenging Inclusive Growth Policies, 2007.

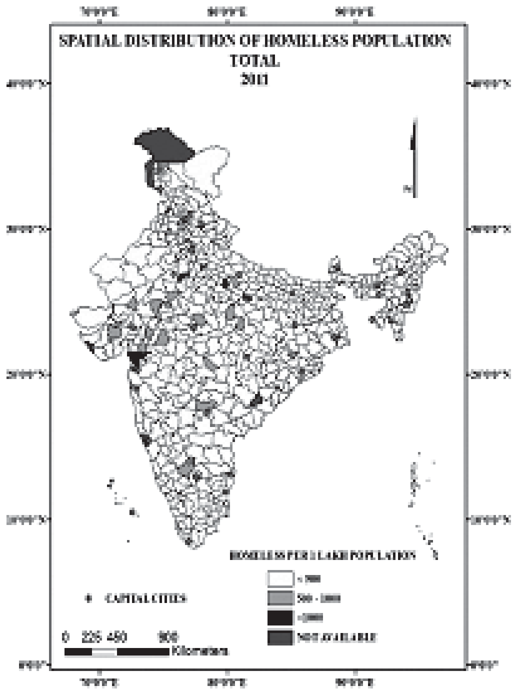
Diagram 1

securing a proper livelihood. Nonetheless the increased cost of living in urban areas forced them to survive on the streets as most of them sends maximum amount of their earnings as remittances back to their villages (Tipple and Speak, 2006). The overall homeless population increased from 1961 to 1981, the year which has seen the maximum rise in the homeless population in the country which amounts to an increase in 1.08 million in homeless population (1.26 million in 1961 to 1.98 million in 1971; to 2.36 million in 1981). However there has been an overall decrease in homeless population since then, and presently India has 1.8 million homeless people, a fall in 0.14 million from the year 2001.

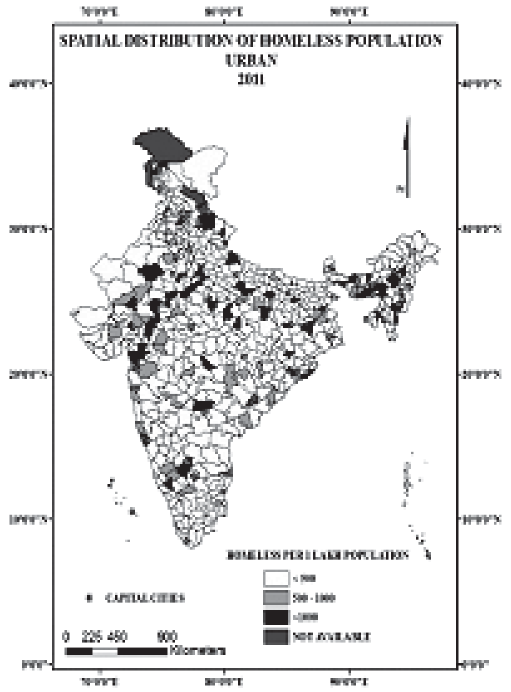
Spatial distribution of homeless population (2011)

The spatial distribution of homeless population is arrived at by calculating the ratio of total homeless population per 1 lakh population of each district. Male female division is deliberately avoided because the absolute number of homeless population in each category for most of the districts is so less that it becomes difficult to calculate. The spatial distribution reveals that overall share of homeless population per 1 lakh population for most of the districts is less i.e. below 500 per 1 lakh population with the lowest being in Kangra district – 1 person per 1 lakh population. There are 30 districts with population more than 500 and 7 districts with population more than 1 thousand. The districts with homeless population more than thousand falls - 3 in Gujarat, 2 in U.P. and 1 each in Rajasthan and West Bengal, with Kanpur Dehat (U.P) having the highest concentration i.e. 4632 homeless per 1 lakh population. The areas of concentration of the homeless population are mostly near the capital cities thus revealing the pull factor the cities exert on the marginalized people.

The urban areas show much better distribution. There are more districts in the urban areas with homeless population more than 500 per 1 lakh population and 60 districts having homeless population more than 1 thousand per 1 lakh population. The concentration



Map 1



Map 2

of the homeless population is higher near the capital cities. Though not very prominent, but still a north south divide can be seen in the concentration of the homeless population, with most of the districts with high homeless population present in northern region., Nalbari (Assam) has the highest urban homeless population i.e. 11000 (approx) with the lowest being in Jammu (Jammu and Kashmir) – 1 person per 1 lakh population. The probable reason for the concentration of the urban homeless population near the capital cities can be the pull factor that the cities exerted on these marginalized people.

Growth of Homeless Population (2001-2011)

In 2001, census estimated about 1.94 million people to be homeless out of which 1.16 million lived in villages and 0.77 million lived in cities and towns (SSC, 2011; Census, 2001). However these numbers remained highly contested and are stated as gross underestimates of the actual scenario (SAM:BKS, 2014)[3]. Further the Census also overlooked other important attributes such as the reasons and the repercussions of homelessness and concentrated only on the head counts[4].

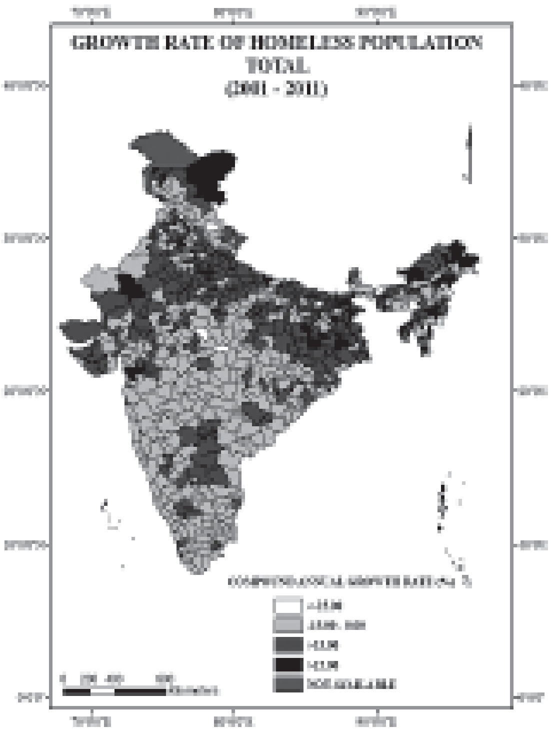
In 2011 the Census enumerated 1.8 million homeless people out of which 0.94 million lived in urban areas and 0.83 million in rural areas. Where the rural areas have experienced decrease in homeless population, in the urban areas the population has increased consistently with a rise in 0.75 million since 1961. These interchange in the rural - urban homeless scenario can be attributed to the increased migration of the marginalized people to the cities, therefore causing transfer of the rural poverty to the urban areas and continuous reclaiming of the urban spaces through large scale demolitions of slums (Maitra and Singh-Mehta, 2007; Banerjee-Guha, 2011, Dupont, 2013).

Nonetheless the present census (2011) also suffers from similar problem of under enumeration as it shows a decline in overall homeless population, which is highly ambiguous (SSC, 2011; SAM:BKS, 2014) and overlooked the reasons behind homelessness and the consequences that people face after becoming homeless. The ambiguous nature of the Census regarding correct enumeration of homeless people is further strengthened by the different statistics presented by different national and international organizations over the time period.

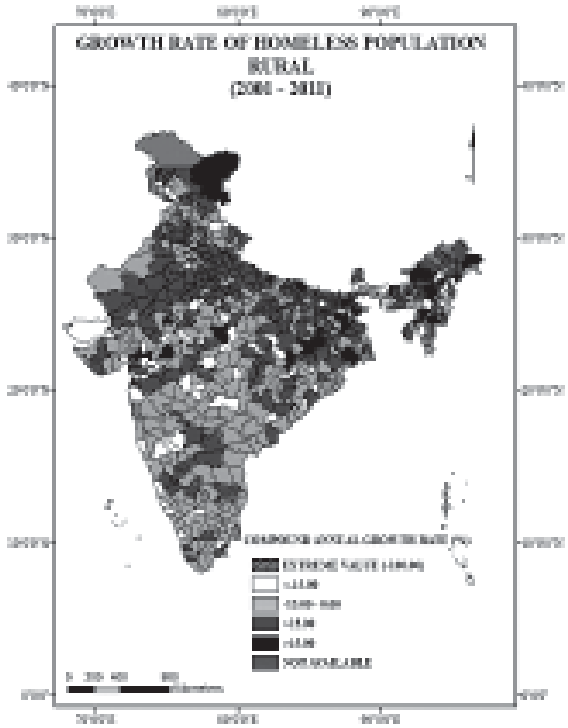
Map 3, represents a vivid picture of the total growth in homeless population in the country from 2001-2011. A clear north south division is visible with the increased concentration of homeless population in the northern region than in the south. This can be attributed to the poor economic condition of the states in the northern regions.

All the economically backward states of Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar and West Bengal show the highest growth in homeless population.

However such divide is absent in urban homeless population as throughout there has been an increase in urban homelessness. The rural growth rate of



Map 3



Map 4

homeless population also shows similar pattern to that of total homeless population (*map 4*). There has been an increased growth of homeless people in economically and socially backward states where as the more developed south shows a decrease in rural homeless population.

The growth rate of total homeless population has decreased to -1.01 per cent; in rural areas it has decreased by 3.63 per cent; and in urban India it has increased by 2.09 per cent. Thus it is apparent that there has been an increase in the urban growth rate of homeless population, with a decrease in rural and therefore a modest decrease in total growth rate of homeless population from 2001-2011.

Rural-urban Differential in Homeless Population (2011)

The rural urban differential clearly (*map 6*) shows an increase in urban homeless population. Kolkata, Chennai, Hyderabad, Mumbai has cent percent urban homeless population with no homeless population in its rural counter parts whereas in Delhi, Chandigarh and Bangalore the share is 98.5, 98.7, and 85.07 per cent respectively. This is mainly because of the increased urbanization in these metropolises. Most of the hilly districts have high rural homeless population. Similarly districts of U.P., Bihar, Orissa, and few districts of West Bengal have highest proportion of rural homeless population.

Table 1
Districts Falling in Each Class Showing the Growth Rate in Homeless Population 2001-2011

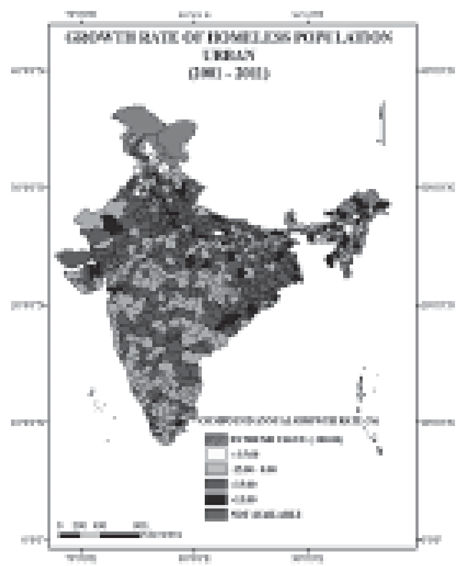
Scale	*Total Growth Rate*	*Rural Growth Rate*	*Urban Growth Rate*
Extreme Values (100)	0	1	1
<-15	19	65	22
0- 207	-15	287	251
0.01- 15	240	221	267
> 15.00	36	31	54
Data Not Available	7	14	30

Source: Computed from Census 2001-2011 data.

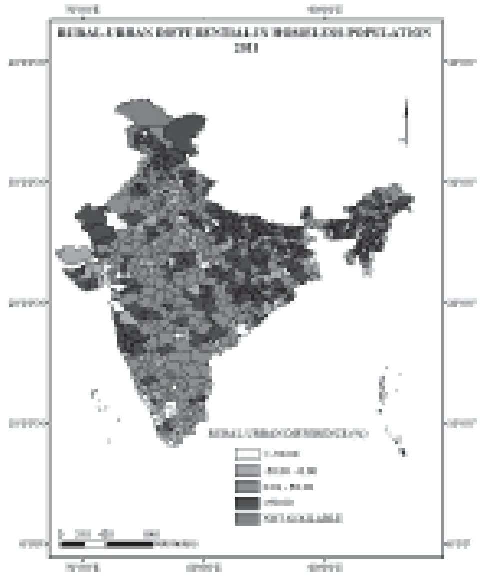
Table 2
Districts Falling in Classes Showing Rural – Urban Differential, 2011

Scale	*Districts*
< -50	40
0--50	100
0.01 – 50	208
>50	226

Source: computed from Census, 2011 data.



Map 5



Map 6

Gender Disparity in Homeless Population

It is mostly considered that men are the worst sufferer of homelessness phenomenon and that they count near to absolute, therefore disparaging the presence of women (McCarthy, 2013). Various studies and also the government and non-government data have proved from time and aging that women does constitute a significant proportion of the homeless population. However the reasons behind their homelessness also stays ignored.

The maps below represents the male female division in homeless population. However, rather than simply presenting maps with male and female homeless population a gender disparity index is worked out to show the ratio between male and female homeless population throughout the country. There are few pockets where the gender disparity is high with significant preponderance of male homeless population to female homeless population among the total homeless population in the country. Many northeastern districts have female homeless population that exceeds the number of male homeless population.

Except a few districts of North East, Andhra Pradesh, Orissa, and Bihar, over all male homeless population is high among all the districts; however the disparity is not stark except in a few districts. Thus, there is a significant preponderance of female homeless population in the country. One district of J&K, and a few districts in north east have more female homeless population than male.

The urban picture is more skewed towards the male homeless population. Major concentration is seen in and around the metropolitan cities in the country. Even the influence of the other class cities cannot be ignored totally. However the reasons behind any of the pattern cannot be stated with assertion as the country's regions possess highly diversified characteristics. Different reasons can give rise to varied pattern in occurrence of any problem in the country and as broad coverage of the causal factors behind homelessness is not taken up by the Census or any such organization, it becomes difficult to give any particular reason behind homelessness in the country. Nonetheless poverty all in all has a big impact on causation of homelessness, as, had they not been poor they would not have ended up on the streets.

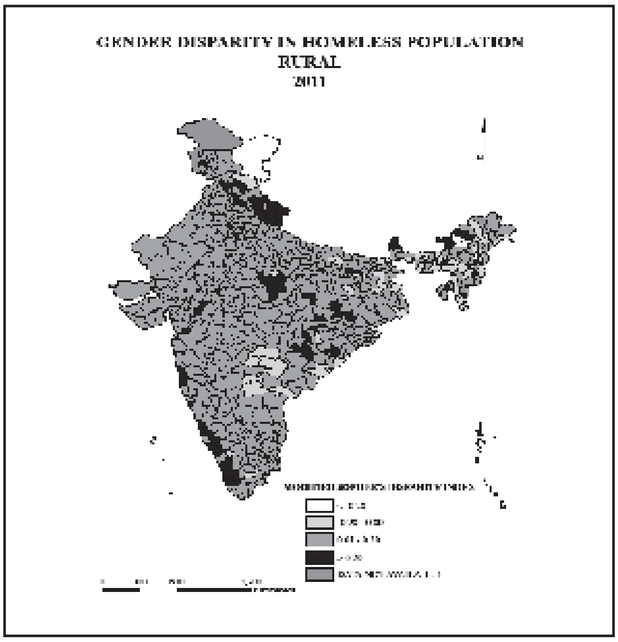
Table 3
Districts Falling n Each Scale Showing Variation in Gender Disparity, 2011

Scale	*Total*	*Rural*	*Urban*
< -0.2	2	5	8
0-0.2	44	59	49
0.01 - 0.20	431	449	315
> 0.20	107	62	196
Data Not Available	5	14	21

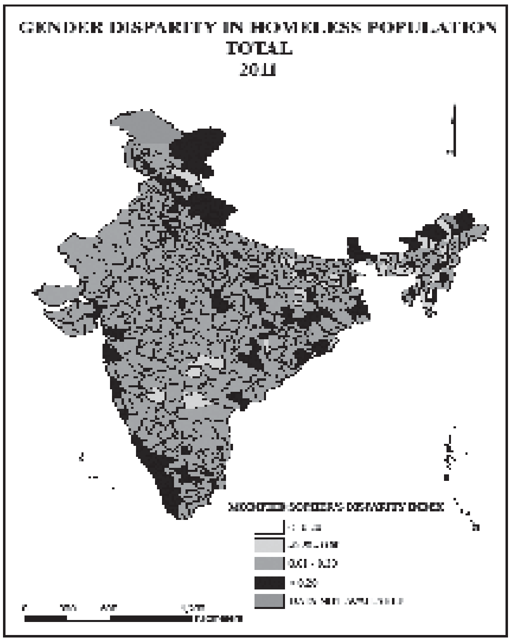
Source: computed from Census, 2011 data.

Difference in Head Counts of Homeless Population

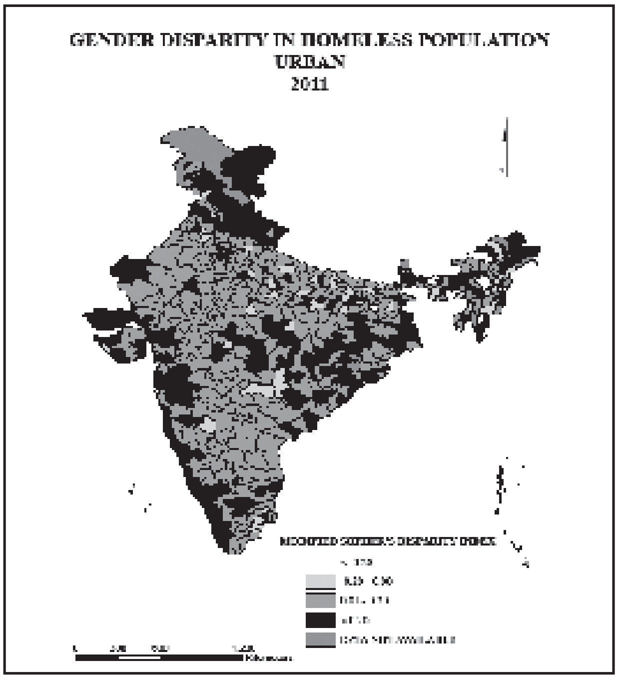
The table 4 shows how there have been large scale discrepancies regarding the enumeration of the homeless population throughout the country. Invisibility of homeless people renders them a difficult group to work with, although many may have lived several years, sometimes even a generation or two on the streets, they are seldom noticed by officials' (SSC, 2011: 03). This brings forth the



Map 7



Map 8



Map 9

Table 4
Homeless Head Counts by Different Government and Non-government Organizations

	SOURCES	YEAR	HOMELESS POPULATION IN MILLIONS
INDIA	CENSUS	2001/2011	1.9/1.8
	UNDP	2010	13
	ACTION AID***	2003	78

Source: Census of India 2001/2011; UNDP India: Homeless Survey 2010

*** The information is taken from http://hungryindia.hpage.co.in/homelessness_16136539.html

magnitude of the problem and the difficulty in effective ways of addressing them. Further neither there is coherence among different organizations in following a standard definition[5] to address homeless population nor do they follow a particular time period for enumerating them[6]. Thus, with the persistent methodological differences among different organizations, homelessness figures are bound to be uncertain and should be treated with caution (FEANTSA, 1999; Maitra and Singh-Mehta, 2007).

One of the important factors that are being brought to notice in the present homelessness trend is the change in the composition of socially marginalized section (Dupont, 2013). However, this does not mean that previously homelessness was not a heterogeneous process, unavailability of the data and the increase in the interest of different organizations in this field only recently prevent us to make any strong assertion regarding the heterogeneity of this population. Nonetheless one cannot deny absolute disappearance of women and children from being facing marginalization equally, as the increasing phenomenon of homelessness among women throughout the world and developing countries were well recognized by different international organizations (with the recent Census (2011) enumeration further strengthens the visibility of heterogeneity of homeless population. Women are not only present in all the districts but also make a significant share of the homeless population except in the highly urbanized areas, where there population is skewed[7].

CONCLUSION

An overall decrease in homeless population since 1961 is observed in both rural and total homeless population. However, the urban homeless population has undergone a continuous increase since 1961. The continuous increase in the urban homeless population can be attributed to the rural – urban migration of the homeless people for seeking better opportunities. The growth of the homeless population also shows similar pattern. A negative growth rate is experienced in overall and rural homeless population whereas a positive growth rate is observed in urban homeless population. The major metropolitan cities of the country have experienced even higher growth in homeless population. A clear north south divide is observed in the growth rate in overall and rural homeless population. The probable reason for this pattern could be attributed to poor economic conditions of the districts falling in this zone. Most of the districts experiencing high growth in homeless people are concentrated in the economically backward states of Madhya Pradesh, U.P., Bihar, Rajasthan and West Bengal which is well established in the maps. The rural urban differential in homeless population shows more concentration of homeless population in the urban areas with extreme concentration in major cities. Kolkata, Chennai, Hyderabad and Mumbai have cent percent concentration of homeless population in its urban areas whereas in Delhi the concentration is 98.5 percent. This is further revealed in the distribution map, where except the major cities the overall distribution of homeless population is low i.e. below 500 per 1 lakh population for most of the districts.

The gender disparity map shows high concentration of male homeless population in the urban areas compared to female. This concentration can be attributed to the increased male migration to the urban areas. The economic distress in the rural regions has forced the male population out of their native places as a result they ended up in the urban region, where the increased cost of living and the responsibility of sending remittances back to their family compelled them to survive on the city streets. Nonetheless, though the proportion of women in overall homeless population is lower than men, the presence of women cannot be ignored. A significant proportion (above 30 per cent except few districts) of women homeless population is present in most of the districts. Apart from economic distress, there are also various social factors which cause homelessness among women. However, due lack of available information, the reasons behind homelessness among women could not be discussed and specified strongly.

End Notes

1. http://www.homelessworldcup.org/content/homelessness-statistics.
2. The National Report on homelessness for Supreme Court of India, 2011.
3. SahriAdhikarManch: BegharonKeSath – Urban Rights Forum: With the Homeless
4. This comment is made by the researcher, as the Census 2001 data presents homeless head counts only. No other important attributes are covered by them. Similarly, in 2011 Census, though proportion of male/female and 0-6 year population was separately enumerated, other important facts as reasons behind homelessness and the problems faced by this marginalized population were not covered.
5. Where the Census counts only those who lives in open spaces unfit for human settlement, Action aid also counts those who are precariously housed and also those who lives in publicly or privately supervised temporary shelters.
6. The Census of India carries its enumeration in one single night. For 2011 Census the night of 28th February was fixed for counting total homeless population in Delhi, whereas AAA conducted its enumeration over 10 days (counting was carried mainly during night). The time taken by UNDP was not given.
7. The probable reason can be stated as increased male migration to the cities due to 'lack of economic opportunities and poverty' in the rural areas (Dupont, 2013).

REFERENCES

1. Argeriou, M., McCarty, D., & Mulvey, K. (1995). Dimensions of Homelessness. *Public Health Reports*, *110*(6), 734.
2. Ashray Adhikar Abhiyan. (2009-2010). Save the Lives Campaign – A Testimony. Retrived from http://homelesspeople.in/winter%20report%202009-10.pdf.
3. Bahr, H. M., & Caplow, T. (1973). *Old men drunk and sober*. New York University Press.
4. Banerjee-Guha, S. (2010). Homeless in Neoliberal Cities: View from Mumbai.*UDRI Mumbai Reader*.
5. Bassuk, E. L. (1993). Social and Economic Hardships of Homeless and other Poor Women. *American Journal of Orthopsychiatry*, *63*(3), 340.
6. Bhattacharya, B. (2012). Homeless Pavement Dwellers: A Case Study of their Social Awareness in Kolkata from Human Rights Perspective. *Journal of Exclusion Studies*, 2(1), 10-29.
7. Dupont, V. (2013). Which place for the homeless in Delhi? Scrutiny of a mobilisation campaign in the

2010 commonwealth games context. *South Asia Multidisciplinary Academic Journal*, (8).

8. Dupont, V. (2008). Slum demolitions in Delhi since the 1990s: An Appraisal. *Economic and Political Weekly*, 79-87.

9. FEANTSA (1999). Women and Homelessness. Retrieved from http://www.feantsaresearch.org/IMG/pdf/ch08.pdf.

10. Maitra, S. Singh Mehta, B. (2007). Shelterless Persons in Delhi Challenging Inclusive Growth Policies. Institute for Human Development. Retrieved from http://www.scribd.com/doc/14282288/Shelter-Less-Persons_in_Delhi.

11. Mander, H. and Jacob, S. (2010). Homeless Deaths on the Streets. Centre for Equity Studies.

12. Speak, S., & Tipple, G. (2006). Perceptions, Persecution and Pity: The Limitations of Interventions for Homelessness in Developing Countries. *International Journal of Urban and Regional Research*, *30*(1), 172-188.

13. Tipple, G., & Speak, S. (2004). Attitudes to and Interventions in Homelessness: Insights from an International Study. In *Paper Delivered to International Conference Adequate and Affordable Housing for All, June* (pp. 24-27).

14. UNCHS (Habitat), 2000, Strategies to Combat Homelessness, Nairobi: UNCHS (Habitat) HS / 599 / 00 E. ISBN 92-1-131458-5. Retrieved from http://ww2.unhabitat.org/programmes/housingpolicy/documents/HS-559x.pdf.

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HOUSING DEPRIVATION IN INDIA: THE MARGINALIZED VOICES

Priyanka KOIRI[1]

ABSTRACT

Housing is accepted as a basic need and fundamental necessity of life and considered as a key element in the process that directly or indirectly contributes to the development of the nation. Housing deprivation is often assumed to be an accumulation of insufficiencies in basic housing conditions such as inadequate construction, inadequate amenities and insufficient space in relation to the number of users. In relation to this, the marginalized section of population i.e. Scheduled Caste (SCs) and Scheduled Tribes (STs) are more vulnerable as they constitute half of the total "poor, deprived households". Therefore, this paper presents a comprehensive index of deprivation with respect to certain basic amenities among the SCs/STs in India. Using the data from Census of India (2011), the deprivation index has been prepared based on United Nations' technique of measuring deprivation in standard of living. Four negative variables showing deprived situation namely; households without pucca house (D_1), households having drinking water facility away from the premise (D_2), households without latrine facility (D_3) and households without electricity connection (D_4) have been used for preparing the deprivation index. Deprivation among marginalized people across the India has been shown by GIS technique, taking into consideration as major and precise cartographic technique for exposing spatial distribution. SCs and STs population have higher propensity of deprivation in terms of housing amenities. Given the fact that Government of India has launched several programs regarding to improve the housing condition but these programs are successfully implemented only in few states. Therefore, government should focus on proper implementation of programs and policies for social and economic inclusion of marginalized population.

***Keywords**: Deprivation Index, Basic amenities, Rural and urban differences, Social groups.*

INTRODUCTION

Basic minimum needs of every individual involve availability of housing amenities. Housing amenities are very important for every individual and household, but a larger part of India's population is deprived of it. Access to basic amenities like drinking water, sanitation, electricity, housing, drainage and others are crucial for the overall well-being of a household. India, like many other developing nations, has also suffered from wide-spread deprivation in access to basic amenities and services (*Kumar 2014)*.There has been a huge interstate disparity across the country. Inadequate water supply, interruptions in power supply have impeded the advancement of backward districts. *The term deprivation is used in the sense of lack of availability to an essential facility (Sundaram, 1995).*The reason behind deprivation may be because of less awareness about the hygiene and the use of sanitation and health status and of the poor living conditions. The UNDP's representation of human development and deprivation encapsulate in the measures in development discussion.

Furthermore, the National Committee on the Development of Backward Areas has listed six types of backward regions facing various adverse physical problems. They include chronically drought-prone areas, desert areas, tribal areas, hilly areas, chronically flood-affected areas and coastal areas affected by salinity. The committee regards these six categories as six types of fundamental backwardness (McCrone, 1969). The most backward districts lie in Eastern Uttar Pradesh, As-sam, and Western Rajasthan, a central plateau region of Telangana, region of Western Ghats and adjacent plateau region of Kerala. The cause of backwardness is related to (a) environmental factors (terrain, relief, heavy rainfall, merges rainfall), (b) economic (low resource devel-opment), (c) cultural (low literacy, less skilled labor, low industrial temperament, and poverty), (d) infrastructural (paucity of basic infrastructure like transport, communication, electricity, raw material etc.), and (e) demographic- high rate of population growth, high fertility, ethnic tension etc. *(Planning Commission, GoI, 2007-12).*

Therefore, to gauge the magnitude of the prevalent deprivation across the Scheduled population, this paper examines the changes in availability to basic amenities like drinking water, sanitation, electricity and quality of housing arrangement in Rural and Urban India using dataset from Census of India, 2011.

Polices on Housing and Basic Amenities

Since independence, a number of policies and programmes have been launched to improve the housing condition and basic amenities of households separately, as rural and urban areas have different administrative settings and different kind of needs

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(Kumar, 2014). The Indian constitution lays down that "the state shall strive to promote the welfare of the people, protecting as effectively as it may a social order in which justice, social, economic and political. It is on these basic principles that India continues to strive to provide its people basic socio-economic necessities such as food, clothing, shelter and so on".

The first housing programme for rural areas, namely the Village Housing Scheme was introduced in 1957 as a part of a total reconstruction programme. This programme hardly touched the fringe of the problem during the *Second and Third Five Year Plans*. The situation improved in *Fourth Five year Plan* because by the introduction of providing free house sites to landless agriculture labourers. In the *Fifth Five Year Plan*, the scheme had a provision for providing construction assistance to beneficiaries and became a part of the Minimum Needs Programme. The*Sixth Five Year Plan*declared that by 1990 all landless workers would get complete housing assistance, especially free house sites as well as construction assistance, along with minimum infrastructure. The Seventh Plan began with a housing shortage. During the *Eighth Plan* the emphasis was on social housing schemes, including those under the Minimum Needs Programme in rural areas. It emphasized the role of the Housing and Urban Development Corporation (HUDCO) and the National Housing Bank (NHB). It also emphasised shelter for the homeless and footpath dwellers, institutional development, technology transfer and development of appropriate building materials, housing information system and housing for industrial workers, working women and artisans, etc. During the *Ninth Plan* (1997-2002), the Ministry of Rural Areas and Employment airing its concern for rural housing has prepared an action plan for achieving the national goal of housing for all by 2000 A. D. The Indira AwaasYojana (IAY) was continued in the current plan period to tackle the problem of homelessness in the rural area. The *Tenth Plan* envisages completing the task at hand, namely, 100 per cent coverage of rural and urban populations with safe drinking water as per the stipulated norms and standards on a sustainable basis. The tenth plan was expected to follow a regional approach rather than sectoral approach to bring down regional inequalities. The Planning Commission set up a Working Group on Rural Housing, for formulation of the *Eleventh Five Year Plan* to look into the aspect of 'Right to Shelter'; assessment of the existing rural housing schemes both at the Central and State levels. Also the main aim of this plan was to provide clean drinking water for all by 2009. The Working Group recommends additional instruments for easy housing finance for Above Poverty Line (APL) families in rural areas under the *Twelfth Five Year Plan* and also to ensure adequate and affordable housing for all and, facilitate development of sustainable and inclusive habitats in rural areas by expanding government support, promoting community participation, self help and public private partnership within the framework of Panchayati Raj. It also recognised the inclusive growth approach as the means to an end that would demand outcomes which yield benefits for all and particularly for the marginalised sections of society(GoI, Five Year Plans).

Hereafter, it can be said that the year of 2005 has been proven the mile stone in the direction of housing for poor as two major programmes were initiated: *Bharat Nirman* and the *Jawaharlal Nehru National Urban Renewal Mission (JNNURM)* launched for rural India and urban India respectively. Apart from these several other schemes were also launched gradually for various kinds of need in housing amenities such as Indira AwaasYojana, National Rural Drinking Water Programme under Rajiv Gandhi National Drinking Water Mission, Total Sanitation Campaign, Rajiv Gandhi GrameenVidyutikaranYojana, and Provision of Urban Amenities to Rural Areas (PURA). Recently launched programmes namely Housing for all, and Swachha Bharat Abhiyan is also a landmark for housing amenities improvement.

Unfortunately, government did not reach at the level of satisfaction yet. However, one cannot deny the fact that various programs are successfully launched and contributed much more towards improving the conditions of household. Though, it has been suggested that the state governments, which are being relieved to a large extent of the responsibility for industrial housing, should concentrate on ameliorating poor conditions of housing in rural areas.

OBJECTIVES

The present paper is an attempt to examine the levels of deprivation of households in terms of basic amenities like, housing condition, drinking water, electricity and sanitation among the SCs and STs; and also it evaluates the degree of relative disadvantage of rural people when compared with their urban counterparts.

DATABASE AND METHODOLOGY

The present study investigates the effect of housing amenities among the inhabitants using secondary data from Tables on Housing Amenities, Census of India, 2011. The study is divided into two sections: section one deals with the deprivation in housing amenities among the social groups across the states of India; section two deals with the deprivation in housing amenities among the social groups across the districts in India.

For the analysis, as deprivation measures, a few indicators is being taken into account, which highlight households not having or the unavailability to the corresponding basic amenities. Deprivation index by UNDPs HDR, 2007 is used as a method to capture the shortfall in the quality of living. It is based on four criteria including the quality of housing, availability of water, good sanitation, and electrification. The index has been prepared as follows:

Deprivation Index = $[1/4(d_1^{3} + d_2^{3} + d_3^{3} + d_4^{3})^{1/3}]$, where,

i. Deprivation in Quality of Housing (d_1): percentage of households not residing in a pucca house.

ii. Deprivation in Availability of to Water (d_2): percentage of households whose source of drinking water is away from their premise.

iii. Deprivation in Good Sanitation (d_3): percentage of households who do not have latrine facility in their premise.

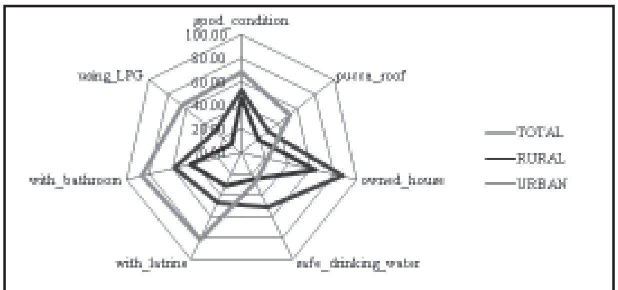
iv. Deprivation in Electricity for Lighting (d_4): percentage of households who do not have electricity as main source of lighting.

Taking the total level of deprivation to be 100 per cent, the districts are arranged accordingly along the categories and the extent of deprivation. The paper attempts to show how basic amenities like access to electricity, safe drinking water, toilet facility, vary across the social groups and these are critical elements of health status and well-being of the people.

DISCUSSIONS AND ANALYSIS

Overview of States with Deprivation of Basic Amenities

Availability to basic amenities is the most important aspect of quality of living. The amenities like electricity, water, sanitation and clean fuel are the critical determinants of living conditions and these amenities are considered as the most essential ones for better livelihood.



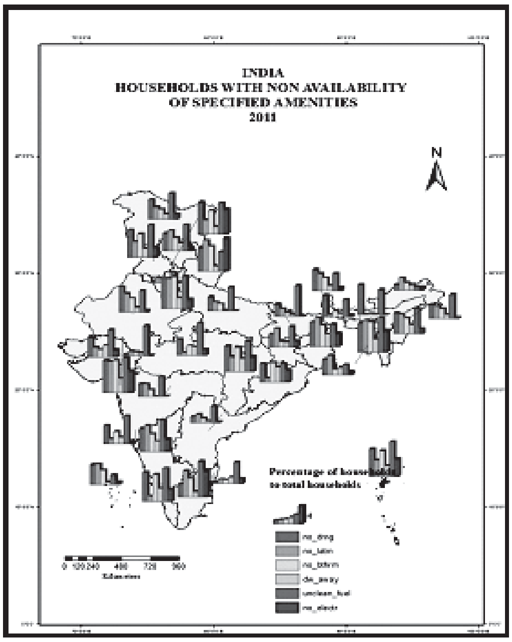
Source: Computed from Census of India, Housing Tables, 2011

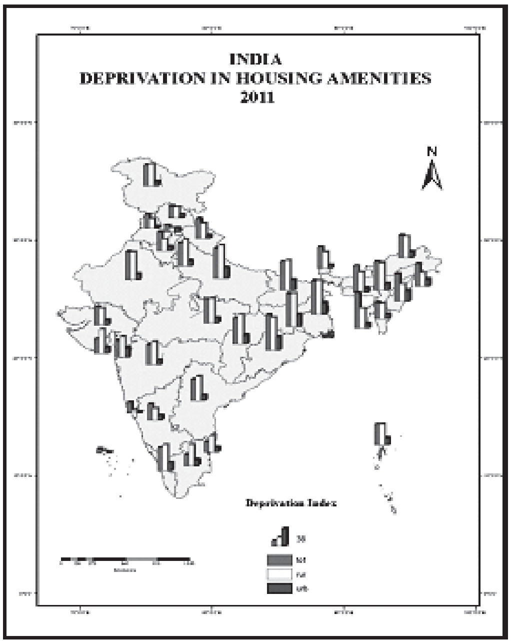
Fig. 1 Percentage Distribution of Households with Availability to Housing Amenities, India, 2001

A radar diagram has been prepared to present the availability of amenities among rural and urban areas. Herein, Fig.1, it is clearly found that households with the good condition of Census houses are higher in urban areas (green colour line) compared to rural (red line). Similarly, households with Pucca roof and wall, safe drinking water, electricity, latrine facility, bathroom facility and use of LPG are higher among urban households with more than 60 per cent compared to rural households with less than 20 per cent. From the figure, the rural urban disparity in availability of household amenities is clearly represented.

To have an overview of the states without availability of housing amenities, few indicators such as households without electricity, drainage, bathroom, latrine, drinking water away from the premise, unclean fuel is taken into account as shown in Map 1. Households without drainage facility are found mostly in the states of Jammu and Kashmir, Gujarat, Bihar, Rajasthan, Madhya Pradesh, Meghalaya, Arunachal Pradesh, Tripura, Chhattisgarh, Assam and Odisha of above 50 per cent. Households without electricity, latrine and bathroom facility are more in the states of Jharkhand, Odisha, Bihar, Chhattisgarh, Uttar Pradesh, Rajasthan, Madhya Pradesh and Andhra Pradesh of above 60 per cent. Drinking water away from the premise is found in the states of Manipur, Odisha, Meghalaya, Tripura, Jharkhand, Madhya Pradesh and Nagaland of above 30 per cent. Households using unclean fuel are more in the states of Uttar Pradesh, Odisha, Jharkhand, Tripura, Mizoram, Chhattisgarh, Arunachal Pradesh, Rajasthan, and Bihar of above 70 per cent. From the picture it is found that households with fewer assets are seen in the states of Meghalaya, Dadra and Nagar Haveli, Nagaland, Madhya Pradesh. Therefore, it can be traced out that Chandigarh, Delhi, Lakshadweep, Haryana, Kerala, Punjab, Goa; Tamil Nadu is among the best states with very less percent of households without the concerned amenities. Hence, Bihar, Uttar Pradesh, Madhya Pradesh, Odisha, Jharkhand, Chhattisgarh, Assam are the states with very less availability of basic facilities for living (Map 1).

Across caste groups, STs and SCs households lag behind in terms of levels and changes (rate of improvement) in availability of basic amenities as per the Census data. Tripura, Odisha, Jharkhand, Uttar Pradesh, Assam, Bihar, West Bengal, Rajasthan and Manipur are among the most deprived states in terms of basic amenities. Computing the deprivation index (Map 2) it is found that the level of deprivation is high above 55 per cent on an average. Uttar Pradesh is the most populous state in India, which lacks in terms of basic services, followed by Bihar, Chhattisgarh and Jharkhand. The level of



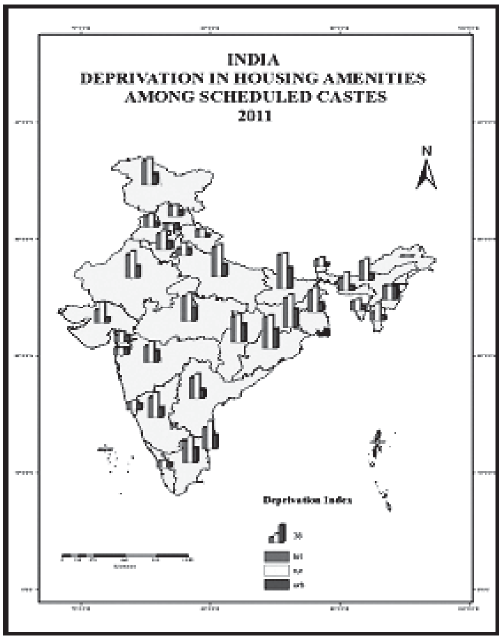


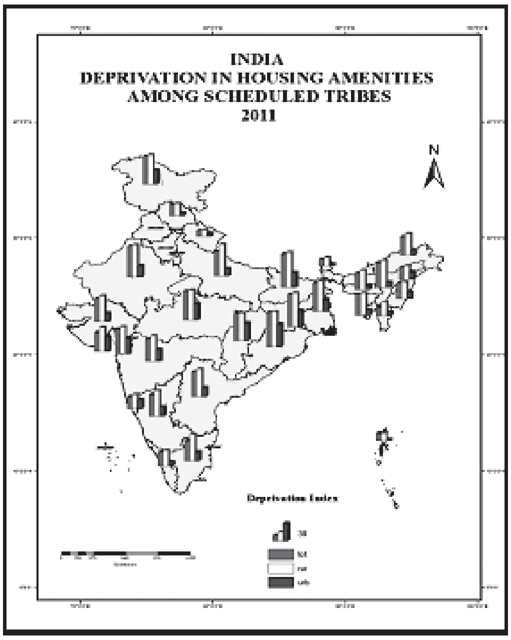
Source : Computed from Census of India, Housing Amenities Data, 2011

Map 1

Map 2

development and the socio-economic condition along with the level of literacy is also very poor in these states. But much improvement is seen in the urban areas of these backward states. The least deprivation is seen among the Union Territories, Lakshadweep (8.87 per cent), Chandigarh (12.96 per cent), Goa (19.57 per cent) followed by the states Tamil Nadu, Punjab, Himachal Pradesh and Haryana (Map 3; Map 4). Table 1 depicts the state-wise level of deprivation among the SCs and STs in India.





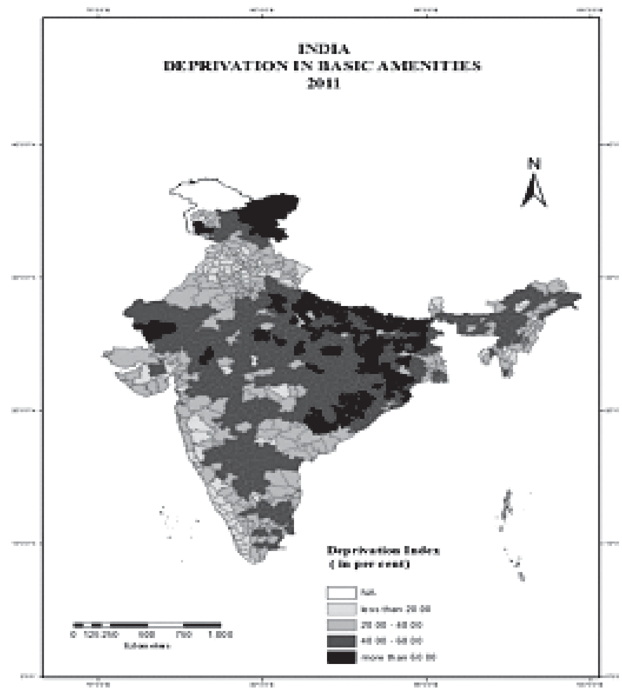
Source : Computed from Census of India, Housing Amenities Data, 2011

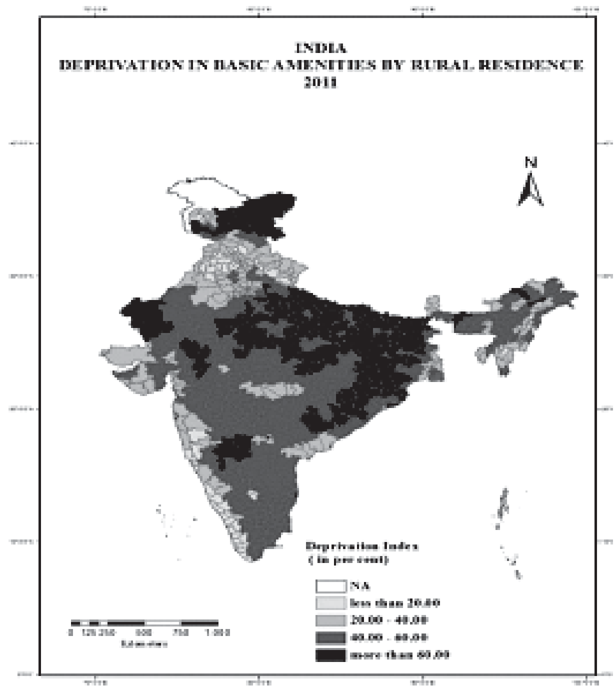
Map 3

Map 4

Deprivation of Basic Amenities across the Districts in India

Access to basic amenities, ensuring well-being of people, is a cornerstone to the development efforts of a country. In India, as the above results imply, worrisome levels of deprivation prevail in access to basic amenities in rural and urban India. It is noted that a high proportion of the households are living in poor housing conditions across the districts in India (Table 2). Of the total 640 districts in India only 107 districts are with available amenities and the rset without it. States with more deprivation are Bihar, Uttar Pradesh, Jharkhand, Chhattisgarh, Western Rajasthan and Odisha. It is most troublesome to state that Bihar accounts only 16 per cent electricity as compared to 47 per cent of the country. Mostly the Northern and Eastern part lies under the unavailability of basic facilities (Map 5). Except for drinking water, other amenities such as electricity, in-house toilet and drainage facilities are mostly absent. Most of the villages are non-electrified in these areas. Because of the very low level of electrification, dependence on non-electric, traditional sources of energy are high. There is a heavy dependence on hay and leaves, wood and cow dung cake for fuel. Availability of oil and gas is quite low (Ministry of Minority Affairs, 2008).





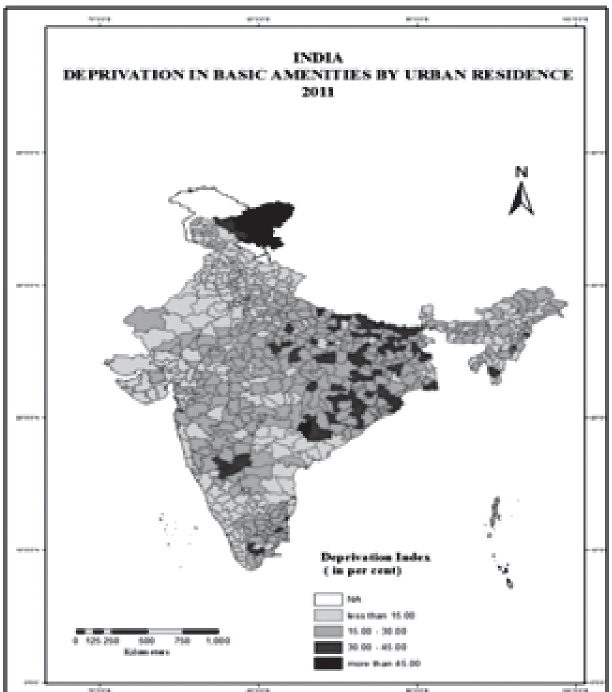
Source : Computed from Census of India, Housing Amenities Data, 2011

Map 5

Map 6

Rural households are having fewer amenities compared to the urban households. As it is known that amenities like having electricity, latrine, and tap supply water are not easily available in the rural household premises. Map 6 depicts that Northern and Eastern region is having much deprivation. More than 60 per cent deprivation level are seen in the states of Bihar, Jammu and Kashmir, Odisha, Uttar Pradesh, Chhattisgarh, Jharkhand, Andhra Pradesh and Madhya Pradesh. Moreover few districts with less deprivation are of Lakshadweep, Chandigarh, Thrissur, Ernakulam, Kollam, North, South, North-East and East Delhi, Malappuram, Ludhiana, Dehradun,Kottayam, Alapuzzha, Kozhikode, Thiruvananthpuram.

Similarly, Map 7 shows the distribution of districts within urban households. Jammu and Kashmir along with the Eastern region of India are having high level of deprivation in terms of basic amenities. On the other hand, Mahe, Srinagar, Hyderabad, Kolkata, Kodagu, Ludhiana, Bangalore, Thrissur, Sirmaur, Dakshina Kannada, Chennai, Jalandhar, Lakshadweep, Dehradun, Nainital, Ernakulam,

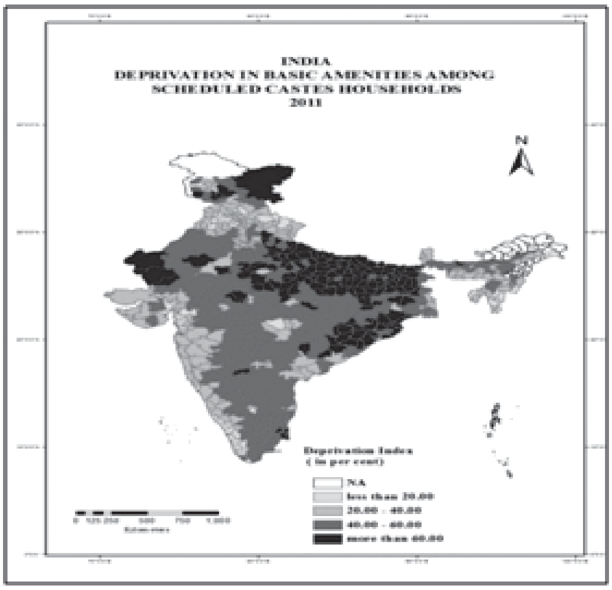


Map 7

Kollam, Kozhikode, Panchkula are the districts having very less deprivation level of less than 5 per cent. Generally the East-West divide is clearly depicted from the picture as the Western part is having low deprivation than the Eastern part. Table 2 presents the number of districts as per the level of deprivation in India.

Deprivation of Basic Amenities among Scheduled Castes

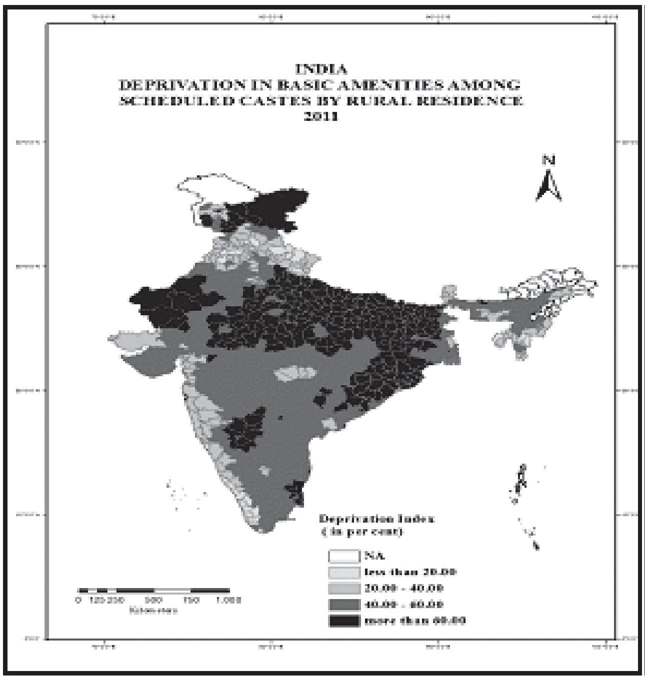
The SCs and STs comprise about 16.6 per cent and 8.6 per cent, respectively, of India's population (Census of India, 2011). It can be argued that the housing problem is related to unequal distribution of availability of services. Results highlight that less availability of amenities are found in the northern region, the Eastern, central and western region. The whole part of India from the picture falls under the category of moderate to high deprivation. The areas covering Uttarakhand, Haryana, Punjab is having low levels of deprivation (Map 8).

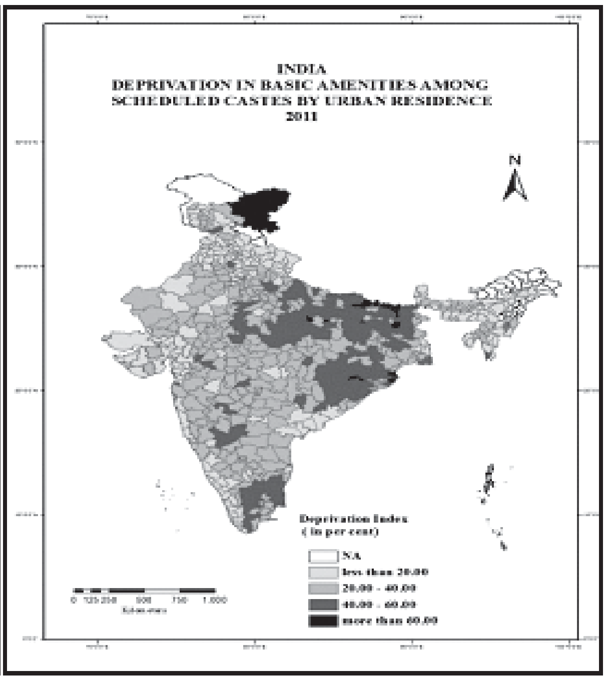


Map 8

Likewise, SCs residing in rural households with more than 75 per cent of deprivation are found in the northern belt along with the central part of India. States such as Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, Odisha, Western Rajasthan and also Jammu and Kashmir are having higher proportion of deprivation. States like Kerala, Punjab and UTs like Delhi, Chandigarh and Daman and Diu are amongst the developed ones with more available amenities and with less level of deprivation (Map 9).

Moreover, urban SCs households are showing a better picture than the rural areas. The Eastern region comprising districts of Odisha, West Bengal, Andhra Pradesh are having moderate to high level of deprivation. The North East regions are having low deprivation and the Western and southern region are having moderate level of deprivation (Map 10). It is also assumed that the people residing in urban areas are getting much more facilities than the rural counterpart. Table 3 presents the number of districts as per the level of deprivation among the Scheduled Castes households in India.





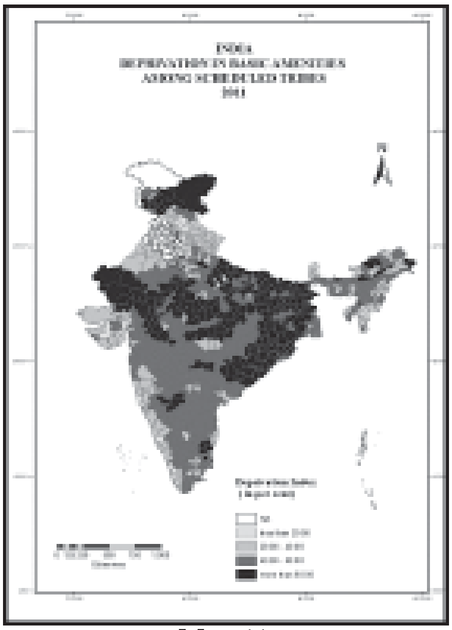
Source : Computed from Census of India, Housbig Amenities Data, 2011.

Map 9

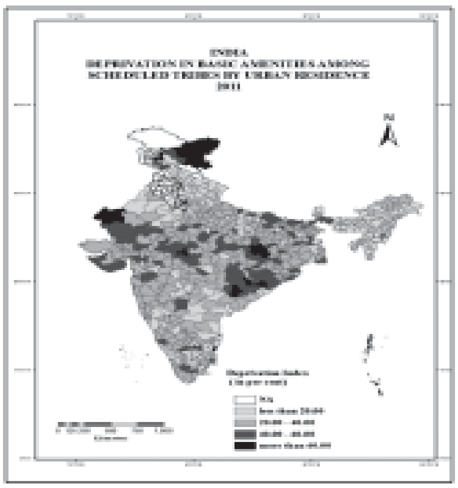
Map 10

Deprivation of Basic Amenities among Scheduled Tribes

As per the magnitude of deprivation, in this section it is found that most of the STs concentrated districts of Wayanad, Idukki and Palakkad have the highest deprivation among all the districts in Kerala, followed by the districts of Bihar, Uttar Pradesh, Odisha, Madhya Pradesh and Rajasthan as depicted from the picture (Map11). As per the calculation it is found that out of total 585 districts with STs households in India, 221 districts are having high level of deprivation and only 42 districts are with low level of deprivation (Table 4). Kerala, Andaman and Nicobar Islands, Lakshadweep, Karnataka, Gujarat, Sikkim and Mizoram have low level of deprivation. Similarly, the Southern region is having less deprivation than the Northern region. The entire Eastern region has more deprivation, which states the condition of the people residing here without the basic facilities (Map 12).

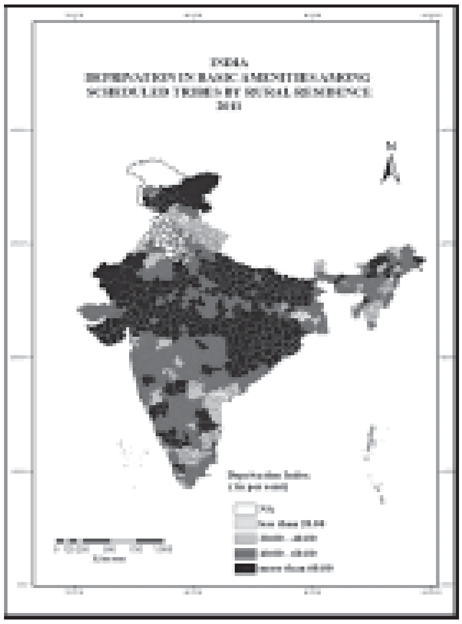


Map 11



Map 13

Scheduled Tribes people who are residing in rural areas are more deprived. It is found from most of the studies that a large number of tribal populations in rural areas are still dependent on forests for their livelihood. A large percentage of tribes that live close to forest areas constitute the most disadvantaged section of society based on per capita income, literacy rate, health status and lack of availability of basic amenities. The most deprived states among the rural areas are Bihar, Jammu and Kashmir, Uttar Pradesh, Rajasthan, Odisha, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal and Andhra Pradesh. The entire India specially the Ganga plains, the western coastal region along wit the eastern coastal region are having high level of deprivation. Only few districts from this region are having moderate deprivation. States of Assam and Arunachal Pradesh are also having moderate to high level of deprivation. It is very worrisome to state the situation of the STs with high levels of unavailability of the basic needs of living (Map 13).



Map 12

Likewise, comparing the urban area households with the rural area, it is found that less than 20 per cent of deprivation is seen in the districts of the North Eastern region, Punjab, Himachal Pradesh, Kerala, Uttarakhand, some districts of Maharashtra, Sikkim and Chandigarh. Mostly the urban areas are far better than the rural areas. From the picture it can be stated that most of the states have the available basic facilities for a better quality of housing and living. Apart from these, few districts of the central region have moderate level of deprivation. Moreover, it is very interesting to see that among the STs, the North Eastern region has no districts with high level of deprivation. Regarding availability of amenities from the study it can be pointed out that the inequality among different oriented social groups was wider in rural areas (Map 12). Table 4 presents the number of districts as per the level of deprivation among the Scheduled Tribes households in India in a detailed manner.

SUMMARY AND CONCLUSION

The proportion of households having availability to each of the amenities, taken singly, showed a clear and unambiguous rise for the rural as well as the urban households in all the states. In terms of the index, amenities deprivation was found to be lower for the urban households than their rural counterparts. The eastern states of Odisha, Bihar, Uttar Pradesh as well as the western states of Rajasthan, Madhya Pradesh report the highest degree of deprivation for both SCs and STs households. In terms of basic amenities and adequate housing, particularly, SCs and STs of rural areas are more disadvantaged. This results is persistent with earlier studies done by Srinivasan and Mohanty, 2004; Dreze and Sen, 2013; Kumar, 2014a; Kumar, 2014b.

Findings from this study suggest that, there is need to special call for focused and immediate attention towards basic amenities like water facilities, sanitation and proper drainage system for marginal population. From one side remote areas and extremely rural areas and another side unawareness about programmes and policies rendered them as most vulnerable in terms of housing amenities. From the study it has been clear that the condition of the Scheduled Tribes is mostly vulnerable than the Scheduled Castes households. Regarding unavailability of amenities, from the study it is seen that the STs are in worst condition. Thus, it can be concluded from this study that the condition of the STs should be modified and certain initiatives should be taken for the STs by the government with the help of policies and programs and the people should be made aware about the consequences of use of improved amenities for better livelihood.

REFERENCES

1. Das Bhaswatiet al. (2013). Household Quality of Living in Indian States: Analysis of 2011 Census. Environment and Urbanization Asia, National Institute of Urban Affairs (NIUA), SAGE Publications. Vol. 4(1): pp.151–171.
2. Dreze Jeanet al. (2013). An Uncertain Glory: India and Its Contradictions, Penguin Books, New Delhi
3. K. Sundaram et al. (1995). On Measuring Shelter Deprivation in India. Indian Economic Review. New Series. Vol. 30(2): pp. 131-165.
4. Kumar A. (2013). Access to Basic Amenities in Urban India – An Analysis across Size Class of Towns/Cities. Urban India. Vol. 33(2): pp. 127-140.
5. Kumar A. (2014 a). Access to Basic Amenities: Aspects of Caste, Ethnicity and Poverty in Rural and Urban India—1993 to 2008–2009. Journal of Land and Rural Studies. Vol. 2: pp. 127-148
6. Kumar A. (2014 b). Devalaya and Shauchalaya: Addressing Socio-Economic Inclusions. Journal of Studies in Dynamics and Change. pp.80-87
7. Kumar A. (2014 c). Estimating Rural Housing Shortage. Economic and Political Weekly. Vol. XLIX (26-27): pp. 74-70.
8. Sim Duncan (1984). Urban Deprivation: Not Just the Inner City. The Royal Geographical Society, Area. Vol. 16(4):pp. 299-306.
9. Srinivasan K et al. (2004). Deprivation of Basic Amenities by Caste and Religion: Empirical Study Using NFHS Data. Economic and Political Weekly. Vol. XXXIX (07).
10. ———— Uttar Pradesh, Human Development Report. (2007). United Nations Development Programme. India, Planning Commission. Government of India.

——— Planning Commission, Five Year Plans, Government of India.

Appendix

Table 1
Index of Deprivation for Basic Amenities, 2011

States	*Total*	*SCs*	*STs*
Jammu & Kashmir	39.49	50.13	58.94
Himachal Pradesh	23.14	23.81	24.66
Punjab	27.22	22.13	NA
Chandigarh	12.96	14.56	NA
Uttarakhand	37.91	14.78	12.14
Haryana	36.20	32.36	NA
NCT Of Delhi	43.94	14.23	NA
Rajasthan	53.02	49.40	64.60
Uttar Pradesh	57.39	62.40	51.39
Bihar	54.58	72.78	70.39
Sikkim	40.68	14.86	14.07
Arunachal Pradesh	43.26	NA	39.26
Nagaland	42.77	NA	24.11
Manipur	52.63	30.47	33.22
Mizoram	31.06	17.65	17.53
Tripura	68.35	21.13	45.31
Meghalaya	51.22	27.54	35.36
Assam	54.80	40.99	52.83
West Bengal	63.41	45.41	59.00
Jharkhand	62.81	61.94	67.02
Odisha	67.52	64.47	72.69
Chhattisgarh	49.68	52.95	56.90
Madhya Pradesh	46.94	53.05	61.70
Gujarat	34.06	27.20	48.50
Daman & Diu	28.54	15.75	39.75
Dadra & Nagar Haveli	31.95	15.72	52.66
Maharashtra	39.07	35.66	47.18
Andhra Pradesh	40.40	42.93	52.51
Karnataka	31.66	44.06	46.12
Goa	19.57	15.79	25.55
Lakshadweep	8.87	NA	1.64
Kerala	43.74	13.09	28.58
Tamil Nadu	21.07	47.04	42.27
Puducherry	20.54	46.15	NA
Andaman & Nicobar Islands	39.61	NA	15.35
All India	37.88	46.94	57.34

Table. 2
India: State-wise deprivation in availability of amenities, 2011

	Number of Districts				
States	*Low*	*Medium*	*High*	*Very High*	*Total*
J & K	4	7	7	4	22
Himachal Pradesh	4	7	1	0	12
Punjab	15	5	0	0	20
Chandigarh	1	0	0	0	1
Uttarakhand	6	7	0	0	13
Haryana	7	13	1	0	21
Delhi	9	0	0	0	9
Rajasthan	0	9	21	3	33
Uttar Pradesh	2	8	34	27	71
Bihar	0	1	6	31	38
Sikkim	4	0	0	0	4
Arunachal Pradesh	3	3	10	0	16
Nagaland	3	6	2	0	11
Manipur	0	8	1	0	9
Mizoram	4	3	1	0	8
Tripura	1	2	1	0	4
Meghalaya	0	3	4	0	7
Assam	1	5	21	0	27
West Bengal	1	7	10	1	19
Jharkhand	0	2	7	15	24
Odisha	0	1	13	16	30
Chhattisgarh	0	0	14	4	18
Madhya Pradesh	2	5	37	6	50
Gujarat	3	16	7	0	26
Daman and Diu	1	1	0	0	2
Dadra and Nagar Haveli	0	1	0	0	1
Maharashtra	5	17	13	0	35
Andhra Pradesh	2	14	7	0	23
Karnataka	6	9	15	0	30
Goa	2	0	0	0	2
Lakshadweep	1	0	0	0	1
Kerala	14	0	0	0	14
Tamil Nadu	2	16	14	0	32
Puducherry	2	2	0	0	4
Andaman & Nicobar Islands	2	1	0	0	3
India	107	179	247	107	640

Source: Computed from Census of India, Housing Amenities Tables, 2011.

Table. 3
India: State-wise deprivation in availability of amenities among SCs, 2011

	Number of Districts				
States	*Low*	*Medium*	*High*	*Very High*	*Total*
J & K	3	6	7	6	22
Himachal Pradesh	2	9	1	0	12
Punjab	8	12	0	0	20
Chandigarh	1	0	0	0	1
Uttarakhand	2	11	0	0	13
Haryana	1	13	7	0	21
Delhi	8	1	0	0	9
Rajasthan	0	2	24	7	33
Uttar Pradesh	0	3	17	51	71
Bihar	0	0	1	37	38
Sikkim	2	2	0	0	4
Manipur	1	6	2	0	9
Mizoram	5	2	1	0	8
Tripura	1	3	0	0	4
Meghalaya	0	7	0	0	7
Assam	1	8	17	1	27
West Bengal	1	4	11	3	19
Jharkhand	0	1	6	17	24
Odisha	0	0	5	25	30
Chhattisgarh	0	0	17	1	18
Madhya Pradesh	0	4	31	15	50
Gujarat	5	16	5	0	26
Daman and Diu	1	1	0	0	2
Dadra and Nagar Haveli	1	0	0	0	1
Maharashtra	1	17	17	0	35
Andhra Pradesh	1	6	16	0	23
Karnataka	1	9	19	1	30
Goa	2	0	0	0	2
Lakshadweep	0	1	0	0	1
Kerala	13	0	1	0	14
Tamil Nadu	2	2	25	3	32
Puducherry	3	0	1	0	4
India	66	146	232	165	609

Source: Computed from Census of India, Housing Amenities Tables, 2011.

Table. 4
India: State-wise deprivation in availability of amenities among STs, 2011

States	*Low*	*Medium*	*High*	*Very High*	*Total*
J & K	1	1	6	14	22
Himachal Pradesh	4	7	1	0	12
Uttarakhand	0	13	0	0	13
Rajasthan	0	5	7	21	33
Uttar Pradesh	3	13	24	31	71
Bihar	0	0	2	36	38
Sikkim	3	1	0	0	4
Arunachal Pradesh	1	6	6	3	16
Nagaland	3	6	2	0	11
Manipur	2	5	2	0	9
Mizoram	4	3	1	0	8
Tripura	0	1	3	0	4
Meghalaya	0	3	4	0	7
Assam	0	4	18	5	27
West Bengal	1	2	7	9	19
Jharkhand	0	0	5	19	24
Odisha	0	0	1	29	30
Chhattisgarh	0	0	11	7	18
Madhya Pradesh	0	2	14	34	50
Gujarat	3	9	12	2	26
Daman and Diu	1	1	0	0	2
Dadra and Nagar Haveli	0	0	1	0	1
Maharashtra	1	10	24	0	35
Andhra Pradesh	1	2	16	4	23
Karnataka	3	5	18	4	30
Goa	0	2	0	0	2
Lakshadweep	1	0	0	0	1
Kerala	6	7	1	0	14
Tamil Nadu	1	6	22	3	32
Andaman & Nicobar Islands	3	0	0	0	3
India	42	114	208	221	585

Source: Computed from Census of India, Housing Amenities Tables, 2011.

TOWARDS EVOLVING PUBLIC-PARTICIPATORY GIS FOR MAPPING SOCIAL EXCLUSION & DISCRIMINATION IN MUMBAI DEVELOPMENT PLAN

Sagat SHAUNIK[1]

ABSTRACT

This paper is a case study of the recently scrapped Mumbai Development Plan 2014-2034, which faced massive public outcry and flak due to its exclusive nature. Some of the problems originated in the way 'resources' were mapped to exclude Mumbai's informal economic sector and environmental concerns which raised further doubt about the development aspects of this plan. The excluded group were displaced persons, disaster affected villagers (eg. from Latur), migrants and others who formed marginalised sections which were more vulnerable to hazards, risks and many other socio-economic challenges.

A development plan, which is drafted without the inclusion of public opinion and needs assessment, in today's world is bound to have many flaws. The outcry displayed during the announcement of this plan shows the need for a participatory approach for good governance. Thereby, coming together and evolving mechanisms for deepening democracy through various inclusive methods are explored. The use of ICT tools and research methods like PRA etc. can be well mixed with the government aspirations and needs. In particular, the paper will see how a public-participatory-GIS (PPGIS) mapping can be done for the same.

This paper, will further examine how far aspects of human security for Mumbai residents can be expanded through GIS platforms while ensuring that development is defined and inclusive of all social sections and meets the requirements of good governance.

Keywords: *Public Participatory GIS; Mumbai Development, Gentrification, Social Exclusion, Human Security.*

INTRODUCTION

The recently scrapped Mumbai Development Plan 2014-2034, faced massive public outcry and flak due to its exclusive nature and questions were raised on the very idea of planning and development. Thereby, the Maharashtra government discarded the original plan and sent it for review to be re-drafted within four months. Some of its problems originated in 'mapping' of resources, since many culturally sensitive areas like religious places were replaced with new roads and other infrastructure, while existing residences of marginalised communities were marked as 'slums'. The proposed plan, lacked the inclusion of Mumbai's informal economic sector and environmental concerns which raised further doubt about the development aspects of this plan. By understanding Mumbai and its dynamics, one can understand why it is crucial to have an inclusive development plan. Further, the use of participatory methods will be explored to aid the process of social inclusion.

Mumbai, the City

Mumbai, as a Commercial-Urban area, is home to many communities that originate from different parts of our country. These communities are attracted to Mumbai in search for employment, opportunities and livelihoods. Often, many are displaced persons, disaster affected villagers (eg. from Latur), migrants etc. These people are the marginalised sections of our society and are more vulnerable to hazards, risks and many other socio-economic challenges that the City poses for them. The gentrification of Mumbai with its high rise apartments and gated communities, has further driven an increase in property prices, to an extent that similar socially excluded-communities are pushed to live in zones that are environmentally prone to more vulnerabilities. Example, the Koliwada communities that live on the edges of this city and are almost at sea.

A study of all the reports released online by the Municipal Corporation of Greater Mumbai (MCGM) shows that a lot of effort and hard-work had gone in to making these plans by including all the government agencies from State to Ward Level, Civil Societies (trusts etc), Institutions and other stake-holders. The plan focussed on matters related to housing, health, education, transportation, water & sanitation, livelihood, public spaces, environment, governance, land use patterns etc (UDRI & Praja Foundation, 2014). All the questions, concerns and needs were looked into and fleshed out with details

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of what, how and where. This was in following the provisions of the Maharashtra Regional and Town Planning Act, (MR&TP), 1966 that made it obligatory for MCGM to revise the existing Development Plan of 1994 before its terminal year of 2014 (MCGM, 2011). These provisions ensure that the plan remains relevant for the economy, society and global trends.

Yet, Kamath & Joseph (2015) argue that the old method of State Development Plans (DP) have an orientation that favours the elite and thereby the technicians who drafted these plans were distanced from the citizens who may not have similar access to resources and mobility. They also argued that Mumbai developed with and without the DP as people negotiated their spaces, built their homes & businesses and survived. While pointing out flaws in the very concpetion of how public participation during the planning stage is conceived by the Maharashtra Regional and Town Planning (MR&TP) Act, Kamath & Joseph (2015) found the lack of inclusion of any mechanism to include local bodies that integrated people's suggestions/objections in the plan.

Towards Participatory Development in an Urban Setting

A development plan, which is drafted without the inclusion of public opinion and needs assessment, in today's world is bound to have many flaws. The outcry displayed during the announcement of *The Development Plan for Greater Mumbai 2014-2034*, shows the need for a participatory approach for good governance. Here, coming together and evolving mechanisms for deepening democracy through various inclusive methods needs to be discussed.

Public participation is the use of a variety of approaches to '*make GIS and other spatial decision-making tools available and accessible to all those with a stake in official decisions*' (Schroeder 1997). Mishra (2002) suggests that the use of maps in modern decision support systems brings convergence of imagery and information. During disasters, a lot of uncertainity exists which can be reduced with the help of maps. It is possible to have a better policy analysis, preparedness and quicker disaster response (Mishra, 2002) when the available maps are accurately made.

Beyond GIS, participatory methods in decision making have been used to understand the needs of the people in a manner, representative of those under study or for whom a public policy is being created. The use of ICT tools and research methods like PRA etc. can be well mixed with the government aspirations and needs. A map created using GIS softwares, can help highlight different social issues and aspirations in a clear and lucid manner. The colour schemes and classification can help understand the ground-situations immediately. Thus GIS moves beyond being a tool (Sheppard 1995) to solve a problem and becomes a social process that can explain patterns and relationships (ibid, 1995). The idea of public participatory GIS (PPGIS) is to make '*maps more adaptable to extra-organizational input from regular citizens and other non-official sources*' (Obermeyer, 1998).

Now, the argument for developing and ensuring the use of participatory methods comes from a critique of development and urban planning whereby scholars have used terms like heterogeneity (Soja, 2001, c.f Banerjee-Guha, 2002) to explain how Mumbai shows extremes in employment opportunities, housing, education patterns etc. This means that the poor would be further marginalised (Banerjee-Guha, 2002) and urban plans have to account for the same- since demolition drives for enforcing these urban plans in Mumbai, *"push out the wayside poor who lived in 'illegal' shanties"* (Kumar, 2005). In fact, these demolitions reversed the slum development policy of the 1990's (ibid, 2005). The substantial numbers of residents in slums of Mumbai means that development will not occur, without their consideration. This lead Kumar (2005) to say that Mumbai's sustainable growth can happen only when '*all stakeholders in the process including slum dwellers and the poor are given a say in schemes that affect them*'.

In the aftermath of the Mumbai deluge, Srivastava & Mukherji (2005) said that damage could have been reduced had Mumbai-DP considered the contours and natural features of Mumbai during its reclamation projects. However, they rightly point out that land regardless of its features, became more important as planners, developers and governing authorities sought to accommodate all the citizens as Mumbai expanded. Further, Revi (2005) called for a political framework that addressed problems of managing Mumbai's hazards, vulnerabilities and lack of infrastructure that delayed response and coordinated efforts during the floods.

Bhagat et al. (2006) suggest that Mumbai's growth in built-up areas has utilised most of the '*open spaces, hills, mangroves, wetlands, and the natural drainages provided by Mithi and Dahisar rivers*'. Therefore the likelihood of another deluge, perhaps more disasters due to such development, means that any urban plan has to *meet the needs of majority of the people and withstand disasters like 26/7* (Bhagat et al., 2006). They also argue that if Mumbai has to become the next Shanghai or Singapore, then the physical and natural aspects must not be overlooked during planning and development of the city. This can only happen when all the citizens participate, until then these visions will remain an illusion (ibid, 2006).

Studying the flooding phenomenon of Mumbai, Parthasarathy (2015) argued that the balkanisation of institutions and governance mechanisms pertaining to urban planning and disaster management was the *key barrier to effective decentralized disaster governance* in Mumbai and its region. This balkanisation could be found in how the city utilises its space; the sectoral differences in urban-governance of drains, pollution etc.; and how government institutions differ in their ways of addressing issues of disasters and development. Shaban (2008) understood issues of social conflict and crime in Mumbai as a consequence of *neo-liberal policies and a deepening social and economic divide* experienced in the city. Parthasarathy (2011) seeks the need to understand and develop *more integrated approaches to social, political and environmental struggles* in Mumbai. Later, he suggested *that the participation of informal-sector actors in disaster governance can both augment the quality of disaster management and enhance the possibility of greater integration of the city's marginalized and excluded groups into its mainstream social fabric* (Parthasarathy, 2015). Thus, disaster governance requires a re-look at how we understand the social processes that are shaping the city.

Sharma (2010) attributed the neo-liberal market-driven economy as a cause of further segregation of citizens, gentrification of cities and the *poorbeing driven out from the core parts of cities to its peripheries.* He believed that market driven development co-opts the state as a 'development agent'. Thus, the idea of a few, exclusionary mega cities may further social conflict by creating pockets of concentrated wealth on one side and *vast regions of deprivation and impoverishment* (Sharma, 2010) on the other.

Kennedy & Zérah (2008) argued that adopting international trends of city centric growth has *far-reaching social and spatial implications in terms of governance*. Here, the need to re-examine *inter-governmental responsibilities, functions and financial transfers* should be a priority in light of the larger social issues. A study of Hyderabad and Mumbai cities (Kennedy & Zérah, 2008), showed that *the ongoing processes are contentious and contradictory, providing a stark contrast to the smooth vision statements that convey an image of the quest for "development" as a consensual process.*

Following the public outrcy against the MCGM 34 plan, the URDI issued a brochure which included the following lines:

> The public authority responsible for the revision of the DP is the Municipal Corporation of Greater Mumbai (MCGM). For the revision of the DP, the MCGM has select an external consultant through a tendering process who has already started working. The people of Mumbai have a say in the process of preparation of the DP as it is going to affect them for a period of 20 years or more (You and the DP, URDI)

Yet when we read this brochure, it remains to show that the DP is a prerogative of the MCGM alone and public participation is merely invited-not-to-be-implemented. This means that there is still a need to devise a method for including the voices of each and every citizen of Mumbai in the plan. Here, the author proposes a plan for integrating the voices of socially excluded citizens in the informal sector.

TOWARDS EVOLVING A METHODOLOGY FOR MUMBAI DEVELOPMENT VIA PP-GIS

The aspects affecting human security of Mumbai's residents, like vulnerability, hazrads, risks etc. have all been mapped previously using GIS platforms in the MCGM-34 plan. However, criticism came for the exclusionary methods of planning. To ensure that development is fully defined in an inclusive manner and for good governance, the author proposes the following points:

- Integration of members from Academia, NGOs, Local Media and Civil Society in to field teams.
- Rapid ethnographies with PRA, Questionnaires and other tools to get voices of previously excluded citizens- map these and enter PPGIS database.
- Add photo-mapping of the informal sector setting- photos with GPS locations (finding patterns) (
- Conduct secondary data analysis: Journals, Govt/NGO records/publications, students thesis etc.
- Generate life histories: origins, livelihood, education, income etc.
- Conduct focus group discussions (FGD) with multiple stakeholders.
- Record field observations - geographic, spatial adjustments, living conditions etc.- Use journalists and academics here.(
- Organise competitions (drawing/essay/debates/plays) on what youth want in all schools, colleges and local residential localities of Mumbai.
- Social Media/ Public-input based website.

DISCUSSION& ANALYSIS

The MCGM-34 had used participatory methods for decision making for over three years. Yet, the informal sector (slums) were continuously marked as brown areas in the maps and the amenities were never disclosed. This was particularly problematic since 33% of Mumbai is inhabited by slums and over 50% of the population resides in them (Kamath & Joseph, 2015). This means that most of the population has already been left out of the DP. Further, this has lead many to believe that the plan was elitist or at least served their interests. Wheras the government was trying to follow the law. The problem arises out of urban informality. Our development and growth story has forcefully migrated people out of their original homes and brought them to the city in search of better lives, jobs, employment and basically access to the facilities of the city. Yet, informality, gentrification and other socio-economic problems have made the city un-liveable for the poor. By following the rule of law in terms of land-records and other official data, most citizens are excluded as Mumbai grows with her informal settlements, lack of documentation and physical records.

Thus, a discussion of our proposed methodology will explain why providing a voice to the informal is necessary for a successful DP. The integration of members from Academia, NGOs, Local Media & Civil Society in to field teams will provide a diverse skill set in order to interact with the informal sector. These teams will gain from experiences of informality by interaction and use of participatory methods. The use of rapid ethnographies can help gain perspectives that were not recorded previously. This includes the generation of life histories of the people's origins, their livelihood, education, income etc and explains why they live in a particular area.

Participatory methods like PRA, focus group discussions (FGD) will help map resources that were previously left out of the MCGM plan due to various decisions. This bottom up mapping will reveal all the information that was left out either by over-sight or deliberation. Further, the use of questionnaires designed to gather socio-economic and related data will provide deeper insight in to the living conditions. Photographs of the living conditions along with their GPS locations will find patterns or clusters of living conditions. All these observations will be recorded especially those of geographic, spatial adjustments, living conditions etc. Here the ethically correct field work of journalists and academics will be the most useful.(Following this, a secondary data analysis of existing academic journals, Government/NGO records/publications, students thesis etc. of work done in the informal sector can then be integrated to avoid duplication of efforts. The organisation of competitions like drawing/essay/debates/plays, in all the Mumbai schools, colleges and residential localities will get the information and thoughts of the youth in the city.

Recently, social-media has emerged as an important tool of social mobilization and organisation. Using these networks, much information can be collected as every citizen uses these tools democratically - via budget-recharge packs for economy phones! Further, as the MCGM already established a website, a space for direct public-input can be made for comments, feedback and updates.

Now, all this information can be verified by various means of triangulation and then entered in a PPGIS database. Kamath & Joseph (2015) have pointed out the problems in land use, as areas belonging to the MCGM were included while, those owned by the government (eg. Mumbai Port Trust)- Central or State, face uncertainty by eviction drives and a lack of rehabilitation.The extention of this PPGIS in these areas, will involve a cost to the exchequer. Yet the participatory methods provide a cheaper alternative to otherwise expensive methods. Further, the very idea that we as citizens reach out to the informal sector will prove beneficial in the long run as our people get integrated in a DP.

CONCLUSION

Although, certain jursidictional concerns may leave people out of democratic processes, the successes of MCGM-34's participatory approaches (Kamath & Joseph, 2015) must be expanded, and the creation of an identity for the informal sector will prove most beneficial not just for them, but for the nation in the deeper-democratic and strategic concerns. Now, it is left for our experienced specialists, civil society and others to decide how my proposal may be expanded. We have the ability and the capabilty, yet the decision needs to be taken. Participatory approaches and the recognition of our urban informality also has the potential to teach humility in our social and economic organisation and structures. Once, we are able to reach out to the previously excluded, it is possible that we can change the way development is visualised and it will then move from a discussion of *'parks & open-spaces'* to an idea of building social infrastructure, curbing pollution and other challenges.

We will also be able to achieve goals of sustainable development and integration of disaster risk reduction strategies as we seek for a better resource utilisation, on an equitable basis. Finally, the participatory approach will make Mumbai, not a Shanghai or any other city but, *Aamchi Mumbai*- a mega-city owned & created by the people and for the world. It will establish a standard not by copying others but by better, greener and more equal opportunities & access. Already, the citizens are approaching such a path, but the pace has to be increased and the DP can be a way of achieving the same, provided it is inclusive of even dissent while seeking better alternatives through democratic processes!

REFERENCES

1. Banerjee-Guha, S. (2002). Shifting Cities: Urban Restructuring in Mumbai. *Economic and Political Weekly, 37* (2). Jan. 12-18, 2002, pp. 121-128.
2. Bhagat, R. B.; Guha, M. & Chattopadhyay, A. (2006). Mumbai After 26/7 Deluge: Issues and Concerns in Urban Planning. *Population and Environment, 27* (4). Mar., 2006, pp. 337-349.
3. Kamath, L. and Joseph, M. (2015). How a Participatory Process Can Matter in Planning the City. *Economic & Political Weekly, 1* (39). September 26, 2015, pp. 54-61.
4. Kennedy, L. & Zérah, M. H. (2008). The Shift to City-Centric Growth Strategies: Perspectives from Hyderabad and Mumbai. *Economic and Political Weekly, 43* (39). Sep. 27 - Oct. 3, 2008, pp. 110-117.
5. Kumar, A. (2005). Mumbai's Expendable Poor. *Economic and Political Weekly, 40* (6). Feb. 5-11, 2005, pp. 506-510.
6. MCGM (2011). The Development Plan for Greater Mumbai 2014-2034: Inception Report. DPGM 34 Project. Municipal Corporation of Greater Mumbai, 12 June 2011.
7. Mishra, P. K. (2002). Maps and Disaster Management. *Economic and Political Weekly, 37* (47). Nov. 23-29, 2002, pp. 4676-4677.
8. Obermeyer, N. J. (1998). The Evolution of Public Participation GIS. *Cartography and Geographic Information Systems, 25* (2). pp. 65-66.
9. Parthasarathy, D. (2011). Hunters, Gatherers and Foragers in a Metropolis: Commonising the Private and Public in Mumbai. *Economic and Political Weekly, 46* (50), pp. 54-63.
10. Parthasarathy, D. (2015). Decentralization, Pluralization, Balkanization? Challenges for Disaster Mitigation and Governance in Mumbai. *Habitat International*, Available online 3 September 2015, ISSN 0197-3975.

    http://dx.doi.org/10.1016/j.habitatint.2015.08.022. (http://www.sciencedirect.com/science/article/pii/S0197397515300333)
11. Parthasarathy, D. (2015). Informality, Resilience, and the Political Implications of Disaster Governance. *Pacific Affairs, 88* (3). September 2015, pp. 551-575.
12. Revi, A. (2005). Lessons from the Deluge: Priorities for Multi-Hazard Risk Mitigation. *Economic and Political Weekly, 40* (36). Sep. 3-9, 2005, pp. 3911-3916.
13. Shaban, A. (2008). Ghettoisation, Crime and Punishment in Mumbai. *Economic and Political Weekly, 43* (33). Aug. 16 - 22, 2008, pp. 68-73.
14. Sharma, R.N. (2010). Mega Transformation of Mumbai: Deepening Enclave Urbanism.(*Sociological Bulletin, 59* (1). January-April 2010, pp. 69-91.
15. Sheppard, E. (1995). GIS and Society: Toward a Research Agenda. *Cartography and Geographic Information Systems, 22* (1), 1995, pp. 5-16.
16. Srivastava, S. & Mukherji, D. (2005). Emerging Cityscapes and Environmental Issues. *Economic and Political Weekly, 40* (36). Sep. 3-9, 2005, pp. 3905-3909.
17. UDRI & Praja Foundation (2014). Planning for Mumbai. The Development Plan for Greater Mumbai 2014-2034. Urban Development Research Institute and Praja Foundation. June 2014.
18. You and the DP. Development Plan: Our Chance for an Open, Efficient and Equitable Mumbai!! Revision of the Development Plan, 2014-2034. *URDI.* Available online: http://www.srtt.org/institutional_grants/pdf/development_plan_brochure.pdf

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INFORMAL SOURCES OF SUPPORT FOR HOUSELESS POPULATION IN KANPUR CITY OF UTTAR PRADESH, INDIA

SHAMSHAD[1]

ABSTRACT

The present research work aims to analyse the perceived problems, sources of help during an emergency, supportive services and expressive ties for the houseless population. The study is based on primary source of data generated through a comprehensive field survey in Kanpur city carried out during 2012. The analysis of research work reveals that out of the total sampled houseless households, about the three-fourth share of houseless persons has reported ill-treatment by the general population to them. The nearly two-third ratio of houseless population observed bad experiences on the occasions of VIP visits, national festivals and various functions/ceremonies. More than ninety-five percent houseless people reported having need of security from humiliations and disturbances in their lives. More than half houseless population received the help from their friends, families, relatives, different individuals, etc. at the time of emergency. More than eighty percent houseless persons were found to be supported by other supportive services like charities, foraging, clothing, food stamps and money. Nearly one-fifth houseless population was totally socially disaffiliated while more than the four-fifth share of persons have social affiliations.

Keyword(s): *Houseless Population, Behaviour of General Population, Experiences, Need of Security, Help in Emergency, Supportive Services and Expressive Ties*

INTRODUCTION

Houselessness continues to be a grave national urban problem in India, because out of total 17,72,889 houseless population of the country, counted over a single night on 28th February 2011 by Indian Census, the number of 9,38,348 houseless people (52.92 percent) live in urban parts of the country without a place to call home. Moreover, more than 100 million people are houseless in this today democratic world or egalitarian society (Badiaga et al., 2008, pp. 1353-1359). Thus, there is nearly two million houseless population in India wherein 18.56 percent (3,29,049 persons) houseless population is just shared by the state of Uttar Pradesh alone, and Kanpur city being the second largest city in the state is the part it (Indian Census 2011). Broadly, the genesis of houselessness runs through the loss of jobs, business closings, broken relationships, lack of employment opportunities, low level of education & skills, drug or alcohol addiction, family violence, mentally & physically illness, fire in or condemnation of apartments, lack of affordable housing, long-term poverty, etc. (Hertzberg, 1992, p. 152 and Burt, 1991, pp. 903-936).

Further, modern development in terms of level of economic growth, education, health services, degree of modernisation & urbanisation, quality of housing, distribution of goods and services, available means of transportation & communication, etc., and emergence of many cities in the world as major regional or global commercial centres, shrinking man-land ratio caused by exponential population growth, and the widening gap between the 'haves and have nots' have made the problem of houselessness very grim. At the same time providing lesser and lesser affordable housing and modern household infrastructure facilities and amenities for rural in-migrants, especially, in the large and metropolitan cities of the developing countries of the world, where, this problem is being aggravated, day by day, with the new arrival of rural poors who come in the cities in search of jobs that they may earn the means for their livelihood (Shamshad, 2015,p . 348).

It has been observed that houseless people in their everyday lives are assessing their information needs in order to improve their everyday living situations (Hersberger, 2001, p. 120). Ending the problem of houselessness as a concept has gained traction internationally too (Quilgars et al., 2011; FEANTSA, 2010; NAEH, 2002 and USICH, 2009). Various previous studies on houselessness also have studied the factors associated with accessing services, considering need, enabling and predisposing variables that may increase one's likelihood to seek and receive health care services (Padgett et al., 1990, pp. 805-821, Wenzel et al., 1995, pp. 1132-1144 and Gelberg et al., 2000, pp. 1273-1302). Therefore, first of all, a focus on prevention should be directed at enhancing protective factors for and resilience of houseless people. The protective factors include one's

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individual qualities and personality traits which help these houseless persons to persevere in the face of stress, traumatic events and several other problems (Smokowski et al., 1999, pp. 425-448; Crosnoe et al., 2002, pp. 515-544; Bender, 2007, pp. 25-42; Gilligan, 2000, pp. 37-47 and Ungar, 2004, pp. 341-365). Since discharging the planning and informal support or help for reintegration into independent living of houseless population might benefits them in terms of reduced recidivism, increased public safety, social inclusion and affiliation and reduced houselessness (Harrison, 2001, pp. 462 485; Visher & Travis, 2003, pp. 89 113; Petersilia, 2001a, pp. 360 375 and 2001b, pp. 3 8 and Travis & Petersilia, 2001, pp. 291 313), as informal sources of help is a kind of assistance that involves emotional support, companionship, advice, solidarity, kinship and relationship, etc.

The Census of India (1991, p. 64) defines houseless population as "the persons who are not living in 'census house', a 'census house' being referred to a 'structure with roof'. The enumerators are instructed to mark out the possible places where the houseless population is likely to live such as on the roadside, pavements, in hump pipes, under staircases or in the open, temples, mandaps, platforms, etc.". In the present study, the houseless population is defined as 'persons who do not live in a house, having few possessions with them and used to sleep and live in the informal places, not meant for human habitation, excluding the slums dwellers, nomadic tribal people (gipsies) and Hindu saints. While, a house is taken as a physical structure of dwelling with roof and walls as a separate unit having the separate main entrance into it from the public way' (Shamshad, 2014, p. 106).

OBJECTIVES OF THE STUDY

The present research work aims to attempt the five main specific objectives of houselessness:

i. to know the perceived problems of the houseless population like nature of the behaviour of the general population, experiences at certain occasions and need of security in the city,

ii. to analyse the sources of help in emergency received by houseless population in the city,

iii. to examine the supportive services availed by houseless population in the study area,

iv. to observe the expressive ties felt by the houseless population, and

v. to look over the relatives of the houseless population who have the houses.

THE STUDY AREA

The Kanpur city of Uttar Pradesh has been selected for the present study. The geographical location of Kanpur city lies between the parallels of 26° 10-′ and 26° 36′north and longitudes of 79° 30′ and 80° 35′east. The lines of 80° 2′ 30″ E longitude and 26° 28′15″ N latitude pass through mid of the city and it is located in the central part of the state of Uttar Pradesh (Figure 1). Kanpur City has been the first largest as well as the most populous metropolitan city of the state till the Indian Census 2001. But in 2011 Census, it slipped down to the second position after Lucknow (28,15,601), the capital city of the state. According to the 2011 Census, the city had a population of 27,67,031 (27.67 lakh) which made it the twelfth most highly populated city in India. As far as the population of Kanpur urban agglomeration (UA) is concerned, it is still maintaining its first position in the state having the population 29,20,067 against the population of Lucknow urban agglomeration (UA) 29,01,474. Out of total population of Kanpur city (27,67,031), 54.30 per cent are males while 45.70 per cent is females. The city has been known as the economic and industrial capital of Uttar Pradesh. Kanpur is also the divisional headquarter of the Kanpur Commissionary consisting of Kanpur Nagar, Kanpur Dehat, Etawah, Auraiya, Farrukhabad and Kannauj districts (Kanpur City Development Plan, 2006). The city is administratively divided into 6 zones and 110 wards (the inner core area of Kanpur constitutes 67 wards) with an average ward population ranging between 20,000 to 25,000 persons. The municipal area of Kanpur city is about 605 square kilometers. However, the Kanpur urban agglomeration, as defined by the Census of 2011, has a population of 29,20,067 persons and area is comprised of Kanpur municipal corporation, Kanpur municipal corporation outgrowth, Kanpur Cantonment board, Armapur Estate, northern railway colony and Chakeri.

DATABASE AND METHODOLOGY

The present study is based on primary source of data generated through a comprehensive field survey in the Kanpur city carried out during 2012. Having identified the houseless households in prior visits in each ward, the individual slips were used to ease the task of the survey in the city. Among the total 110 wards of the Kanpur city, the houseless population was found only in the 96 wards and Cantonment area while houselessness was not found in remaining 14 wards, Armapur Estate, Aerodrome and C.O.D. (Central Ordinance Depot) areas during the survey in the city.

Ward in Kanpur city is the smallest administrative unit, and houseless household has been taken as the smallest unit for data collection. For ease of understanding, the collected data were spatially

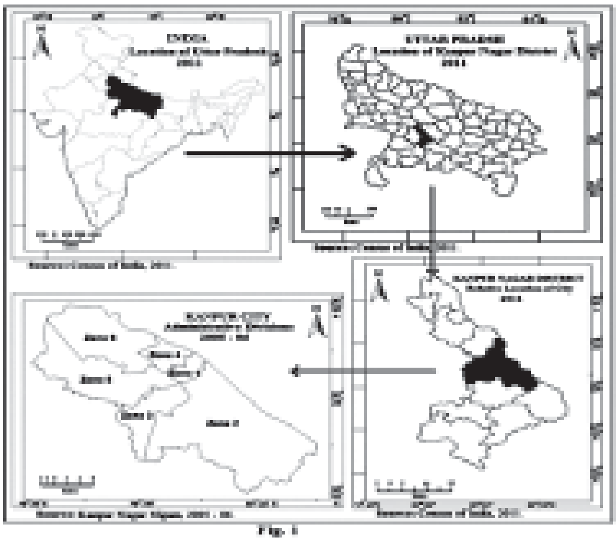

Fig. 1

presented through zone-wise maps of the city. Initially, it was planned to select 30 per cent houseless households randomly from each ward. However, the three pilot surveys were carried out in the city during May, August and November in 2011, in these surveys; it was observed that the number of houseless households used to vary over time even within a day and from place to another place in an area.

Thus, the four periods of time in a day i.e. early morning (6 am to 9 am); noon (12 pm to 3 pm), evening (6 pm to 9 pm) and late night (9 pm 12 midnight) were taken to record the number of houseless households. However, during the two periods (early morning and late night) large number of houseless people were found due to availability of space for sleeping/living after closing of shops/ markets while during the other two periods (i.e. noon and evening) small number of houseless people were found due to opening of shops/markets, and the working hours as most of the houseless people go to work during daytime. However, some houseless people were very difficult to be identified due to lack of their fixed abode. Moreover, it was also difficult to distinguish houseless person among the general public. Therefore, 10 percent of the houseless population was considered as hidden. Keeping these things in mind, a sample of 25 per cent houseless households was randomly selected for the survey from each ward. At last, the sampled houseless people of all the wards lying in a zone were summed up zone-wise for easy spatial data analysis. The survey consisted of 1384 houseless persons of the Kanpur city.

RESULTS AND DISCUSSION

Perceived Problems of Houseless Population

Table 1 presents data regarding the nature of the behaviour of the general people towards the houseless population, experiences at certain occasions and need of security felt by houseless population in the Kanpur city. An examination of the data given in Table 1 reveals that most of the general population of the city behaved badly with the houseless persons instead having a sympathetic attitude towards them, which they deserve, being rough sleepers.

Table 1
Distribution of Perceived Problems of Houseless Population in Kanpur City

Zones	*Male/ Female*	*Behaviour*		*Experiences*		*Need of security*	
		Good	*Bad*	*Good*	*Bad*	*No need of security*	*Need of security*
Zone 1	Male	19.51	80.49	21.01	78.99	3.83	96.17
	Female	-	100.0	8.33	91.67	12.28	87.72
	Total	18.67	81.33	20.47	79.53	4.20	95.80
Zone 2	Male	22.33	77.67	28.16	71.84	4.68	95.32
	Female	10.00	90.00	20.00	80.00	4.76	95.24
	Total	21.24	78.76	27.43	72.57	4.69	95.31
Zone 3	Male	30.33	69.67	46.90	53.10	5.38	94.62
	Female	9.09	90.91	22.73	77.27	1.82	98.18
	Total	27.08	72.92	42.96	57.04	4.76	95.24
Zone 4	Male	26.78	73.22	40.00	60.00	5.35	94.65
	Female	67.86	32.14	41.67	58.33	8.82	91.18
	Total	32.23	67.77	40.11	59.89	5.59	94.41
Zone 5	Male	36.94	63.06	49.04	50.96	2.65	97.35
	Female	56.25	43.75	62.50	37.50	2.63	97.37
	Total	38.73	61.27	50.29	49.71	2.65	97.35
Zone 6	Male	25.00	75.00	42.29	57.71	1.53	98.47
	Female	28.57	71.43	31.82	68.18	3.17	96.83
	Total	25.38	74.62	41.12	58.88	1.73	98.27
Total	Male	24.73	75.27	33.01	66.99	3.76	96.24
	Female	30.58	69.42	29.25	70.75	5.60	94.40
	Total	25.23	74.77	32.72	67.28	3.91	96.09

Source: Based on Primary Survey by Author.

As, about the three-fourth proportion of houseless people has reported very ill-treatment by the general population namely policemen, officers (municipal people, leaders, transport officers, shelter in-charges, park security men, bus stands & railway station security men, etc.), gangs and local people. While only one-fourth houseless persons reported to be treated well. The ratio of houseless males who met ill-treatment by the general population is higher than the females. The inauspicious behaviour of the general population was reported the highest in Zone 1 (81.33 percent) and the lowest in Zone 5 (61.27 percent).

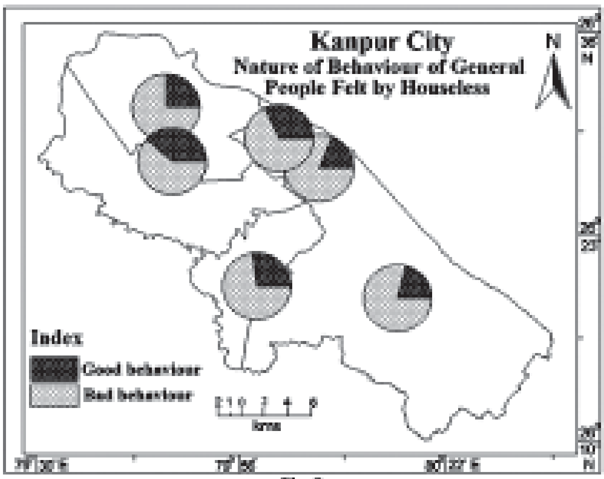

Fig. 2

It means that in each zone of the city, more than the two-third proportion of houseless persons faced ill-treatment barring the Zone 5 which recorded the lowest value 61.27. In other words, Zone 5 witnessed the highest ratio of houseless people who experienced good treatment by the general population in comparison the remaining zones. In Zones 1, 2 and 3, houseless females reported having faced the bad attitude of the general population in a higher degree than the males and vice versa in the remaining zones namely Zones 4, 5 and 6 (Fig. 2).Table 1 also contains data about the experiences felt by the houseless population at various occasions in Kanpur city. As can be seen from the table, nearly one-third and two-third houseless population has good and bad experiences respectively at the occasions of VIP visits, national festivals (Independence Day, Republic Day, Environment Day, Earth Day etc.), and various functions/ceremonies (marriages, religious festivals, various campaigns, etc.). The respective figures for houseless males are 33.01 and 66.99 percent, and 29.25 and 70.75 percent for houseless females. The largest section of houseless population having bad experience at the various occasions as mentioned above lies in Zone 1, followed by Zone 2 (72.57 percent), Zone 4 (59.89 percent), Zone 6 (58.88 percent), Zone 3 (57. 04 percent), and Zone 5 (49.71 percent), whereas the reverse trends have been followed in these zones regarding the good experience at the various occasions (Fig. 3). The ratio of houseless males having a good experience on such occasions has been identified higher than the females in Zones 1, 2, 3 and 6, whereas in Zones 4 and 5, the houseless females exceeded males in the said category. In other words, the ratio of houseless females in Zones 1, 2, 3 and 6 surmounted the houseless males regarding the bad experiences, but opposite trend has been followed in Zones 4 and 5.

The percent distribution of data about the need of

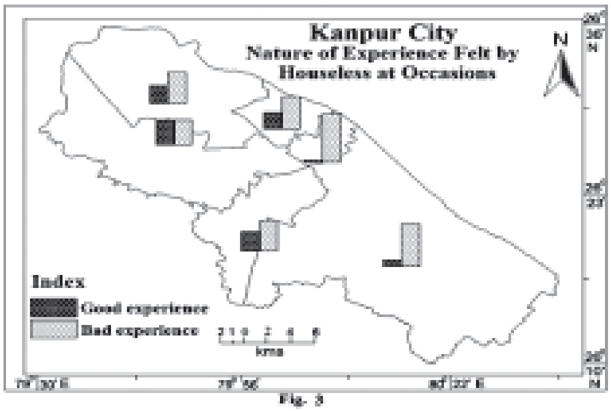

Fig. 3

security felt by the houseless population has been also inserted in Table 1. It would be seen from the table that a huge proportion (96.09 percent) of houseless population needs security in their lives from different kinds of humiliations and disturbances like public harassment, police chasing, municipal torment, traffic, aggression, noise, disputes and A to Z society. Only a very small fraction of houseless population (3.91 percent) did not report for this need. The need for security was demanded more by houseless males (96.24 percent) than the females (94.40 percent) because a larger ratio of houseless males was found living as individuals rather than with families while

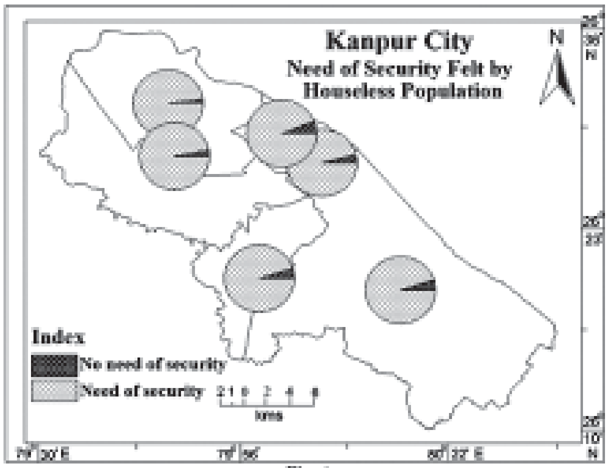

Fig. 4

the houseless females were identified more either as the members of the houseless families or mental.

Zone wise analysis reveals that the houseless population who didn't feel the need for security was limited to the proportion of five percent in all the zones of the city excluding Zone 4 wherein they recorded 5.59 percent, whereas even the lowest proportion of houseless people who expressed the need for security was found as high as 94.41 percent (Zone 4), their highest limit having reached 98.27 percent (Zone 6), who need security from public harassment, police chasing, municipal torment, traffic, aggression, noise, disputes and A to Z society (Fig. 4).

Sources of Help for Houseless Population during Emergency

Percentage distribution of the sources of help received in an emergency by the houseless population is set-out in Table 2. It can be seen from Table 2 that more than half houseless population received help at the time of emergency from friends, family members, relatives, different individuals and others while less than fifty percent (46.21 percent) houseless persons didn't have any sources of help in an emergency. The houseless males registered lesser ratio among those who received help during an emergency than the houseless females and vice versa. Zone wise analysis reveals that the maximum number of houseless people who have access to such help lies in, Zone 3 (72.92 percent) subsequently followed by Zone 4 (61.65 percent), Zone 6 (59.05 percent), Zone 2 (56.69 percent), Zone 5 (47.80 percent), and Zone 1 (43.41 percent), and a reverse condition is observed in case of non-availability of help in emergency (see Figure 5). The houseless males registered a greater ratio in terms of receiving help in an emergency in Zones 1, 2 and 3, whereas houseless females dominated in Zones 4, 5 and 6 in the same category and vice versa.

Table 2
Percentage of Help Received in Emergency by Houseless Population

Zones	Male/ Female	Status		Help in Emergency					
		No help	Received help	Individual	Friends	Family	Relatives	God	Others
Zone 1	Male	58.00	42.00	24.48	14.50	1.32	0.56	0.94	0.19
	Female	6.67	93.33	80.00	6.67	-	-	6.67	-
	Total	56.59	43.41	26.01	14.29	1.28	0.55	1.10	0.18
Zone 2	Male	44.74	55.26	21.93	11.40	16.67	4.39	0.88	-
	Female	30.77	69.23	46.15	7.69	-	15.38	-	-
	Total	43.31	56.69	24.41	11.02	14.96	5.51	0.79	-
Zone 3	Male	27.98	72.02	14.88	14.88	10.71	13.69	5.95	11.90
	Female	20.83	79.17	58.33	8.33	4.17	8.33	-	-
	Total	27.08	72.92	20.31	14.06	9.90	13.02	5.21	10.42
Zone 4	Male	37.44	62.56	33.85	22.05	4.10	2.56	-	-
	Female	54.55	45.45	36.36	9.09	-	-	-	-
	Total	38.35	61.65	33.98	21.36	3.88	2.43	-	-
Zone 5	Male	50.6	49.4	21.08	13.86	6.02	8.43	-	-
	Female	68.75	31.25	25.00	-	6.25	-	-	-
	Total	52.2	47.80	21.43	12.64	6.04	7.69	-	-
Zone 6	Male	39.89	60.11	21.28	14.36	11.70	12.77	-	-
	Female	50.00	50.00	27.27	9.09	9.09	4.55	-	-
	Total	40.95	59.05	21.90	13.81	11.43	11.90	-	-
Total	Male	46.84	53.16	23.57	15.27	6.17	5.43	1.17	1.54
	Female	37.62	62.38	45.54	6.93	3.96	4.95	0.99	-
	Total	46.21	53.79	25.09	14.70	6.02	5.40	1.16	1.44

Source: Based on primary survey by author.

Further analysis of Table 2 shows that out of the total houseless population who received help in an emergency, about one-fourth houseless people have been helped by different individuals like employers, passers-by, social help groups, policemen, propitiators, etc. Friends are the second most important source of help for houseless people during the emergency period because 14.70 percent houseless people received help from their friends, followed by those helped by family (6.02 percent), relatives (5.40 percent), and others (1.44 percent). However, 1.16 percent houseless persons commented that only God helps every time, thus indicating the absence of any helping source. The ratio of males dominated the females in each category except the individuals' help (Box 1).

The category of others helps included the policemen and NGOs (0.68 percent each) and governmental officers (0.07 percent). Table 2 also illustrates that the most basic source of help in an emergency for the houseless population in each zone of the city is the individuals' help which is accessible by more than one-fourth to the one-third houseless people. The second significant source of emergency help after the individuals' help, i.e. help from the friends, has been experienced by houseless persons in all the zones, barring Zone 2. The ratio of houseless persons having family help during emergency period varied from 1.28 percent in Zone 1 to 14.96 percent in Zone 2.

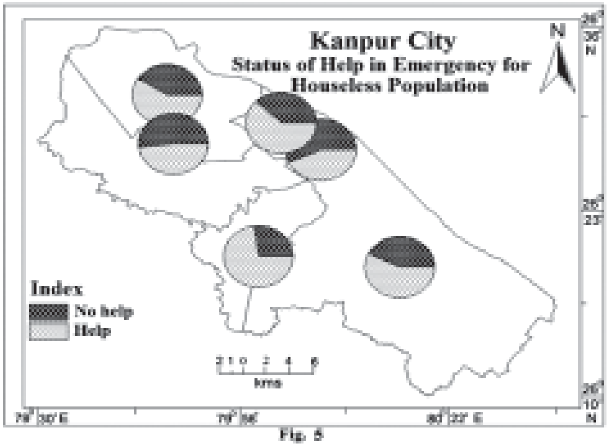

Fig. 5

However, the emergency help received from the relatives is ascertained in descending percental order among the zones i.e. Zone 3 (13.02 percent), Zone 6 (11.90 percent), Zone 5 (7.69 percent), Zone 2 (5.51 percent), Zone 4 (2.43 percent) and Zone 1 (0.55 percent). The emergency help from various other sources namely policemen, NGOs and governmental officers, has been identified only in two zones i.e. Zone 1 (0.18 percent) and Zone 3 (10.42 percent).

Box 1: Some Kind of Help Felt by Houseless Population

1. "Please help us. Please do not displace from this place, how we will survive in this period of the high price level, anybody, please think about these situations" (Madhu: 47, Kanpur Nagar).
2. "Today, nobody is there to help anybody, except *Allah*" (Mubarak Ali: 35, Odisha).
3. "I use to clean plates in a hotel in order to satisfy the hunger pangs of my family members. My father is handicapped by legs and we are seven brothers and sisters. Tell me how to pass our lives. I do not know from where the government runs, if I had known, I would have gone there and said: I will also live here, either, you will beat me, I will die here, my soul says it again and again" (Kushum Singh: 24, Kanpur Nagar).
4. "We should not be removed from this place so that we can earn our means of livelihood" (Baburam: 54, Kanpur Nagar).
5. "My God and my work help me only" (Basant Lal Gautam: 49, Unnao).

Source: Based on primary survey by the author.

A small fraction of houseless people didn't say anything regarding the sources of help during the emergency period, ironically commenting that it's only God who always help them in each and every condition. Such fraction of houseless persons has been observed only in three zones namely Zone 1 (1.10 percent), Zone 2 (0.79 percent) and Zone 3 (5.21 percent). The gender wise analysis of data shows that barring few exceptions, the proportion of houseless males exceeded the females in all the sources of help accessed during emergency period in all the zones of the city, excluding the source of individuals' help in which the ratio of houseless females overstepped the males in each zone of the study area.

Other Supportive Services for Houseless Population

Table 3 provides information about the percentage distribution of other supportive services availed by houseless population in Kanpur city. It is evident from this table that nearly twenty percent houseless persons are found to be supported each in the category of charities and foraging, followed by clothing (16.49 percent), food stamps (16.49 percent), asking for money (10.37 percent), friends' help (8.35 percent), advice (3.20 percent), families' help (2.23 percent), medicare (2.09 percent) employers' aid (1.95 percent) and pensions (0.21 percent).

Data in Table 3 reveal that more than one-fourth houseless people in Zone 1 are assisted by the foraging, with other significant services in the zone being the charities (22.95 percent), food stamps (22.13 percent) and clothing (18.65 percent). In Zone 2, the very marginal percental differences have been observed among the charities, foraging, clothing and food stamps as supportive services availed by the houseless population accounting to 16.56, 17.22, 17.22 and 15.23 percent respectively. The respective figures for the Zone 4 are 16.91, 15.44, 15.81 and 13.24 percent. More than one-fifth proportion is constituted by the charities as a supportive service in both Zones 5 and 6. Out of eleven supportive services listed in Table 3, only five, namely charities, foraging, clothing, food stamps and asking for money, are found to be most significant in helping the houseless population, their combined share together constituting 96.31, 77.49, 73.23, 72.06, 83.33 and 72.19 percent of all the supportive services in Zones 1, 2, 3, 4, 5 and 6 respectively. On the other hand, the aggregate proportion of the remaining six supportive services i.e. friends' help, advice, families' help, Medicare, employers' help and pensions have not been registered more than thirty percent in any of the zones in the whole Kanpur city.

Table 3: Percent Distribution of Other Supportive Services for Houseless Population

Zones	M/F/T	Other Supportive Services for Houseless Population											
		Charities	Foraging	Clothing	Food stamps	Asking for money	Friends' help	Advice	Families' help	Medicare	Employers' aids	Pensions	Total
Zone 1	M	23.02	26.86	18.47	23.02	5.28	0.48	-	-	2.88	-	-	100.00
	F	22.54	26.76	19.72	16.90	8.45	-	-	-	5.63	-	-	100.00
	T	22.95	26.84	18.65	22.13	5.74	0.41	-	-	3.28	-	-	100.00
Zone 2	M	15.60	16.51	16.51	15.60	12.84	7.34	6.42	4.59	2.75	1.83	-	100.00
	F	19.05	19.05	19.05	14.29	7.14	4.76	9.52	-	7.14	-	-	100.00
	T	16.56	17.22	17.22	15.23	11.26	6.62	7.28	3.31	3.97	1.32	-	100.00
Zone 3	M	10.84	13.25	15.66	10.84	14.46	16.87	10.84	3.61	2.41	1.20	-	100.00
	F	14.00	17.00	19.00	14.00	16.00	15.00	2.00	1.00	1.00	1.00	-	100.00
	T	12.57	15.30	17.49	12.57	15.30	15.85	6.01	2.19	1.64	1.09	-	100.00
Zone 4	M	16.88	15.15	16.02	13.85	11.26	11.69	5.63	3.03	0.87	5.19	0.43	100.00
	F	17.07	17.07	14.63	9.76	7.32	14.63	14.63	2.44	2.44	-	-	100.00
	T	16.91	15.44	15.81	13.24	10.66	12.13	6.99	2.94	1.10	4.41	0.37	100.00
Zone 5	M	21.05	18.42	17.11	11.84	11.84	3.95	2.63	3.95	2.63	3.95	2.63	100.00
	F	22.73	18.18	18.18	15.91	13.64	4.55	-	-	-	6.82	-	100.00
	T	21.67	18.33	17.50	13.33	12.50	4.17	1.67	2.50	1.67	5.00	1.67	100.00
Zone 6	M	21.84	11.49	9.77	12.64	14.37	18.39	1.72	6.32	-	3.45	-	100.00
	F	20.41	12.24	14.29	18.37	14.29	18.37	-	2.04	-	-	-	100.00
	T	21.52	11.66	10.76	13.90	14.35	18.39	1.35	5.38	-	2.69	-	100.00
Total	M	19.72	19.27	16.06	16.97	9.91	7.89	3.12	2.66	1.93	2.20	0.28	100.00
	F	18.73	18.73	17.87	14.99	11.82	9.80	3.46	0.86	2.59	1.15	-	100.00
	T	19.49	19.14	16.49	16.49	10.37	8.35	3.20	2.23	2.09	1.95	0.21	100.00

Source: Based on primary survey by the author. **Note:** T- Total; M- Male; F- Female

Table 4: Percent Distribution of Expressive Ties Felt by Houseless Population

Zones	Male/ Female	Expressive ties							
		Socially disaffiliated	Socially affiliated	Siblings/ wives	Parents	Relatives	Close non-local friends	Close local friends	Group of people
Zone 1	Male	20.31	79.69	32.53	30.26	5.68	6.68	3.13	1.42
	Female	42.86	57.14	28.57	7.14	14.29	-	7.14	-
	Total	21.17	78.83	32.38	29.37	6.01	6.42	3.28	1.37
Zone 2	Male	12.78	87.22	39.10	33.08	12.03	1.50	-	1.50
	Female	63.64	36.36	18.18	9.09	-	-	9.09	-
	Total	16.67	83.33	37.50	31.25	11.11	1.39	0.69	1.39
Zone 3	Male	4.76	95.24	31.90	22.86	20.00	7.62	8.10	4.76
	Female	3.33	96.67	56.67	6.67	20.00	10.00	3.33	-
	Total	4.58	95.42	35.00	20.83	20.00	7.92	7.50	4.17
Zone 4	Male	29.65	70.35	32.30	22.12	11.95	1.33	2.65	-
	Female	61.54	38.46	7.69	-	23.08	7.69	-	-
	Total	31.38	68.62	30.96	20.92	12.55	1.67	2.51	-
Zone 5	Male	16.82	83.18	40.65	28.97	10.28	1.40	1.87	-
	Female	47.06	52.94	29.41	5.88	17.65	-	-	-
	Total	19.05	80.95	39.83	27.27	10.82	1.30	1.73	-
Zone 6	Male	18.75	81.25	31.73	20.67	18.27	4.81	5.77	-
	Female	30.77	69.23	26.92	3.85	23.08	3.85	11.54	-
	Total	20.09	79.91	31.20	18.80	18.80	4.70	6.41	-
Total	Male	18.41	81.59	33.86	27.14	10.91	4.78	3.60	1.30
	Female	35.20	64.80	32.00	5.60	17.60	4.00	5.60	-
	Total	19.56	80.44	33.74	25.66	11.37	4.73	3.74	1.21

Source: Based on primary survey by the author.

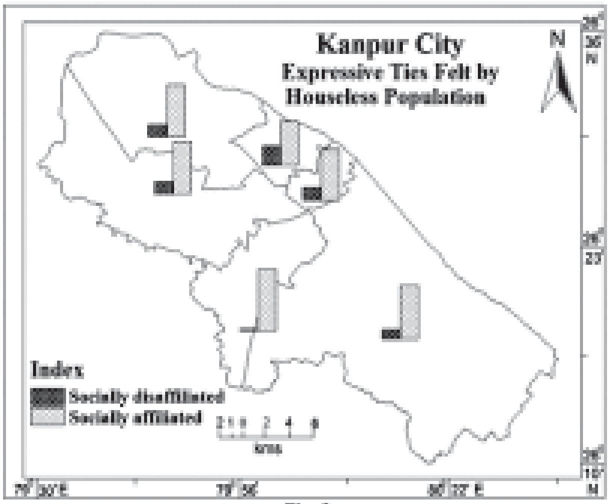

Fig. 6

Expressive Ties of Houseless Population

The data about the expressive ties felt by the houseless population has been presented in Table 4. The table depicts that nearly one-fifth (19.56 percent) houseless population was socially disaffiliated this section of the houseless population may also be called as homeless people due to social exclusion or disaffiliation, while more than four-fifth (80.44 percent) houseless people was socially affiliated in the city.

Among the socially affiliated houseless population, one-third (33.74 percent) and one-fourth (25.66 percent) houseless people have their expressive ties with their siblings/wives and parents respectively, subsequently followed by those having ties with relatives (11.37 percent), close non-local friends (4.73 percent), close local friends (3.74 percent) and group of people (1.21 percent). The proportion of houseless males was greater than the females in all types of social affiliation excluding the categories of relatives and close local friends.

Table 4 shows that about the one-fifth proportion of the houseless population was socially disaffiliated in Zone 1 (21.17 percent), Zone 6 (20.09 percent), and Zone 5 (19.05 percent) which is much higher in comparison with such people in other zones. The least share of socially disaffiliated houseless people was identified in Zone 3 (4.58 percent) (Fig. 6). Among the socially affiliated, the majority of the houseless population was affiliated with their siblings/wives; as nearly four-fifth of them in Zone 5 and 30.96 percent in Zone 4 have expressive ties with their siblings/wives. It means that nearly one-third of the houseless persons in each zone has their social connections with the siblings/wives. The second largest proportion of the houseless people was found affiliated with their parents, varying from the highest 31.25 percent in Zone 2 to the lowest 18.80 percent in Zone 6. The highest social expressive ties with relatives were witnessed in Zone 3 where one-fifth of the houseless people were socially affiliated with their relatives, while the lowest fraction (6.01 percent) in this category was registered in Zone 1. There has been found a significant proportion of houseless people having social relationships with their close non-local friends ranging from maximum 7.92 percent in Zone 3 to minimum 1.30 percent in Zone 5. The social affiliation with close local friends and group of people was again observed in greater proportions in Zone 3 in comparison to other zones of the city viz. 7.50 and 4.17 percent respectively.

The male-female break-up of the data about the expressive ties felt by houseless population shows that barring few exceptions, the ratio of houseless males in the categories of expressive ties with siblings/wives, parents, close non-local friends and group of people exceeded that of females. While, the opposite trend has been registered in the case of relatives and close local friends. Moreover, no houseless female has been found in the category of having expressive ties with the group of people in which the males also registered their presence only in three zones namely Zones 1, 2 and 3.

Relatives of Houseless Population having Houses

The percent distribution of data about the relatives of the houseless population who have the houses to live in is given in Table 5. An analysis of Table 5 shows that most of the relatives (i.e. 84.45 percent) of the houseless population have houses, it means that houseless people have a good social connection with their relatives because their relatives have the house. Whereas only 15.55 percent relatives of the houseless persons do not have houses, which indicates the presence of houselessness in various other parts of the country also where they live. The respective figures for the relatives of houseless male and female population are 85.97 percent and 14.03 percent (for males) and 66.36 percent and 33.64 percent (for females).

The houseless male-female differential depicts that the ratio of houseless relatives is higher in the case of houseless females in comparison to the relatives of houseless males. Further, more than the three-fourth proportion of the houseless population in each zone of the city has reported that their relatives have houses, barring Zone 2 where their percentage marginally falls to 73.45 percent. In other words, the highest ratio of the houseless relatives (26.55 percent) has been accounted among the houseless people in Zone 2 followed by Zone 4 (18.37 percent), Zone 6 (16.67 percent), Zone 1 (15.50 percent), Zone 3 (10.14 percent) and Zone 5 (8.67 percent) (Figure 7).

Table 5
Percentage of Relatives of Houseless Population having Houses

Zones	*Male/ Female*	*Relatives who have the houses*		
		House	*No house*	*Total*
Zone 1	Male	86.04	13.96	100.00
	Female	52.00	48.00	100.00
	Total	84.50	15.50	100.00
Zone 2	Male	77.67	22.33	100.00
	Female	30.00	70.00	100.00
	Total	73.45	26.55	100.00
Zone 3	Male	88.89	11.11	100.00
	Female	95.45	4.55	100.00
	Total	89.86	10.14	100.00
Zone 4	Male	83.15	16.85	100.00
	Female	58.33	41.67	100.00
	Total	81.63	18.37	100.00
Zone 5	Male	93.63	6.37	100.00
	Female	68.75	31.25	100.00
	Total	91.33	8.67	100.00
Zone 6	Male	84.66	15.34	100.00
	Female	72.73	27.27	100.00
	Total	83.33	16.67	100.00
Total	Male	85.97	14.03	100.00
	Female	66.36	33.64	100.00
	Total	84.45	15.55	100.00

Source: Based on primary survey by the author.

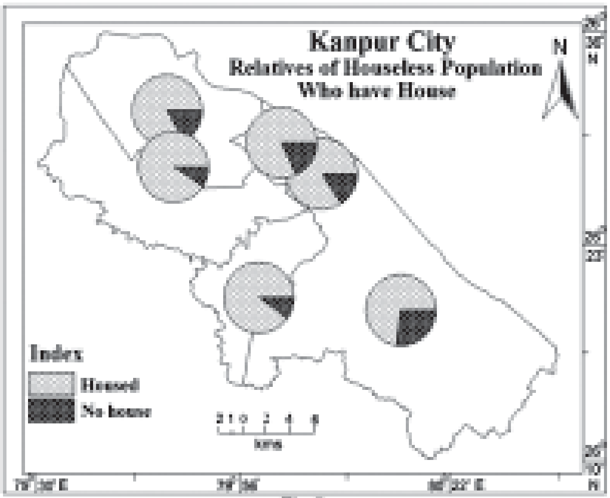

Fig. 7

The share of relatives of the houseless male population who have houses exceeded the relatives of the houseless female population in all the zones of the city except in Zone 3. It implies that the proportion of relatives of houseless females in the whole city, who are also houseless, is greater than the ratio of relatives of houseless males excluding Zone 3 in which the ratio of houseless relatives of males overstepped the houseless relatives of females.

CONCLUSIONS

The general analysis of the whole study reveals that most of the general population has negative behaviour with the houseless persons instead of having a sympathetic attitude towards them which they deserve, being rough sleepers or houseless persons in the city; because about three-fourth proportion of houseless people has reported very ill-treatment by the general population towards them. Whilst, merely one-fourth share of houseless persons, reported having a good treatment from the general population in the city. Likewise, the two-third ratio of the houseless population has bad experiences on the occasions of VIPs' visits, national festivals and various functions/ceremonies (marriages, religious festivals, various campaigns, etc.). This major section of houseless population having bad experiences at these times was usually displaced, physically tortured, emotionally humiliated, and even their belongings/ luggage were either crushed down, thrown away, ravished or taken away, whilst, these people being citizens of the country, on the ground of humanity at these occasions, should be well treated with respect, safety, compensations, etc. However, nearly one-third proportion of houseless population received the good experiences on these occasions in the city.

Further, the more than ninety percent houseless population needed security in their daily lives on the footpaths from various kinds of humiliations and disturbances such as public harassment, police chasing, municipal torment, traffic, aggression, noise, disputes, etc. in the city. Only a very small fraction of the houseless population did not report the need of security from these humiliations and disturbances. Nevertheless, the majority of the houseless population in the city has been getting the various kinds of help during the emergency and social affiliations from several sources. For instance, more than half houseless population received help at the time of emergency from friends, families, relatives and from different individuals, while, less than fifty percent houseless persons didn't have any sources of help in an emergency. The houseless males registered lesser ratio among those who received help during an emergency than the houseless females and vice versa. Because most of the houseless males in the city lived as single or individual houseless households, whereas, the majority of houseless females lived with their family members as houseless households with families in the city.

In addition to it, apart from the sources of income earned by houseless population after works, there are other informal supportive services availed or used by houseless population for their survival. Nearly seventy percent houseless persons were found to be supported by charities, foraging, clothing and food stamps whereas remaining proportion of the houseless population were availing supportive services in terms of asking for help by money, friends' help, advice, families' help, medicare, employers' aid and pensions. Nearly one-fifth houseless population was found socially disaffiliated in the city. This particular section of the houseless population may also be called as 'homeless people' because these people were excluded and disaffiliated from the social networks of families, relatives, friends, and even from their native living places, while, more than four-fifth share of houseless people has social affiliations. Among the socially affiliated houseless population, one-third and one-fourth houseless people have their expressive ties with their siblings/wives and parents respectively, subsequently followed by those having social affiliations with relatives, close non-local friends, close local friends and group of people.

At last, most of the relatives of the houseless population (more than eighty percent) have houses at their respective places. It indirectly shows that houseless people might also have good social as well as economic conditions at some point of time, but later, they might have been became houseless due to some socio-economic reasons, because these houseless people have good social connections with their relatives who have the houses. However, only 15.55 percent relatives of the houseless persons also do not have the houses, which indicate the presence of the problem of houselessness in various other parts of the country where they live.

REFERENCES

1. Bender, K., Thompson, S. J., McManus, H., Lantry, J., & Flynn, P. M. (2007). Capacity for Survival: Exploring Strengths of Homeless Street youth. *Child Youth Care Forum*, 36, 25-42.
2. Burt, M. R. (1991). Causes of the Growth of Homelessness during the 1980s. *Housing Policy Debate*, 2(3), 903-936.
3. Census of India. (1991). Primary Census Abstract, Total Population, Series-1, Table A-5. Ministry of Home Affairs, Office of the Registrar General. Govt. of India, New Delhi, 64.
4. Census of India. (2001). Primary Census Abstract, Total Population Series-1, Table A-5. Ministry of Home Affairs, Office of the Registrar General. Govt. of India, New Delhi.
5. Census of India. (2011). Primary Census Abstract for Total Population and Houseless Population. Office of the Registrar General & Census Commissioner Govt. of India, New Delhi.
6. Census of India. (2011). Primary Census Abstract, Total Population Series-1, Table A-5. Ministry of Home Affairs, Office of the Registrar General. Govt. of India, New Delhi.
7. Crosnoe, R., Erickson, K. G., & Dornbusch, S. M. (2002). Protective Functions of Family Relationships and School Factors on the Deviant Behaviour of Adolescent Boys and Girls: Reducing the Impact of Risky Friendships. *Youth & Society*, 33(4), 515-544.
8. FEANTSA. (2010). Ending Homelessness: A Handbook for Policy Makers. European Federation of National Organisations Working with the Homeless. Retrieved from: http://www.epha.org/IMG/pdf/HANDBOOK_TO_END_ HOMELESSESS.pdf
9. Gelberg, L., Anderson R. M., & Leake B. D. (2000). The Behavioral Model for Vulnerable Populations: Applications to Medical Care Use and Outcomes for Homeless People. *Health Services Research*, 34(6), 1273–1302.
10. Gilligan, R. (2002). Adversity, Resilience and Young People: The Protective Value of Positive School and Spare Time Experiences. *Children and Society*, 14(1), 37-47.
11. Harrison, L. (2001). The Revolving Prison Door for Drug Involved Offenders: Challenges and Opportunities. *Crime & Delinquency*, 47(3), 462 485.
12. Hersberger, J. A. (2001). Everyday Information needs and information sources of homeless parents. *The New Review of Information Behavior Research*, 119-134.
13. Hertzberg, E. (1992). The Homeless in the United States: Conditions, Typology and Interventions. *International Social Work*, 35(2), 149-161.
14. Kanpur City Development Plan. (2006). Final Report. Under Jawaharlal Nehru National Urban Renewal Mission (JNNURM). JPS Associates (P) Ltd., 252.
15. National Alliance to End Homelessness. (2002) A Plan not a Dream: How to end Homelessness in Ten Years. Washington: National Alliance to End Homelessness. Retrieved from: http://www.endhomelessness.org/library/entry/a-plan-not-a-dream-how-toend-homelessness-in-ten-years
16. Padgett, D., Struening E. L., & Andrews, H. (1990). Factors Affecting the Use of Medical, Mental Health, and Alcohol and Drug Treatment Services by Homeless Adults. *Medical Care*, 28(9), 805–821.
17. Petersilia, J. (2001a). Prisoner Reentry: Public Safety and Reintegration Challenges. *The Prison Journal*, 81(3), 360 375.
18. Petersilia, J. (2001b). When Prisoners Return to

Communities. *Federal Probation*, 65, 3 8.

19. Quilgars, D., Fitzpatrick, S., & Pleace, N. (2011). *Ending Youth Homelessness: Possibilities, Challenges and Practical Solutions*. York, UK: Centre for Housing Policy, University of York & School of the Built Environment, Heriot-Watt University.

20. Shamshad (2014). An Ethnographic Study of Houseless Population in Kanpur city. *Annals of Rajasthan Geographical Association*, 31, 106-113.

21. Shamshad (2015). Houselessness: People on the roads. Delhi: Academic Publication, 348.

22. Smokowski, P. R., Reynolds, A. J., & Bezruckzo, N. (1999). Resilience and Protective Factors in Adolescence: An Autobiographical Perspective from Disadvantaged Youth. *Journal of School Psychology*, 37(4), 425–448.

23. Travis, J., & Petersilia, J. (2001). Reentry Reconsidered: A New Look at an Old Question. *Crime & Delinquency*, 47(3), 291 313.

24. Ungar, M. (2004). A Constructionist Discourse on Resilience: Multiple Contexts, Multiple Realities among at-risk Children and Youth. *Youth & Society*, 35(3), 341-365.

25. United States Interagency Council on Homelessness. (2010). Federal Homelessness Workgroups Listening Session Background materials from February 2010. Retrieved from:http://www.usich.gov/resources/uploads/asset_library/ExpertsBriefs_ All5Workgroups.pdf

26. Visher, C. A., & Travis, J. (2003). Transitions from prison to community: Understanding Individual Pathway. *Annual Review of Sociology*, 29, 89 113.

27. Wenzel S. L., Bakhtiar L., Caskey N. H., et al., (1995). Homeless Veterans' Utilization of Medical, Psychiatric, and Substance abuse Services. *Medical Care*, 33(11), 1132–1144.

GEOGRAPHICAL REMOTENESS AND UNDERDEVELOPMENT: MAPPING THE SPATIAL ECONOMIC STRUCTURE OF SOUTHERN REGION OF ODISHA

Siba Sankar SAHU[1]

ABSTRACT

Caste, ethnicity and geographical inequalities reinforce one another and create pockets of extreme poverty impacting certain groups. Tribal are more than two and half more likely to be in poverty than non deprived group of Odisha. High level poverty and inequality (both horizontal and vertical) one of the acute problems associated with the southern region. The paper seeks to examine the extent, nature and structural factors leading to poverty and underdevelopment in southern region of Odisha. The analysis is based on both secondary as well as primary data. PCA, Coefficient of variance and Lorenz curve is used to identify the extent of poverty and inequality then mapping the spatial and economic structure of the region as well. The present paper shows the extent of backwardness in southern region as compared to other part of Odisha and identifies process and intersecting dynamics that produces socio-spatial inequality in the region. It highlights on the existing policy initiatives and suggests addressing the issue of chronic poverty and inequality

Keywords: *Geographical Remoteness, Inequality, Poverty, Spatial exclusion*

INTRODUCTION

Regional (economic) development has been an important dimension to assess the development process, its spatial manifestations and regional performance. This is the relevance of this interdisciplinary research framework that in the age of neoliberal dominance, the field of regional development retains its unique position in understanding the nature of development at regional scale. In fact, the role of regions in national economies is prominent in order to make a sense of how regional economies perform and the kind of disparities and inequalities exists between and within them. At the national level, studies also have largely focused on the North South divide in India taking into account multiple aspects and parameters of development to assess the regional performance (Dreze & Sen: 1997, Ghosh: 2006). In this context, there is a large literature on convergence/divergence between states, horizontal and vertical inequalities and intra-regional disparities that persists at different scales (Diwakar: 2009, Paul & Sridhar: 2015). The contemporary discourse on policies for poverty reduction lays special emphasis on expediting economic growth and sectoral diversification of the state economy. Though there has been a considerable poverty reduction at the national level, 54.88% in 1973-74 to 21.50% by 2011-12, the performance of states varies geographically. Amita Shah's (2007) study depicts that within rural areas poverty is concentrated in five out of the seventeen major (undivided) states, which account for nearly two-thirds of poor people in the country. These states are Bihar, Odisha, Uttar Pradesh, Madhya Pradesh and Maharashtra. Though globalization has potential to change the development scenario at different scale, there has been a marginal change in terms of demographic, economic and social aspects in most of the lagging behind region in Odisha. Longitudinal researches have shown that with increased commercialization of health and education inputs, in other words with more market instruments put in place as result of reforms, it is likely that different regions, rural and urban or various states converge in terms of their achievements in income and human development.

The extent of inequality may vary from region to region and from time to time. Considerable attention has been paid by a number of regional scientists on the behaviour of regional disparities over a period of time in a country. Therefore it is important to study the various attempts made to identify such a regional dimension of development. There is a wide difference of opinion among the social scientists about the existence of regional disparity, during the process of development. At least different views stood in that respect. The proponents of the 'self perpetuation' hypothesis propounded by Hughes (1961) and found empirically valid by Booth (1964) are of the view that regional disparities diverse in the process of economic development. Perloff et.al (1960) and Hanna (1959) in their hypothesis known as 'accordion effect' propounded that regional disparities converge in the course of economic development. The third view known as the 'Concentration Cycle' Williamson (1965) developed the view that regional disparities diverge initially and converge later on. Accordingly

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most scholars expressed the views in favour of dualism in economic development in the initial stage. Friedman (1969) explains that nations are not homogeneous and the development does not affect all parts equally, some experts of the developing countries have accepted the same opinion. Among them Nath (1994), Sailabala Devi (1996) and Rao (1995) argued that the existence of inequality necessitates the growth which may bring a balance between different regions at the later stage. Several studies indicate that there is a trade-off between economic development at the national level and reduction of regional disparities in the regional level.

On the other side, the need for bridging the development gaps has been emphasized for maintaining social justice, national integration, political stability and national unity. Disparity in socio-economic development has become an extreme sensitive issue in recent times with serious social and political ramifications. In developed countries the problem of backward region is somewhat different from that of developing countries. Rao (1987), Shabin and Bhole (1999) and Hasim (1995), express their fears of political and social tensions and their capability of assuming serious dimension and threatening the very existence of nation, if regional disparities are neglected and unchecked. Several studies in India emphasize that inequality cannot be tolerated on the gains of few regions. In their brief survey of the government policy on backward area development Selvi and Pethar (1994) explain that the economic backwardness of Orissa and North Bihar is a result of backwash effect of the growth of Kolkata and they suggested that if timely action is not taken, the less developed regions will be trapped in a vicious circle. In fact earlier studies have shown that economic growth would not reduce poverty substantially unless the spread of additional income goes more in favour of the depressed classes along with improvements in social indicators (Pradhan et al. 2000). The gap between rich and poor is reaching new extremes. Credit Suisse recently revealed that the richest 1% have now accumulated more wealth than the rest of the world put together. Meanwhile, the wealth owned by the bottom half of humanity has fallen by a trillion dollars in the past five years. Oxfam has calculated that in 2015, just 62 individuals had the same wealth as 3.6 billion people the bottom half of humanity. Since the turn of the century, the poorest half of the world's population has received just 1% of the total increase in global wealth, while half of that increase has gone to the top 1%. This is just the latest evidence that today we live in a world with levels of inequality we may not have seen for over a century (Oxfam 2016).

Importance of the Present Study in Context of Sourthern Region Odisha

NSSO divides odisha into three major regions such as northern, southern and coastal. Out of total thirty districts in Odisha twelve districts (Ganjam, Gajapati, Kandhamal, Boudha, Sonepur, Bolangir, Nuapara, Kalahandi, Rayagara, Nabarangpur, Koraput and Malkangir) comes under the southern part of Odisha. The all eight districts of KBK (Kalahandi-Bolangir-Koraput) come under the southern region. Viewing the poverty in the southern region of Orissa as dynamic, severe and multifarious, to study the income poverty and multi-dimensional poverty, horizontal and vertical inequality to identify the causes of chronic poverty in this region. Spatial disadvantages of the southern region in terms of remoteness, agriculture based subsistence economy and depleting income from NTFP (Non Timber Forest Products) are major factors contributing to chronic poverty. Analysis by Deaton has shown that comparisons are sensitive to price indices (particularly in rural-urban comparisons). The picture regarding high levels of poverty in the South may be influenced by the picture of disparities substantially. Analysis by Panda (2003) using adjusted cereal price indicates that poverty in the Southern region would still be two and a half times that in the Coastal region. It is equally important to highlight, as done in an in-depth study by Currie of Kalahandi, that even the districts that witness hunger have continued to produce food surplus, i.e. showing classic cases of entitlement failures and processes of marginalization at local level.

The key aspects of poverty in southern region of Orissa are that "lower caste" social groups (ST and SC) are discriminated with respect to "higher caste" social groups. Social exclusion from participation in political, economic and social processes creates conditions for the persistence of chronic poverty. Haan and Dubey (2005) reported that the trend of poverty reduction in Orissa and KBK (Part of southern region) is different than other regions in India. The STs of Orissa experienced the least reduction in poverty from 1983 to 1999 (only 14%) as compared to 23% among other group. This present paper addresses the following objectives: To identify some of the critical deficit areas important from the point of balanced regional development. To discuss the process and intersecting dynamics that produces socio-economic inequality, exclusion in Southern region of Odisha and to understand the regional nature of inequalities with an account of socio-economic indicators.

METHODOLOGY AND SOURCES OF DATA

The study divides Orissa into three regions such as coastal Odisha which comprises 9 districts, southern Odisha 12 districts and northern Odisha 9 districts on the basis of NSSO division. For showing inter-regional as well as intra regional disparity 18 indicators (data from the secondary sources) have been selected from four major sectors such as agriculture, Infrastructure, Gender and Human development these are as follows

Indicators of agricultural development: Consumption of fertilizer (kilogram per hectares), Yield rate of rice (quintal per hectares, Wage rate of male agricultural labour, Net irrigated Kharif crop area per 1000 hectares.

Indicators of human development indicators: Retention rate at primary level, Number of secondary school per lakh population, General colleges per lakh population, Success rate of matriculation exam (HSE Examination), Infant mortality rate (inverse rate) and literacy.

Indicators of infrastructural development: Total percentage of village electrified, Railway route per 1000 square kilometer, Number of telephone/mobile phone per lakh population, Bank per lakh population.

Indicators of gender development: Women agricultural wage rate, General enrollment of girls (primary and upper primary level), Female literacy, and success rate of female in matriculation exam in reference year (HSE Examination).

The above indicators have been chosen for the suitability of running Principal Component Analysis because of this property it may be considered as the best representative of all selected variables. In this method, all the eighteen variables were used for calculation. The Principal Component Analysis starts with a matrix of correlation coefficients measuring the degree of correlation between the indicators. Operation upon the basic data matrix then the exact the first factor, which accounts of the greatest proportion of the inter-correlation, leaving proportion not account for residual matrix. Before running PCA it should be scale free to every indicator and there are various methods to scale free the indicators. Author has used standardisation method to scale free the indicators and range equalization method to make the categories of PCA values. The standardisation method to scale free is given below

$$\frac{(X_j - X)}{ä\,Xj} \quad \text{or standardized variable.}$$

To show the inter regional variation and inequality between region various Quantitative methods are used such as Composite development index (to make the data scale free and prepare the range of socio-economic development in various regions), Principal component analysis (for showing the importance of indicators in various regions), Coefficient of Correlation (to show the relationship between various indicators),Lorenz Curve and Range method to show the inequality among regions.

Principal Component Analysis

Principal Component Analysis, which is a useful statistical technique in the present context to identify the development of districts on the basis of agriculture, Human development, infrastructure and gender development in a quantitative terms. PCA is one such method, which help in deciding the weights objectively and also suggest a way combining various indicators, in other words the variables are not assigned weight arbitrarily but are determined by the system. In the method of PCA, the weight are supposed to reflect the degree of importance that each indicator is considered to have in the measurement of the whole. Realizing the importance of a scientific and less subjective index of development, PCA has been employed here to compute the index of development at the various sector levels.

The Model: First Principal Component is that linear combination of weighted variables which explains the maximum variance. Then P_1 = a11 X 1 + a21 X 2 + …………….. + an1 X n. The measure of the first Principal Component can also be written in the following way.

$$\frac{P_i = (a_{j1} X Z_j)}{\lambda_1}$$

Where a_{j1} (j = 1, 2 …………n) are the factor loading

$$Z_j = \text{standardized variable i.e.} = \frac{(X_i - X)}{\delta X_i}$$

λ1 = Eigen value (largest characteristic root)

The Composite Index 'I' either at the sectoral level or at the aggregate level is nothing but the First Principal Component itself. $I_{1k} = P_{1k}$ where k = 1, 2……………. k observations A simple measure adopted to arrive at I_{1k} or P_{1k} in the study is =

$$I_{1k} = \frac{a_{j1} X (X_{jk} - X)}{\delta X_j}$$

I_{1k} = Composite index value of k^{th} observation

a_{j1} = Factor loading of 'j'th variable on k^{th} observation and

X_{jk} = 'j'th variable on k^{th} observation and

δ X j = standard deviation of 'j' variable.

The First Principal component being a Linear combination of different original variables and explaining the largest Variance among the set of variables, the Correlation matrix of different variables with First Principal Component can be used to drop the relatively less important variables for construction of Composite Index. Coefficient of variance and Lorenz curve statistical methods applied for measuring the extent of inequality among region and social groups. Data source from Census of India 2001 and 2011, Statistical Abstract of Odisha National Sample Survey 66th round, Economic survey of Odisha 2012, District Handbook of Odisha have been applied in the study.

INEQUALITY IN ACCESS TO HOUSING AMENITIES

Housing and access basic amenities such as available of drinking water, toilet facilities and lighting facilities play a dominant role human capital development. These affect the level of social consumption in particular area. Distribution of social consumption influences inequalities in physical and human capital. Census 2001 and 2011 brings out clearly the trends and pattern in housing and amenities structure in India. Access to basic amenities and housing pattern in Odisha within a decade changes significantly and the variation within districts also changes .The growth rate of this above phenomenon is very less in Odisha as compared to national average. Census 2011 data shows 53.2% of the total census houses in India are comes under good condition whereas in Odisha its only 28.73%. More than 72% of total houses are either in livable or dilapidated condition. In 2001 census only four districts from coastal region (Khorda,Cuttack, Ganjam and Nayagarh) where more than 30% of total house was in a good condition and majority of house from southern and northern districts either livable or dilapidated. Coefficient of variation of district-wise total good houses in 2001 was 19.5 and it just increased to 22.3 in 2011. There is increase in inter district disparity in access to total good houses in Odisha. The access to tap water in odisha is only 13% which is very less as compared to the national average 43.5% in 2011. In 2001 census only khorda district where state capital Bhubaneswar situated more than 20% of household were using tap water but in 2011 census Cuttack, Ganjam, Gajapati in coastal area and Sambalpur in the northern part comes under the highest category of access to tap water (more than 20%). Most of the district in northern and southern remains in the least category in access to tap water in both time period. The housing amenities index constructed through getting the composite score from four major indictors such as access to electricity, access to tap water, latrine facility and good housing condition. Khorda in coastal part remains top in the index in both time periods whereas debgarh in northern part in the bottom. The highest composite score districts surrounding two nodes i.e. the state capital Bhubaneswar (coastal part) and the steel city Rourkela (northern part). All the districts in southern part remain in the least category in both census periods. Most of the districts in southern part remain D and E category in two census period.

The following map shows the district level variation in access to housing amenities in Odisha

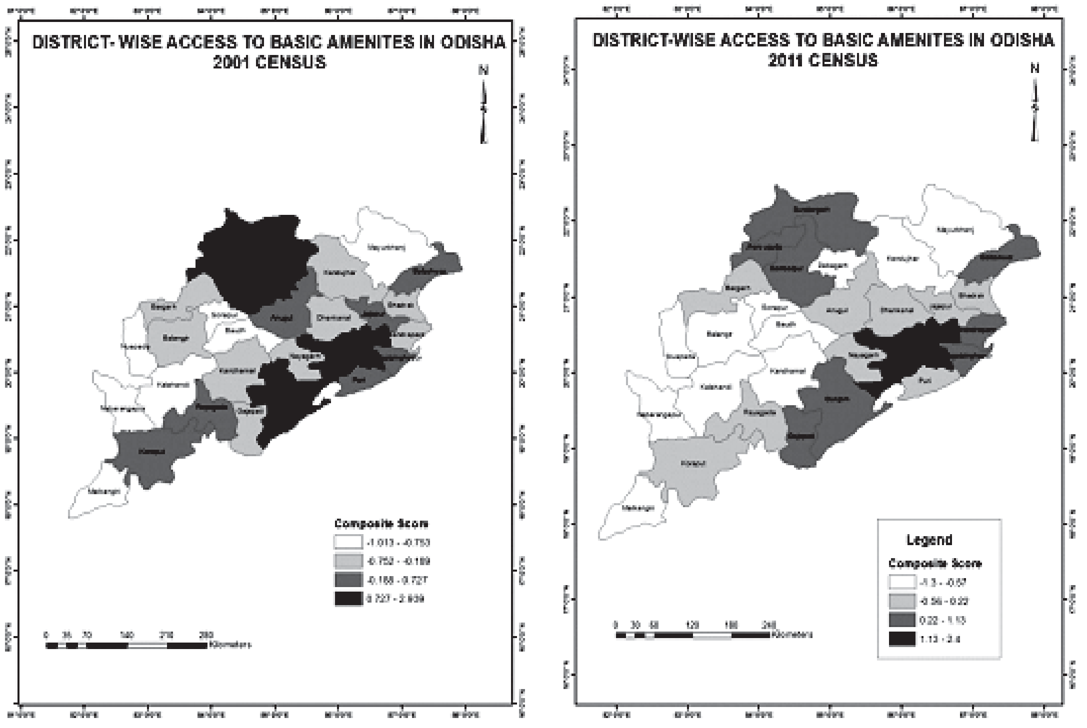


Fig. 1

Inter regional variation in the level of development in Odisha (2001-02 to 2011-12)

The position of districts on the basis of composite index of overall development obtained using composite indices of different sectors which has comprises 18 indicators from four major sectors of development. In all the above four major sector Orissa is lag behind the national average. An important problem related to the development Orissa as shown by the maps and table indicates a high level of unevenness in socio-economic development within the state. The fruits of development go to only specific region and a few sections of people whereas maximum sections remain in a much deteriorated condition. The disparities within regions increase over the time. These can be correlated from the following facts and analysis.

The highest Eigen value of Principal Component is 6.498 which explains 37% of variation of given eighteen variables in 2001 and the value increases to7.387, explains 42% variations of the indicators in 2011. The highly correlated Indicators in 2001-02 were literacy level, female agricultural wage rate, female literacy, male agricultual wage rate, retention rate and number of secondary school showing higher weightage where as in 2011-12 the higher weightage variables are child mortality rate, village electrification, banking facilities, literacy and secondary school per lakh population. In 2001-02 the weightage of infrastructure indicators are comparatively lower than 2011-12 PCA. In both cases the weightage of HDI and gender development indicators are high. The districts classified into four categories such as Developed, Medium developed, less developed and Very less developed and it assigned in alphabet as A, B, C, D on the basis of first Principal Component Analysis values and Average Range method according to their level of development in composite Development Indicators.

District-wise Composite Development score during 2001-02 as a follows

The composite score varies from 3.56 to -4.116

Category A (Developed Region): Khurda and Cuttack (2.32 to 3.56) both are Coastal districts.

Category B (Medium Developed Region): Puri, Kendrapara, Nayagarh, Deogarh, Jagatsingpur and Dhenkanal (1.151 to 2.32)

Category D: Malkangiri and Nabarangpur (-4.116 to -3.330), The rest 20 districts come under Category C, whose composite value varies from (-3.33 to 1.151) which includes all southern districts of Odisha.

District-wise Composite Development score during 2011-12 as follows

Category A : Khurda and Jagatsingpur (2.242 to 4.167)

Category B : Kendrapara, Balasore, Dhenkanal, Nayagarh, puri, Jharsuguda, Cuttack, Jajpur, Angul, Bhadrak, Sambalpur, Deogarh, Sundargarh and Ganjam (-0.481 to 2.242)

Category C : The composite value in between -2.602 and -0.481 comes under category 'C' The rest of the 12 districts of Orissa come under this category.

Category D : Malkangiri, and Nabarangpur (-3.018 to -2.602)

Table – 1

Principal Component Values in 2001 and 2011

PCA Value (2001-02)	*category*	*No of districts*	*PCA Value 2011-12*	*Category*	*No of districts*
2.32 to 3.56	A	2 (Coastal)	2.242 to 4.167	A	2 (Coastal)
1.15 to 2.31	B	6	-0.481 to 2.241	B	14
-3.33 to 1.14	C	20	-2.602 to -0.480	C	12
(-4.116 to -3.330)	D	2 (Southern)	-3.018 to -2.601	D	2 (Southern)

Level of overall development in Odisha (2001 and 2011)

It is seen from above table and map all the districts in the category 'A' and 'B' situated in the coastal region and very few in the northern region. All the districts in southern region are comes under category 'D' which is known as most backward in composite development. Malkangiri and Nabarangpur in the southern region remain at the bottom through the two time period. The spatial patterns in the distribution of composite scores evidently indicate that development process in the state is mainly

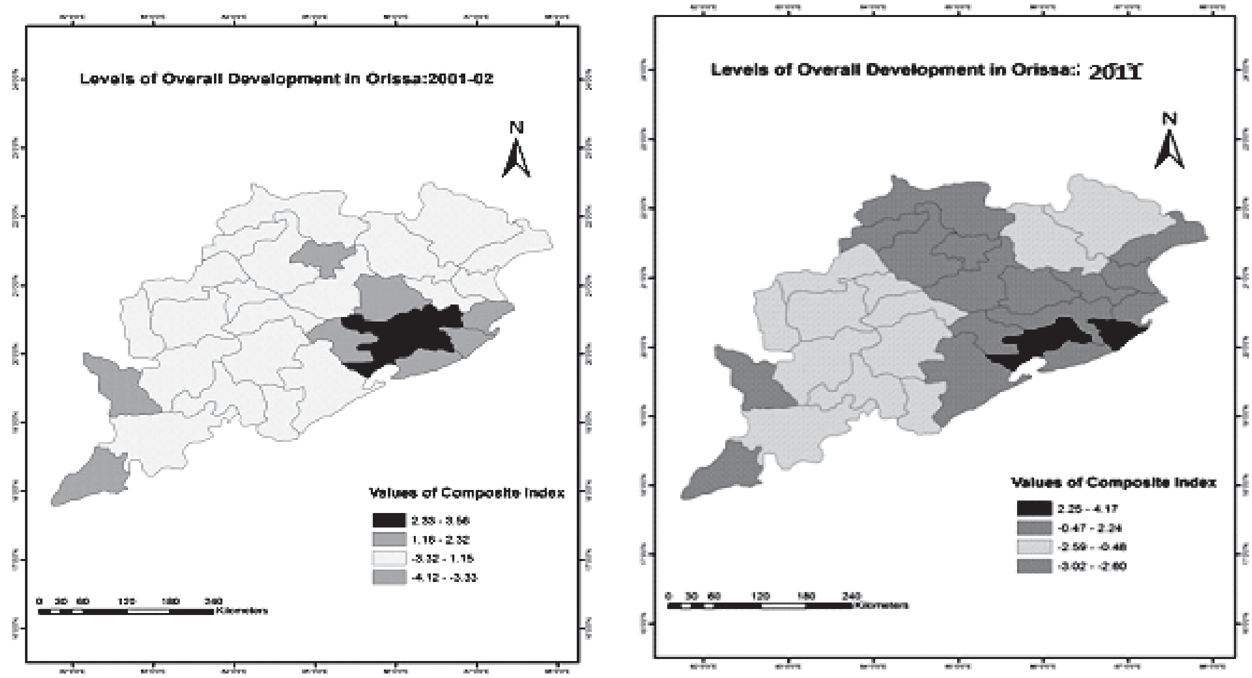


Fig. 2

concentrated around the coastal region and few in the northern region. All the districts from coastal region come under category 'A' in both periods. The composite score of northern districts in 2011-12 shows a better position in comparison to year 2001-02. The conditions of southern districts have worsened during this time period. Out of total 12 districts in southern region 11 remains at bottom list in 2001-02 and the same districts also at the bottom in 2011-12. The Coefficient of variance which was 27% in 2001, it increases 42% in 2011. It clearly shows the inter-regional inequality increases in a great extent over the period and highly uneven development pattern seen in Odisha. The southern region specifically very much lagged behind than other regions. The fruits of development basically confines to coastal and some parts of northern region of Odisha.

Regional disparities overlap with social disparities particularly related to social group identity. STs of Southern region are more than two time poor than coastal region. Both social and spatial disadvantage mutually reinforcing each other in the southern region. There is a big difference in HCR among ST, SC and OBC people among southern and coastal region but very little gap among other category. That clearly shows the lower caste people are more vulnerable in a geographical disadvantage area like southern part of Odisha.

Table 2

Socio-economic Inequality and Underdevelopment in Southern Odisha

Social Group	*Head Count Ratio (HCR) 66th round NSSO , Odisha*				*% Share of BPL Population*			
	Coastal	*Southern*	*Northern*	*Total*	*Coastal*	*Southern*	*Northern*	*Total*
ST	30.1	66.64	47.28	54.92	7.44	50.89	54.43	42.93
SC	28.43	41.94	32.43	34.07	38.14	22.23	21.23	25.24
OBC	8.57	24.11	19.31	16.88	18.48	21.60	18.37	19.89
OTHERS	15.32	16.87	19.00	16.13	35.95	5.28	5.97	11.94
Total	16.42	39.95	32.56	20.06	100	100	100	100

Source: NSSO 66th round

Total head count ratio declined in three regions from 61st NSSO round to 66th round. The HCR of other category people in southern region was nearly 30% but it was drastically declined to 16.8% in 66th round. Head Count Ratio of ST and SC in southern region decreases at a very slow rate. The HCR difference among other groups is very minimum in three regions in 66th round. The other category gets wealthier in southern region but in coastal part the conditions being worsen in 66th round. The condition of tribal

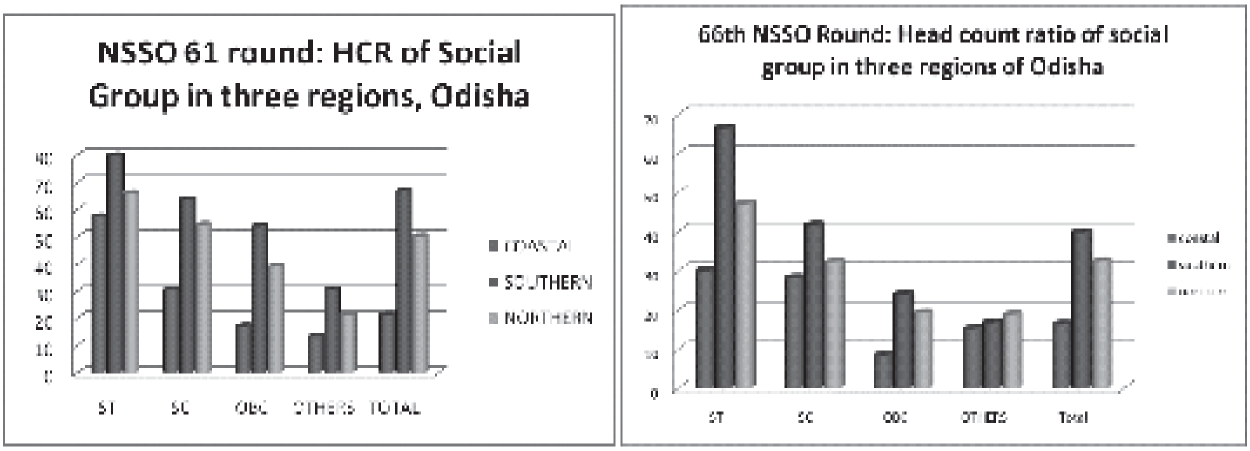


Fig. 3

and scheduled caste people not such changes over the time. This clearly shows the fruits of development confined to certain specific group i.e. general category in the southern region. Inequitable social structure, home of tribal groups, Cultural devaluation of groups and category, internalization of inferiority (belief, norms and value), Intergeneration transmission of poverty, high gender discrimination, Alcoholism, lack of social and cultural capital, Capture of local state by rentier elites, frequency of drought, Role of Zamindar, Gauntias, money lenders and traders, colonization by outsiders are some of the major causes of the destitute condition of the tribal and dalit of southern Odisha.

Table 3
Monthly average PCI and PCE (Rs)

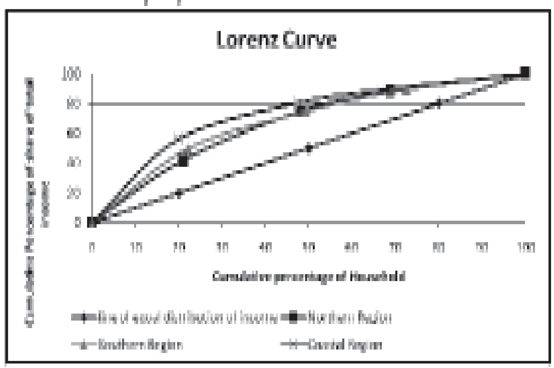
Average PCI and PCE(Rs)	*North*	*South*	*Coastal*
Avg. PCI	1846	1540	2622
Avg. PCE in basic need	850	605	1055
PCE in Education	185	98	262
PCE in Health	78	46	108
PCE in durable goods & saving	200	188	264
PCE in energy	116	136	116
PCE in tobacco & alcohol	53	135	105
PCE in luxury & ceremony	132	104	257

Primary Survey (Author 2014) *PCI – Per Capita Income, *PCE- Per Capita Expenditure

The above table shows the variation in income and expenditure among the three regions of Odisha. The PCI of Coastal region is more than half as compared to southern region of Odisha. Per capita expenditure on education and health in coastal region is nearly three times of southern region. The negative expenditure like tobacco and alcohol is high in southern region. There is a high correlation of consumption of alcohol and tobacco with the poverty and illiteracy. The high expenditure on energy in southern region is due to government banning the NTFP(Non Timber Forest Product).

The Lorenz curve is a graphical device used to represent distributional inequality. The horizontal axis measure the cumulative percentage of household and along the vertical axis measures the cumulative percentage of wealth. The more bowed the coastal region next to southern and northern region from the line of equal distribution. Top 20% household in

Inequality in Income distribution



Source Primary data collected by Author 2014

Fig. 4

coastal region hold 56% of total wealth, in northern region 40% and in southern 45%. The Coastal region is more prosperous than other two regions but the wealth distribution among the households is very unequal as compared to other region. The northern region show less unequal distribution as compared to other region.

CONCLUSION

It is generally argued that development initially leads to widening of the inter-regional inequalities in the economy. The gap between the development and underdevelopment region tends to narrow down in the later stage of development. But how far this theory satisfies in case of Orissa? It has been seen that the regional disparity and inequalities growing over time period. Evidence have shown regional inequalities based on district level data on select indicators that the widening gap between districts after 1990s owes much to worsened. The development concentrated in the node Khurda,Cuttack and its periphery in coastal region and another node situated in northern part of upland plateau i.e,Samalpur, Jharsuguda and Sundargarh. The southern region is very much lag behind in the composite development as compared to coastal and northern region. Inequalities in terms distribution of income and expenditure is highly prevalent among the region. The fruits of development cannot reach the periphery areas which remains deprived in every respect. Regional inequality intersects social inequality and spatial deprivation in Southern region. This is one of the measure cause of creating regionalism (Demand of Koshala state comprising southern districts and some northern part).The plans should include adequate programmes of human resource development with economic growth in backward areas to converge disparities. There is a tendency of centralisation in the capitalist system. To address the issues of concern such as poverty, inequality and social exclusion in southern region what is needed is the effective implementation and monitoring of macroeconomic policies and sectoral policies. To achieve higher standard of human and social capital a multi-pronged approach is necessary. This approach must comprise the indigenous knowledge system (IKS) of the local tribals (or other subalterns) should be properly studied before make plan and policy, improvement of traditional technology, faster development of social sector; promote community participation, bottom up approach of development and continuous and proper monitoring system. The development approach need special attention to the depressed region and marginalised section. Let me conclude with a Chinese saying " if you give a poor man a fish, his immediate problem of hunger may be satisfied, but if you teach him fishing he will be a micro entrepreneur and get out of poverty permanently in long run.

REFERENCES

1. Abdi. H., & Williams, L.J. *(2010), 'Principal Component Analysis', Wiley Interdisciplinary Reviews, Computational Statistics* Vol**2**: *pp433–459*
2. Curie, Bob (2000): *The Politics of Hunger in India*, Macmillan Press, Chennai.
3. Dash, Satya P. (2007), 'Development and Poverty in Indian state: A study of KBK districts of Odisha',*Social Change*, Vol. 37, No.2, pp. 76-98.
4. Diwakar, D.M. (2009): "Intra-Regional Disparities, Inequality and Poverty in Uttar Pradesh", *Economic and Political Weekly*, Vol. XLVI, No.26, pp.264-273.
5. Dholakia. Ravindra H. (2003b): "Regional Disparity in Economic and Human Development in 324 India", *Economic and Political Weekly*, Vo1.18, No.39, September 27, pp.4l66-4172.
6. Dreze, J. and Amartya Sen (ed.) (1997): *Indian Development: Selected Regional Perspectives,* Oxford University Press, New Delhi.
7. Friedman J. and Alonso W. (1975): *Regional Policy: Beadings in Theory and Applications*, MIT press, Cambridge
8. Haan, A. and Dubey A. (2005) Poverty, Disparities, or the Development of Underdevelopment in Orissa*, Economic and Political Weekly*, May 28-June 4, pp. 2321- 2329.
9. Hirschman, Albert. O (1961), *The Strategy of Economic Development*, Yale University Press, New Haven.
10. Kumar, S. (2001) "Adivasis of South Orissa: Enduring Poverty", *Economic and Political Weekly*, Vol. 36, No. 43, pp. 4052-4054.
11. Kurian, N. J. (2000), 'Widening Regional Disparities in India: Some Indicators', Economic and Political Weekly, 35(7): 538-550.
12. Mishra, Deepak and R.S.Rao (1992): 'Hunger in Kalahandi: Blinkered Understanding', *Economic and Political Weekly*, Vol. 27, No. 24-25, pp. 1245-46.
13. Myrdal, G (1957)**:** *Economic Theory and Underdeveloped Regions* (London: Duckworth).
14. Nath, V. (1970): ' Regional Development in Indian Planning' *Economic and Political Weekly*. Annual Number. January. pp. 247-259.
15. Panda, T. (2003), 'Sustainable Change through Transfer Technology and Produce Marketing-A Case Study of Dongriya Kondh of Odisha', *Social Channge*, Vol. 33, No.1, pp. 55-66.
16. Paul, S and Sridhar K. (2015): *The Paradox of India's North South Divide- Lessons from the States and Regions*, Sage Publications India Pvt Ltd, New Delhi.
17. Patnaik, Utsa (2007): *The Republic of Hunger and Other Essays*, Three Collective Essays, Gurgaon.
18. Perloff H. S. et al (1960), Regions, Resources and Economic Growth, John Hopkins Press, Baltimore
19. Perroux F. (1950), *Economic Space: Theory and Application, in Friedman and Alonso* (eds.) 1964, Regional Development and Planning: A Reader, MIT Press, Cambridge, Mass
20. Pradhan et al (2000): "Rural-Urban Disparities- Income D akistribution, Expenditure Pattern and

Social Sector", *Economic and Political Weekly*, Vol. 35, No. 28/29, pp. 2527-2539.

21. Rao H, (1984): '*Regional Disparities and Development in India*' Ashish Publishimg House, New Delhi-26.
22. Scott, Allen J. (2006): *Geography and Economy*, Oxford University Press, New York.
23. Sen, A., (1973) "Poverty, Inequality and Unemployment: Some Conceptual Issues in Measurement", *Economic and Political Weekly*, Vol. 8, No. 33/33, pp 1457-1464.
24. Devi, S.(1996): 'Regional Inequalities in Education Orissa', *Indian Journal of Regional Science*, xxvm (2), 11-24.

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Historical Cartography, Web Maps and Atlases

DISCOVERING THE GLOBE: THE JOURNEY OF MAP-MAKING IN A DYNAMIC WORLD

Bidisha CHATTOPADHYAY[1], Twisha SINGH[2], Anuradha BANERJEE[3]

ABSTRACT

The science and art of map making involves the conversion of a three-dimensional earth into a two-dimensional paper analogue. Mapping is a science as well as an art since it involves portrayal of real earth features through symbolisation. Maps measure distances, provides direction and depict natural and political boundarieswith reasonable accuracies. The history of mapmaking is a long tale spanning the lanes of human history of almost 8000 years. The present paper is an endeavour to trace the rudiments of this cartographic exercise and its development across people and places.

Keywords: *Three-Dimensional, Paper Analogue, Symbolisation, Cartographic, Accuracy.*

INTRODUCTION

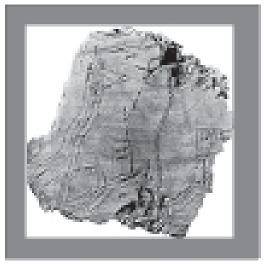
Maps historically have evolved as graphical two-dimensional representations of three-dimensional earth. Throughout human history, man has been interested in learning about the earth inhabited by him and also locating himself vis-a-vis other objects. This laid the foundations of cartography. The developments in the art and science of cartography can be however contributed to technological developments throughout human history. With each paradigm shift newer methods have been discovered, deciphered and implemented for the creation of more accurate maps that justify human aspirations and needs. Thus, cartography has evolved through ages and with ever increasing human knowledge has transcended to new heights under contemporary developments in science and technology.

OBJECTIVES

Throughout human history man has tried to position himself vis-à-vis earth and heavenly objects and features. This has resulted in discovering the real earth form. The history of cartography therefore is coincident with the discovery of the earth form. It also entails the discovery of people and places, new instruments of surveying and representing the collected data. With the progress of civilisation, science and technology has developed and this is associated with the paradigm shifts in data acquisition and mapping. The aim of the present paper is to undertake this traverse of discovery of the globle through the history of map making. In this process an affort has been placed to re-write the history of cartography in the world and then to focus on India's developments in this discipline.

THE EARLY DEVELOPMENTS

The earliest known evidences of mapping through plans or charts had been discovered in the cave paintings that depicted either landscape features, the night sky or even Neolithic villages. However, these exercises also involved basic surveying as in the ancient Babylonian representation on tablets. Similar representations in archaeological remains can be seen in the Egyptian paintings in the early tombs. A tablet excavated in Iraq (1000 BCE) represents a disk shaped earth with Babylon as its centre, surrounded by water on all sides was perhaps the first attempt to portray the form and extent of the world in totality. Apart from this, most of the earliest efforts had arisen out



Babylonian Clay Tablet portraying the city of NIPPUR (ca 1400 BC)

Babylonian Clay Tablet Map showing Babylon in the Centre with the river Euphrates, mountains and surrounding oceans.

of the practical needs i.e. for the establishment of boundaries.

The first formal attempts of representing the "earth form" can be seen in the works pertaining to the Greek civilisation. Eratosthenes, already in the 3rd century BC, contributed greatly to the history of geographic knowledge with his Geography and accompanying World Map. Unfortunately we only have indirect references to this work through other authors like Strabo and Elea, whose work is far better known in our time. Though Hecataeus postulated the concept of the Earth as a flat disk, Herodotus and his followers were suggestive of a number of other

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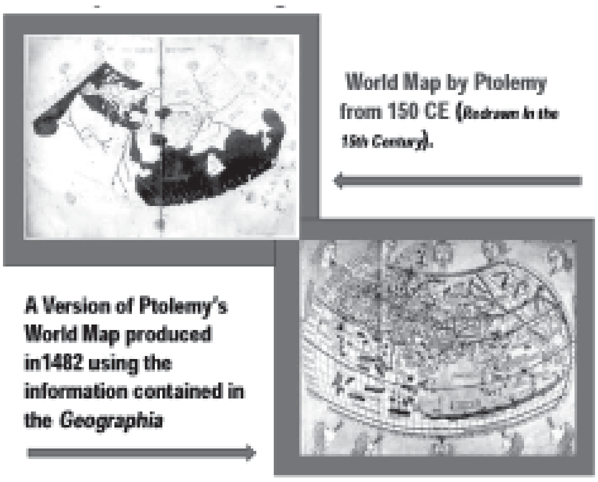


possible forms. Modern scholars propose the first hypothesis of a spherical earth to Pythagoras (6th Century BC) or Parmenides (5th Century). But it is now generally understood that the concept of the spherical earth developed as a general consensus over several years. However, the greatest advancement in cartography i.e. map projection and globe construction can be seen in the work of Claudius Ptolemaeus or Ptolemy that elevated the discipline to new heights.

These advancements in ancient cartography went into oblivion in the middle ages and some of the earlier evidences were also lost; making historical reconstruction rather difficult. During Europe's Dark Ages, Islamic and Chinese map-making made considerable progress. These efforts can be clearly seen in the world map constructed by Muhammad Al-ídrisi (1154) and in the Chinese maps during 1137. Revival of Ptolemy's attempt can be seen again in the age of discovery and explorations concomitant to the developments in navigation, instruments for observations, compass and astronomy.

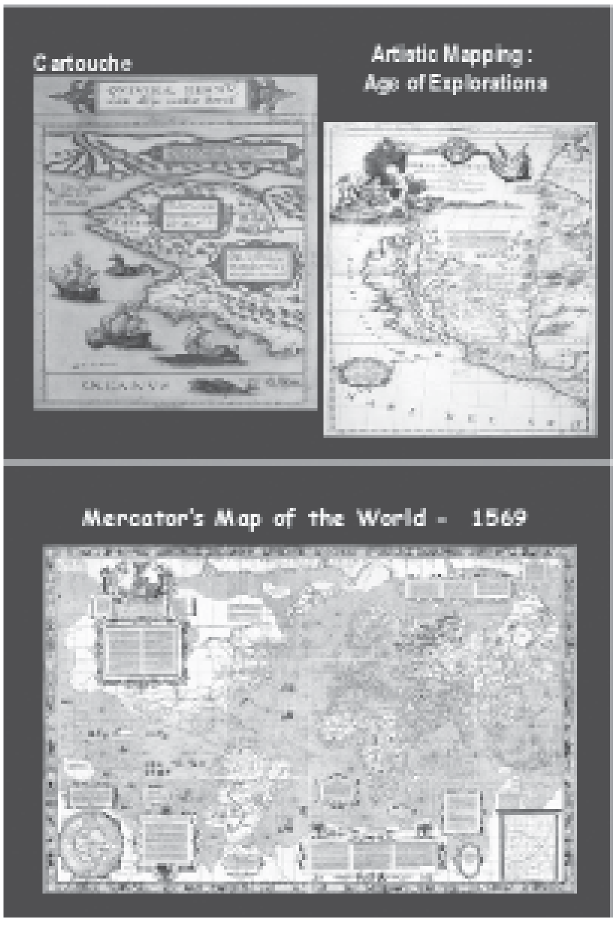
"Tabula Rogeriana by Al Idrisi, isn't just a map of the world- it's an extensively researched geographical text that covers natural features, ethnic and cultural groups, socioeconomic features, and other characteristics of every area he mapped. This work was created for King Roger II of Sicily. Al Idrisi drew upon his own extensive travels, interviews with explorers, and draftsmen paid to travel and map their routes in order to create the maps in the Tabula Rogeriana. These maps describe the world as a sphere, and break it up into seventy different rectangular sections, each of which is discussed in exacting detail in the remainder of the Tabula".

Thus the 15th and the 16th centuries saw the foundations of modern day cartography through the attempts of navigation exercises undertaken by Columbus, Vasco da Gama, Vespucci, Cabot, Magellan and others.

THE AGE OF EXPLORATIONS

Geographic knowledge increased enormously during the age of explorations. The need for navigation, designing and construction of ships, developments in astronomy and instruments in observation and set the arena for the creation of the newer maps much more accurate than the earlier ones. The post medieval maps were highly artistic representation of the world and incorporated effectively the artist's imagination. "The cartouche or the title block became more elaborate amounting to a small work of art. Works of this period have great artistic value. *"The first map printings were made from woodcuts. Later they were engraved on copper, a process that made it possible to reproduce much finer lines. The finished plates were inked and wiped, leaving ink in the cut lines. Dampened paper was then pressed on the plate and into the engraved line work, resulting in very fine impressions. The process remained the basis of fine map reproduction until the comparatively recent advent of photolithography". (Encyclopaedia Britannica)*

However, the most renowned cartographer in the age of explorations was Gerhard Kremer or Gerardus Mercator whose Mercator map was the first attempt

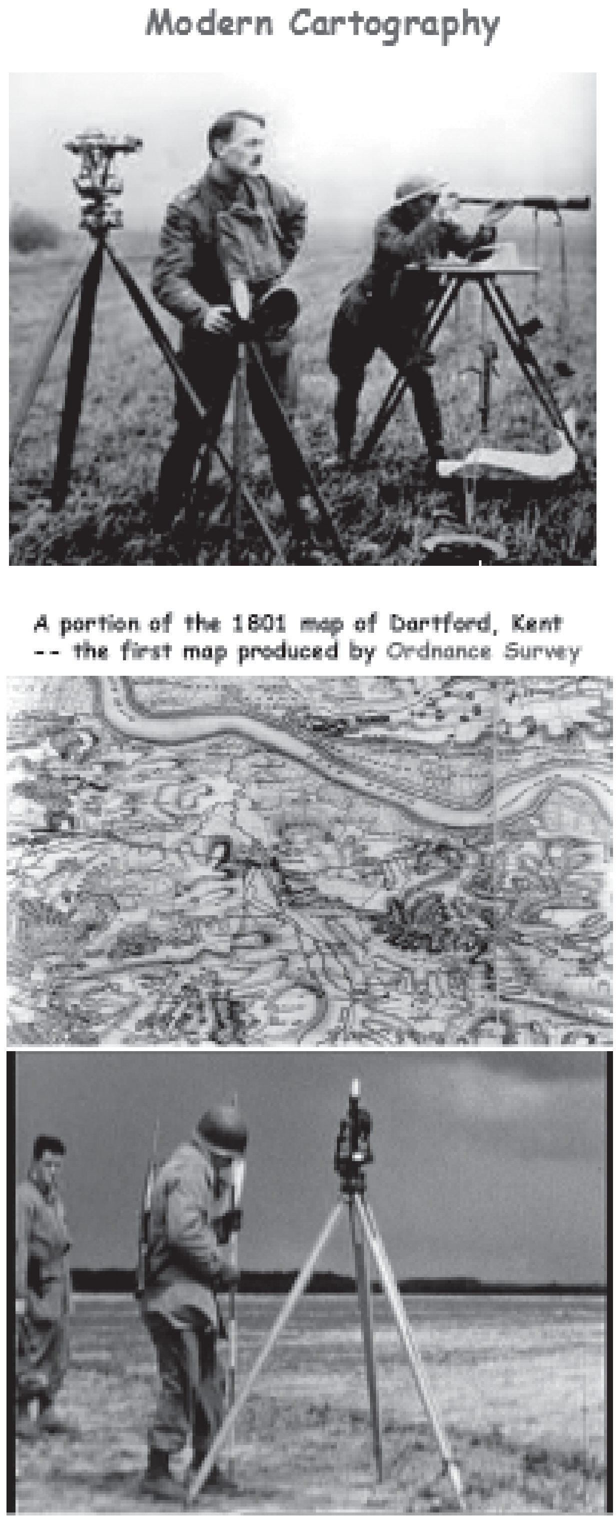


to make a round earth look "right" on a flat surface. Representing a spherical shape on a flat plane often invites various distortions. Lines of latitude and longitude, useful for navigating, become warped and useless on a flat map. Mercator sought to account for this by keeping the lines straight, and distorting the size of objects closest to the poles. The result was the famous Mercator Projection, an invaluable tool for navigation at sea. The Mercator Projection allowed for straight lines, called loxodromes, making easier for navigators to use maps to chart a course, despite the trade-off of distortion. Mercator also became a designer of globes and maps. Other notable cartographers of that period are Abraham Ortelius, who prepared the first Modern Atlas in 1570 and Jadocus Hondius. They represented the Dutch-Flemish School of Cartography.

Cartography again went through a paradigm shift during the 18th Century marked by more accuracy due to scientific development. Monsters, lions, and swash lines disappeared and were replaced by more factual content. The map interiors contained all the increasing information available, often with explanatory notes. Map-making now transcended the attempts based on reports of travellers and explorers to scientific expositions. French Cartographers undertook expensive ventures, such as the triangulation of two degrees of a meridian to determine the Earth's size more accurately. This New Cartography, more scientific than earlier, was based on better instruments like the telescope and the chronometer.

Modern Cartography

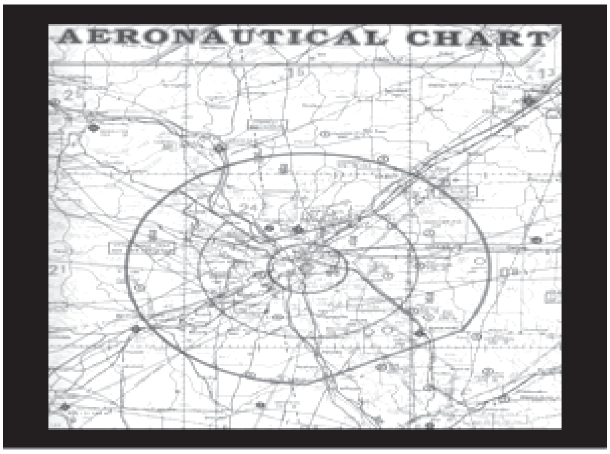
Soon the world saw another landmark in the advancement of Cartography with the rise of the National Surveys in many nation states that were systematic efforts of mapping territories and topographies. Originally exclusively military, the National Surveys later became civilian in character. The Ordnance Survey of Britain, the Institut Geographique National of France, Landestopographie of Switzerland and civilian ones such as US Geological Survey and National Ocean Survey/Service etc are some examples. Due to evolution of Great Britain as the leading maritime power of Europe, other nations accepted Britain's proposal that the Prime Meridian for longitude reference should pass through Greenwich. Edmund Halley's Magnetic Chart was also another achievement in early oceanography. However, elaborate national surveys were undertaken only in certain countries and had a Eurocentric focus. The rest of the world remained largely unmapped until the World War II. The International Geographical Congress 1891 proposed the International Map of the World (IMW) on a 1: 1,000,000 scale. World War I and to a greater extent

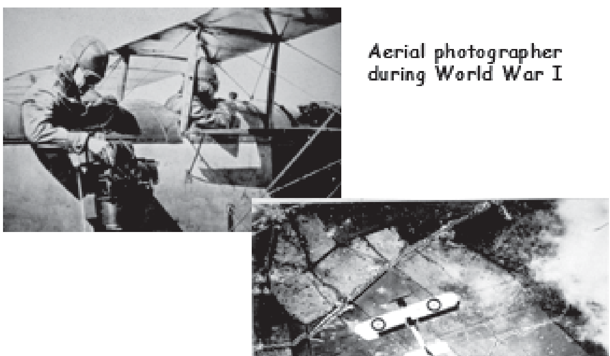


World War II brought a milestone in mapping; as exercises were started also for the unmapped areas of the world. A major programme of aerial photography and reconnaissance mapping, employing the trimetrogen method was developed. World aeronautical charts were also prepared.

The 50's and the 60's Cold War promoted military oriented mapping and both NATO and the Warsaw

Stielers Handetlas (after Adolf Stieler, (1775-1836), was the leading German world atlas of the last three decades of the 19th and the first half of the 20th century.

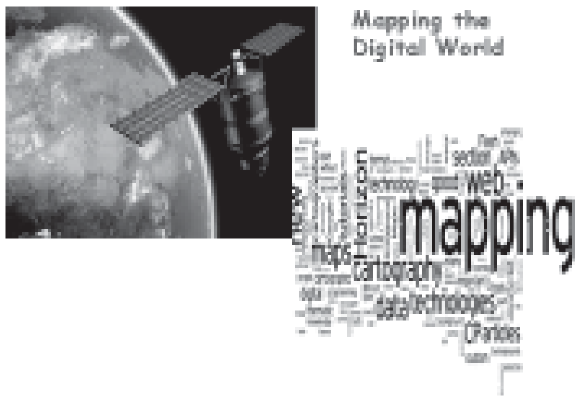




Pact countries continued to improve their mapping exercises. The United Nations also contributed to mapping post Second World War. Increased instrumentation and surveying equipments like electronic-distance measuring equipments and transit theodolites resulted in greater accuracy and together with computers and automation transformed the map-making exercise. Modern Cartography thus evolved as a combination of ground observations and surveys and remotely sensed data sources.

Mapping the Digital World

Revolutions in information and technology led to a paradigm shift in cartography, that transcended the map-making business from paper analogues to digital and virtual realms. GIS and Remote Sensing became the principles of such endeavours. Multiplicity of data sources and in particular digital data has resulted in the generation of Metadata, involving processes of data mining. The scope of Photogrammetry was also enlarged to employ high-speed imaging and remote



sensing in order to detect, measure and record complex 2-D and 3-D motion fields. Increasingly geospatial data and mapping applications are being made available via the World Wide Web. Open Source GIS programmes based on different base programming languages (C" languages, Java, and NET) have become the order of the day. Cloud computing or on-demand computing is based on the internet where shared information and resources are provided to computers and other devices. The aim is to maximise the effectiveness of the shared resources. Thus ever changing technologies have always placed a considerable impact on Cartography and in that sense this discipline has become increasingly technology driven. The new technology has enabled the production and usage of huge amounts of data, multiple partners and the best possible usage of the digital platforms for automation and cartographic visualisation. The transformations have resulted in the evolution of neo-cartography, i.e the most recent trends in the history of map-making in the world.

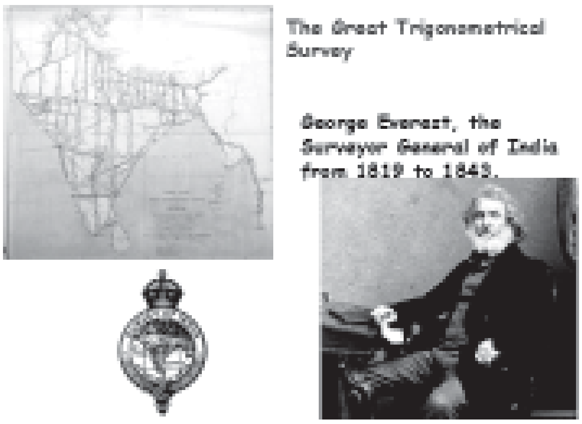
According to the Neo-cartography Commission of the International Cartographic Association (ICA) "many examples of new and innovative mapping are being produced outside the normal orbit of existing cartographers or map producers. The term neo-cartographers is being used to describe map makers who may not have come from traditional mapping backgrounds, and are frequently using open data and open source mapping tools. Another difference is in the blurring of boundaries between map producers and map consumers. The availability of data and tools allows neo-cartographers to make their own maps, *show what they want, and often be the intended audience as well – that is to say they may make the maps for themselves, just because they can. There is a real need for a discipline to be established to study this essentially undisciplined field of neo-cartography."*

India's Journey

India's development of modern Cartography also has a rich heritage. Historical evidences point out the elementary efforts to the ancient and medieval periods; though organised development of Indian Cartography took place during the British colonialism. Arising out of the British interest of conquests and domination of the people of India, the

colonial maps were largely aimed to foster British interest in India. Nonetheless, it did result in the production of more accurate maps through the introduction of scientific instrumentation.

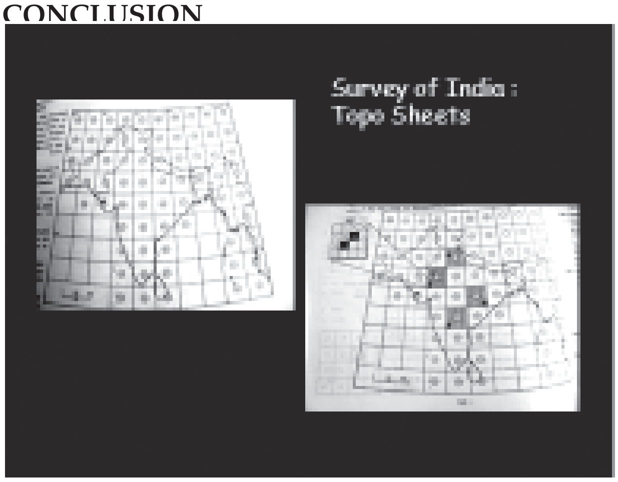
The Great Trigonometrical Survey and the great obsession of accuracy by Everest are some of the examples. The British period also saw the establishment of The Survey of India in 1767 that has

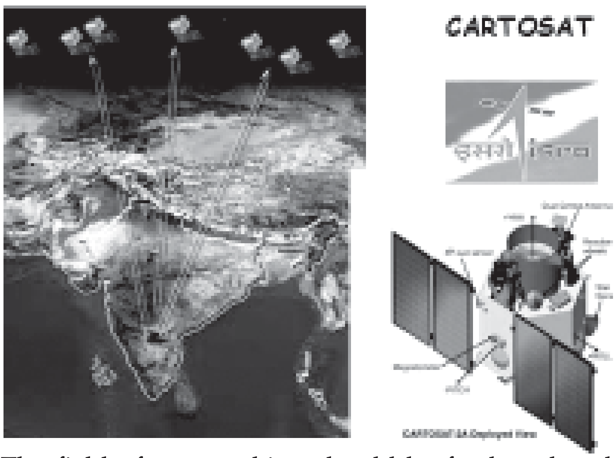


flowered s the Nation's premier mapping agency over several decades.

Topographical sheets of the SOI are greatly popular among researchers and students in particular. Another organisation whose contribution in this field should not go unrecognised is the Geological Survey of India (1851). After independence, The National Atlas of India (later renamed as the National Atlas and Thematic mapping Organisation) was born in 1954 under the auspices of Prof. S.P.Chatterjee. The organisation excellently portrays a rich legacy of map-making on various themes and the incorporation of changing technologies under several luminaries who had served the organisation as Directors. Today, we find several government and non-government agencies engaged in map-making in India; and the list is enormous. DST, ISRO, NRSC, SACs, NHO, and other organisations have elevated the discipline in the Indian context by giving it a rich methodological, technological and thematic content.

CONCLUSION





The field of map-making should be furthered and endeavours should be placed in popularising Cartography. This can be done by encouraging everyone not only in making maps but to promote this discipline further, by increasing collaboration between academia, professionals and industrialists. Furthermore, maps generated, should be user friendly so as to also benefit the common man. A holistic approach is needed for popularising Cartography and extending its professionalism on one hand and on the other to encourage its usage among people for furthering national life with the ultimate aim of human development.

REFERENCES

1. Barrow Ian J. (2003): *Making History, Drawing Territory: British Mapping in India, c.1756-1905,* Oxford University Press, India, ISBN-10: 0195665465, pp. 225.
2. Markham Clement R. (1871): *A Memoir on Indian Surveys* W.H. Allen and Company, London.
3. Mukherji Chandra (1983): *From Graven Images: Patterns of Modern Materialism,* Cambridge University Press, New York.
4. Nag Prithvish (2016): *Indian Geospatial Infrastructure,* Bharati Prakashan Varanasi, ISBN -978-93-80550-83-1, pp. 220
5. Nag Prithvish (2003): "*The Great Arc*"; Department of Science and Technology, Government of India, New Delhi.

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MAPPING GOVERNMENTALITY OF COLONIAL SPACES IN INDIA

Gloria KUZUR[1] & Swagata BASU[2]

ABSTRACT

Maps represent history. Historical Cartography in India has been used to meet diverse motives of empire building (colonialist ideology) and nation building (nationalist ideology) (Edney, 1999). Colonial cartographic investigations look into the rationalities of three significant questions viz. who is mapping, who is being mapped, and what purposes are served by the cartographic projects (Sarkar, 2012). Colonial cartography is understood as part of the process of appropriation, reconfiguration and modification of colonial spaces rather than a purely technical project (Thompson, 2012).

The Colonial Power has almost always resorted to governmental rationalities to exclude, racialize, and pathologize the subject population. Colonial cities in India were mostly developed under the 'garden city' concept aimed at segregation of the colonizers from the native population. While colonial towns acted as disciplinary institutions (e.g., military cantonments, schools, hospitals, asylums), they were also assigned as means of surveillance (e.g., hill station towns acting as panoptic). The case of Delhi bears testimony to the organization, re-organization and representation of space used as a central mechanism of exclusion and control (Legg, 2007). While the motive and patterns of segregation remains consistent in all Colonial settlements; it is interesting to classify urban spaces in categories assigned by the colonizers and draw out the physical and cultural landscapes that were produced from the segregation processes as well as question of access to goods and services of the settlement concerned. The paper attempts to explore aspects of Historical Cartography which was used as a tool for creation and appropriation of spaces in India by the Colonial power. The different strategies of colonial domination and control would be analyzed with the help of Foucauldian concepts of 'governmentality'; 'power over subjects' (techniques of power and their effects upon subjects) and as reorganization of spaces as panopticons for surveillance over native population.

Methodology: Colonial towns of India have been selected as the subjects of colonial domains of power. The strategies of 'authoritarian governmentality' adopted by the colonizers have been studied in terms of the pattern of colonial spaces created in the colonial towns as the units of analysis. The categories of colonial towns undertaken for the analysis are Cantonment towns, Administration towns, Hill stations, Port towns (trading towns) in India which were assigned with special functions of ordering, grading, excluding, dominating and appropriating the colonial system in India. The various patterns of colonial spaces would be analyzed cartographically using archival documents and historical maps.

Keywords: *Colonial Spaces, Governmentality, Colonial Towns, Colonial Cartography*

INTRODUCTION

Differentiated Landscapes of Empire : Boundaries as Imperial Mechanism of Control

Imperial Space used boundaries as a mechanism to convert abstract space into concrete reality of territory. (Kalpagam,2014) The colonial project of knowledge production is replete with inherent biases that have in the later period been well acknowledged and documented by scholars. The creation of the colonial archive was a part of the project of conquest, rule and administration of the Indian Empire.

Cartographic knowledge and modern cartographic representation too is at the heart of the project. Surveying and mapping fixed boundaries and located persons and objects in space. On large scale maps, Rennel's Bengal Atlas and Map of Hindoostan set the stage for modern mapping techniques and later mapping for the purpose of revenue collection made mapping an integral part of the colonial porject of expansion and domination of places and people.

The discursive activity of 'mapping space' is a fundamental prerequisite to the structuring of any kind of knowledge. All talk about 'situatedness', 'location' and 'positionality' is meaningless without a mapping of the space in which those situations, locales and positions occur. And this is equally true no matter whether the space being mapped is metaphorical or real. (Harvey, 1996)

Maps represent history. Historical Cartography in India has been used to meet diverse motives of empire building (colonialist ideology) and nation building (nationalist ideology) (Edney, 1999). Colonial cartographic investigations look into the rationalities

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of three significant questions viz. who is mapping, who is being mapped, and what purposes are served by the cartographic projects (Sarkar, 2012). Colonial cartography is understood as part of the process of appropriation, reconfiguration and modification of colonial spaces rather than a purely technical project (Thompson, 2012).

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Drawing from Governmentality Studies, Foucault (1991) noted the transition of the nation from a "territorial state" to a "population state". Since Population occupy up spaces/ territories and territories as containers of population are thus spaces that need to be demarcated[1].

Mapping as a tool of Colonial Gaze to administer power and control over the colonial subjects. Colonial motives of mapping have been articulated by different scholars. The process of mapping the city spaces came as a later engagement.

Masselos (2014) categorised the colonial urban centres based on their functions which were further studied through the unfolding of the historical processes that these centres underwent as the transition process from company towns, cantonments to capital cities and towns created to cater to recreationary activities of the colonisers by recreating landscapes and spaces similar to their homeland as found in the hill stations of India. Kidwai (2005) with the help of demographic indicators indicate towards urban atrophy in India during the colonial period. Colonial urbanisation may be viewed as an extension of the stes of dominance and dependence of the metropolitan economy.

Reeta Grewal (2005) in her analysis of colonial towns of Punjab, found three distinct categories in terms of layout. Indigenous towns usually walled within gates where roads were widened by the British, and anglicised colonies cropped up next to the railway stations. Cantonment towns had green belts separating the 'unhealthy, noisy and distasteful parts of the towns. The colony towns were usually colonies if rectangles of canal colonies, mandis, with suburbs parks and gardens but did not have cantonments.

Masselos (2014) categorised the colonial urban centres based on their functions which were further studied through the unfolding of the historical processes that these centres underwent as the transition process from company towns, cantonments to capital cities and towns created to cater to recreationary activities of the colonisers by recreating landscapes and spaces similar to their homeland as found in the hill stations of India. Company towns were established in 1600 with the permission from the Mughal emperor Jahangir, for trading and establishing factories, warehouses by the East India Company. Calcutta was selected by Job Charnok, on the banks of River Hoogly in 1690, Madras was established between 1639 and 1640 through a land grant by the ruling Nayakas, Bombay came as a gift to the Charles II as a dowry for marrying Catherine of Portugal. Cartographic prudence was at the heart of choosing the company towns located at strategic harbours and waterways which elicited the access to the hinterland form these locations while facilitating transfer of goods to the metropole. Masselos then focuses on the next phase of town building by the British through establishing the capital cities with their functions enhanced and diversified beyond trading and moving towards disciplining population and ruling over them. 1780 onwards saw the transformation of Calcutta as a monumental imperial city; with the dual functions of creating a visible spectacle to the native population while it served as a similar landscape of Neo Classical Victorian replica of London, complete with large park-maidan; tank square-Dalhousie; St John's in the lines of St Gibb's and the spectacular Victoria Memorial. The Capital shifted to Shimla for six months a year since 1864 in order to escape the hot sultry climate in favour of salubrious mountain climes. Images of the British lifestyle in Shimla became symbols of aloofiness, arrogance, remoteness and wastefulness of the British Rule often referred to as 'government by picnic'. Similar landscapes were carved in Mahabaleshwar, Othacamund, Mt Abu, Nainital and Darjeeling.

Burton (2001) considers exploring newer sources of doing historical analysis of the and the impact of the present in writing about the past. Burton's new Imperial History questions the flow from the core to the periphery and points out that colonies too had a role in the way the metropole appeared rather than the other way round. Drawing from literary studies, anthropology and geography; geography according to her was the most influential in the long run for the response to spatial ways of thinking and interpreting. Through historian's borrowing from geographer's vocabulary and geographer's attention to histories of spaces and places; academicians have ended up with maps and webs and networks not only in descriptive terms but as the basis for methodological and prescriptive theories of empires as well. Maps and city built environments; segregation of population and limited access to spaces within settlements enhance the role of spectacle in shaping domestic apprehensions of imperial citizenship.

OBJECTIVES

The paper attempts to explore aspects of historical cartography which was used as a tool for creation, appropriation and segregation of spaces in India by the Colonial power.

DATABASE AND METHODOLOGY

Maps of 10 towns were selected for the study from The Imperial Gazetteer of India Atlas1931.

The characteristics of the town maps were looked through the 'colonial lens' to examine the spatial techniques of colonial governance in India during the 1930s.

The different strategies of colonial domination and control would be analyzed with the help of Foucauldian concepts of 'governmentality'; 'power over subjects' (techniques of power and their effects upon subjects) and as reorganization of spaces as panopticons for surveillance over native population.

DISCUSSIONS AND ANALYSIS

The towns selected for the study were :

Spatial Techniques of Colonial Governance in India

Colonial towns in India may be grouped into the following categories[2]:

1. Port towns
2. Cantonment towns: permanent military bases
3. Hill station towns
4. Up gradation of towns to Colonial Capitals

Each of these towns had a distinctive morphology akin to the kind of function the town had been serving. The following section delves into the characteristic features of the different categories of Colonial towns.

Colonial Port Towns of India: Techniques of Spatial Occupancy, Dominance and Control

Port town were first urban centers that were developed by the British. These were the spaces that they first lay their foot on, and with time delineated their private, exclusive spaces. The urban space was encrypted with names and landscapes of the land of their origin, while the native population too was allocated space in the vicinity for the services the native populations were expected to provide. The Colonial port towns had typical boundary lines that separated the forts (defence), cantonments, civil lines. They also had provision for Open Spaces or Esplanade or Maidan and that zone also doubled up as the zone of separation for unobstructed exchange of gunfire.

Symbolic significance/ Importance of Symbology: Indexing of maps, Colonial Street names this began getting inscribed on our maps. Apart from the morphology of the town, the town's location, the toponymic inscriptions on the maps made ruling over the colony so much simplifies. The native subjects lost their cot only control of the spaces that were erstwhile theirs but also on the names of those places, alienating them further and obliterating any opportunity to claim their stake over the colonized spaces.

The British laid emphasis on the water front (river and sea), roads and railways for accessibility and defense purposes of the urban spaces.

The model of a Colonial Port City in India would typically grow around a fort located adjacent to the commercial waterfront. The Fort area would be girdled by the open ground of the Espanade or Maidan. Adjacent to the Maidan, the Original European Suburbs, the western type shopping district, Government and Public Buildings, Western type Central Business District. Beyond these land use zones the mixed residential and commercial Indian Bazaar would be located. The slums housing laboring classes would be located further away dovetailed with the industrial suburb, which would provide the basis for the trading activities of the British. The agricultural villages for food supply and the Military Cantonments were located away from the town zone. Colonial port towns were the spaces of colonial economic and military power.

This paper looks into the maps of Madras, Calcutta and Bombay have been analyzed to explore the spatial model that the colonial port towns were based on.

The first phase of the growth of these towns saw the development of fortified factories in underdeveloped village sites, later forts were constructed, namely Fort St George in Madras, Fort William in Kolkata and Fort George in Bombay re built with ramparts, bastions, moats, and draw bridges and esplanades revamped. This was done for administrative and military functions very distinctly shown in the maps below.

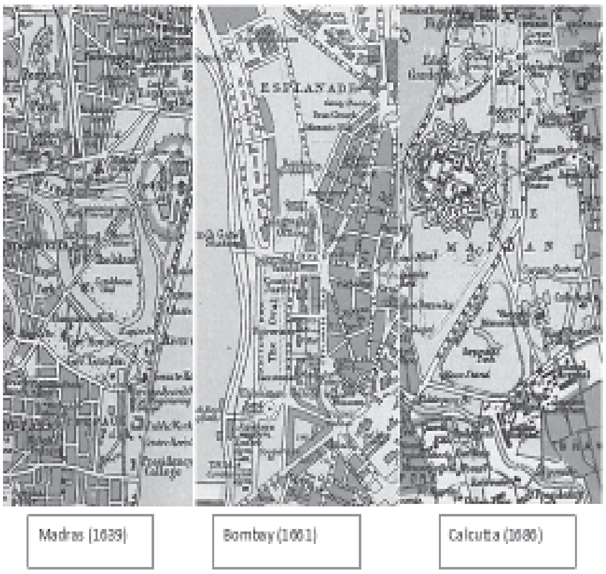

Fig. 1: Port Towns of British India

European suburbanisation was more or less not as compact as the densely knit housing of English residential zones depicted in red colour. The main roads and streets offered arterial function of transportation of the raw materials and processed goods from the hinterland and factories to the ports. The idea of ruling from distance was made facile with the preparation of the maps as planning for urban expansion or changes in the land use pattern of the urban centres could take place in the metropole (Britain) and the altered arrangements could be implemented in the colony. Maps were by far the simplest yet the most effective tool used to depict the control of the Empire over spaces. The idea of the panopticon that Foucault recurrently uses in his writings as the mode to watch over people and govern their movements. Maps too have been a tool for self surveillance of the native population; for them to know and be aware of the spaces that are out of bounds for them.

Cantonment Towns

Cantonment towns were organized on the lines with a separate self sufficient camp for the military. This secluded space was usually located a few miles away from the native city. The 'western' or 'anglicized' cantonment towns were never superimposed or thrust over the existing settlements. A stereo typical Cantonment Town of British India would have had green belts separating the 'unhealthy, noisy and distasteful' parts of the towns. Grewal (2005). These towns came up at a distance from the old city or town. The civil lines and cantonments were planned settlements and mapping their morphology depicted the stark contrast these towns had with the indigenous towns.

The Cartographic techniques used for show casing this secluded space can be seen on the profiles of the town maps with cantonments encircled with thick yellow lines distinguishing those spaces as spaces of the British living in India.

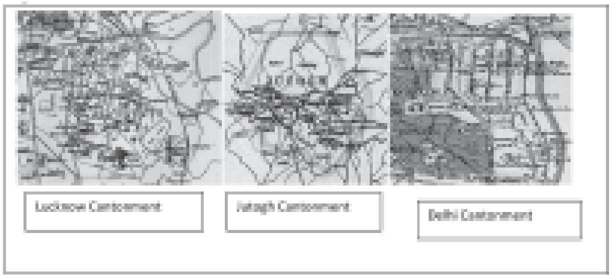

Fig: 2 Cantonment Towns of the British India

When the British armies were at war or were between campaigns, they were housed in cantonments. These were Physical Township with wide roads, straight streets, well spaced bungalows, expensive drill grounds, churches, and clubs and proficiently run municipal facilities. Military proficiency and pride ensured that all the physical needs of the cantonment

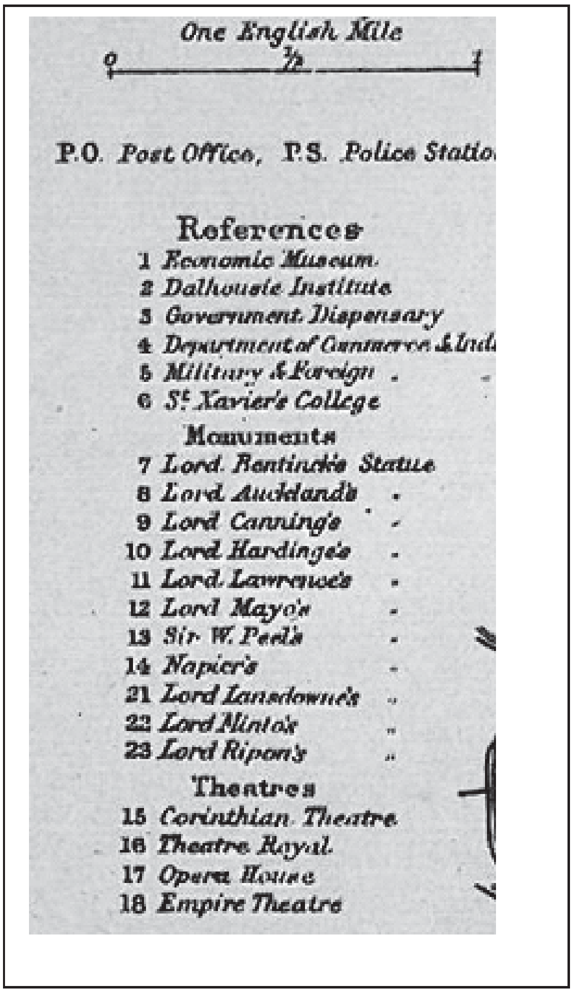

Fig: 3. Index of Colonial Town Map

were efficiently satisfied so that they invariably appeared spic and span. Cantonment was a military space under exclusive military control. It was not subject to any of the town's municipal regulations, taxes or other aspects of town governance. Soldiers were usually kept out of the Indian towns. Geographical exclusion was thus reinforced by limiting the possibility of fraternalisation. The only fluidity one experienced over these tightly compartmentalized spaces of the cantonment with the rest of the town is that if the language. Chai or tea and Bunglows became a common word among the British and the Indians.

Cartographically too the provision of various western facilities as well as the west – loke inscription on the town spaces may be found in the index of the cantonment maps prepared by the British. One such index is being presented below.

All public buildings, museums and recreational spaces were neatly marked out, also commemorative spaces in the forms of monuments and streets too are well etched on the map. Subjects exploring the map get a good idea of the spaces which have completely been anglicized and the readers too imbibe the easy familiarity that the newly colonized space has to offer. Apart from marking an imprint on the disciplining and sovereign power was expressed through the residential landscape of cantonment towns. In the case of Delhi; aesthetic, sanitary and policing concerns were mapped and population controls designed to segregate and prevent cross over between the old and the new housing the natives and the British respectively. The cordon sanitaire protected the privilege and assured order through partitioning of space. Legg (2007)

Emergence of Imperial Summer Capitals

The image of the Indian hills and the plains were created as a contrast in the British writings as the plains being densely populated while the hills as serene and isolated. Climate wise too the plains were hot and humid while the hills boasted of a salubrious climate. The empty hills were soon occupied to escape from the summer heat. These spaces for rest and enjoyment amidst the lap of nature soon transformed into major imperialistic-capitalistic design. The yearly exodus from the summer heat of the plains to the hills brewed the idea of converting the hills stations into summer capitals where the British government officials and employees could carry out their functions from the scenic locale. Mapping of the hill spaces had begun prior to the town creation in order to propagate the idea that the hills were isolated, uninhabited spaces and there would be no-contestations for space in those areas (Pradhan, 2007)[3].

Apart from the initial mapping techniques, maps helped the British to locate habitable spots to build their summer capital in. These summers were also paces of work as for six months the government operated from the high. The hill towns had become sanatoriums or military bases. The mapping of those regions also helped in identifying vantage spots for surveying distant horizons.

The map below shows Simla and its twin cantonment town of Jutogh.

Fig: 4. Map of Shimla and Jutogh.

The settlement of Shimla is being seen cordoned off by thick red line, and the cantonment Jutogh with a thick yellow line.

A detailed analysis of the map reveals that all major ridge points were mentioned followed by the estates owned by the British elite in Shimla. Clubs were marked prominently, as the emergence of clubs as spaces of recreation emerged at the urban centres in the plains too, but achieved a new high in the hill town as Shimla was both an official city and a social one (Sinha, 2001)[4]

The Jutogh Cantonment area highlights more functional aspects as the artillery lines, Officer's Mess, Cemetery, Canteens and Hospitals.

The maps of these hill stations along with the accounts of the British life together created the complete control over the idea of the urban spaces during British Raj in India. Apart from the benefits of "ruling from the high" where once again the idea of the panopticon dominated, and the officers of the Raj could have a thorough control over the movement of people, and also remain prepared for any approaching problem.

CONCLUSION

The spatial segregation of races reinforcing cultural differences and unequal power relations was strongly developed in the colonial towns, and mapping of the zones was an important tool to conceive them and execute these differences through practices, discourses and institutions. It was through maps that the abstract spaces of difference were converted into real spaces.

It is still pertinent to research on the morphology of Colonial towns in India, even though Post-colonial states have consigned oppressive and racist township rules to the 'dustbins of history' but the colonial legacy continues to affect contemporary city form and urban practices in the post-colonial spaces as the regions set aside for the Europeans are now inhabited by the bureaucrats and elites. Similar segregation in terms of class structure is still prevalent in the modern Indian towns and maps can become powerful tools to depict those differences as to how power is can be exercised on people through self surveillance just by making them charting out spaces as their own and spaces which belong to others'.

Endnotes

1. *The idea of the Panopticon was taken by Foucault from Jeremy Bentham's work on prison structure. The same structure may be applied to the city morphology*
2. See Masselos (2014) Empire and City, where he categorises Colonial Towns based on their functions.
3. Pradhan (2007) deconstructs the idea how the hill stations of the Raj were uncontested zones in vast barren uninhabited parts.
4. *Read Sinha (2001) how the social clubs reproduced the comfort of home in the colonies.*

REFERENCES

1. Foucault M (1991) "Governmentality" In Graham Burchell, Colin Gordon and Peter Miller eds. The Foucault effect: Studies in Governmentality, Harvestor Heathsheaf, London. 87-104.
2. Grewal R (1991) "Urban Morphology under Colonial Rule" in Indu Banga eds.The City in Indian History: Urban Demography, Society and Politics. Manohar Publishers, New Delhi, 170-205.
3. Kalpagam U (1995) "Cartography in Colonial India" Economic and Political Weekly, No 30.
4. Kalpagam U (2015) "Rule by Numbers: Governmentality in Colonial India" Orient Longman, New Delhi.
5. Kidwai A (1991) "Urban Atrophy in Colonial India: Some Demographic Indicators" " in Indu Banga eds.The City in Indian History: Urban Demography, Society and Politics. Manohar Publishers, New Delhi, 149-172.
6. Legg S (2007) Spaces of Colonialism: Delhi's Urban Governmentalities, Blackwell Publishing.
7. Masselos J (2014) "Empire and City: The imprerial presence in urban India" in Robert Aldrich and Kirsten McKenzie eds. The Routledge History of Western Empire, Routledge.
8. Meera Kosambi and John E. Brush (1988): "Three Colonial Port Cities in India", Geographical Review, Vol. 78, No. 1, p.34
9. Pradhan Q (2007) "Empire in the Hills: The Making of Hill Stations in Colonial India, Stidies in History, 23,1,n.s. 33-91.

Sarkar O (2012) "The Great Trigonometrical Survey: Histories of Mapping", 1790 -1850, eTraverse: The Indian Journal of Spatial Science, Vol III, No 1, Article 4-5.

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DEVELOPMENTS IN NAUTICAL CARTOGRAPHY AND ITS INFLUENCE ON MARITIME NAVIGATION

Madhubani SEN [1], Sangeetha ESTHER [1]

ABSTRACT

Cartography has been used from ancient times, beginning with the cave paintings to modern computerized methods to help represent space - to show city plans, chorographic maps and world maps, and route maps. Cartography gained a major thrust with the development of maritime traffic which led to a continuous endeavor for improving cartographic methods to regulate maritime navigation. ‘

Starting with the initial, rudimentary nautical charts which depicted the coastlines, nautical maps have made great leaps in the past few centuries, incorporating more and more information for accurate navigation and safety of the ships. The 20th century saw the advancement of information and communication technology in all fields of life that has enabled maritime navigation to progress the most.

In this research paper, we will attempt to give a detailed account of the various developments in the field of nautical cartography which have helped nautical maps to evolve into essential tools of maritime navigation. Starting with the rudimentary paper nautical charts of the 2nd century BC, followed by the portalan charts in the mid thirteenth century to the most recent developments of the Electronic Nautical Charts with the integration of maps with GPS, GIS and Remote Sensing in the Electronic Chart Display and Information System (ECDIS). Most of the current nautical maps are provided by the national or International Hydrographic Organization. An account of the various international bodies, which are involved in the publication of nautical maps together with the development of new navigation techniques, has been undertaken along with methods to standardize and unify the various chart systems.

While most of the historical developments have been contributed by the Europeans, it is also important to give an account of the developments that have taken place in India. From using different types of maps by Indian mariners to the developments in the 20th century where the National Hydrographic Office of India played an important role in the world of digital nautical cartography.

Keywords: *Nautical Charts, Maritime Navigation, International Hydrographic Organization, Electronic Nautical Charts.*

INTRODUCTION:

From ancient times man has always endeavored to visualize, and represent space on a plane surface. As man became more curious about his surroundings and started exploring, the utility of maps began to change. From being used merely as a tool for recording property or describing space, it became an essential tool in the hands of explorers.

Human ingenuity led mankind to conquer the rivers and the seas. Initially dug boats were used for fishing and travelling in the rivers. With the advent of sails used by the Egyptians, man was soon able to venture into the sea. This was followed by various developments when the early civilizations were able to develop their vessels for travelling, and ultimately for trading.

Maps are essential for mariners who are navigating over the vast open seas or even just near the harbour, where they heavily rely on navigation charts. Navigation Charts combine aspects of topographic, general reference and thematic maps and are produced as navigational aids for ships and boats. These charts are different from navigational maps, in a sense that charts show greater detail about the water and its edge with little information about the land (expect for features such as cliffs and lighthouses that aid navigation) and is embedded with specialist information and text notes such as tide levels and so on which is why specialist knowledge is usually required to read charts. Like topographic maps, charts are typically produced by government mapping agencies, such as Navy and possibly also civil defence bodies and/or port management authorities (ICSM).

DEVELOPMENTS IN THE ANCIENT PERIOD

The first Western civilizations known to have developed the art of navigation at sea were the Phoenicians, about 4,000 years ago. Phoenician sailors accomplished navigation by using primitive charts and observations of the Sun and stars to determine directions. Using the location of particular stars and constellations, they were able to orient the ship in the correct direction. This method was used in the Mediterranean Sea, Aegean Sea and the China Sea. While celestial navigation was the main means of

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navigation in those times, they had their drawbacks. The sea being treacherous and volatile made it very difficult to navigate mainly based on the directions ascertained by the stars and winds. The early sailors also realized these drawbacks and were always in search of new methods to aid navigation.

The earliest record of nautical charts were from around 2nd century BC (Bowditch 2002). These maps were used with 'sounding weights' which determines how far from the coast they were sailing according to the depth of the sea.

During the time of the Romans and Greeks, seamen were sailing with aid of written descriptions of the coasts, There are also evidences of nautical guides dating as early as the 5th and 4th century BC, one example of the earliest being "Scylax of Caryanda and his circumnavigation of the sea of the inhabited part of Europe, Asia and Libya". During these times, there were great developments in cartography but there have been no evidences of maps being used for the sole purpose of aiding seafarers. (Putnam 1908).

DEVELOPMENTS IN THE MEDIVAL PERIOD

With the fall of the Roman Empire and the coming of religious fanaticism, science and cartography had several setbacks. Nevertheless the contributions of other empires played an important part during this period especially in the innovations and dissemination of new navigational tools and technology in Europe.

While sailors were still navigating with the help of celestial bodies, the coming of the mariners compass was a great boon to nautical navigation and cartography. The magnetic compass was already in use in China by the 2nd century BC but only in 1000 AD, the Chinese had started using the magnetic compass known as the 'south pointing needle' for navigation, which was a magnetized needle floating in a bowl of water (Ricker 2011).

The idea of the magnetic compass was passed on from the Arabs to the Europeans during the crusades. The Arabs had also invented their version of the magnetic compass, along with other navigational tool such as the Kamal which is used to determining latitudes (Paselk 2008). The use of magnetic compass among the western civilizations hadn't been initiated till the 13th century, as they were often unsuitable for marine navigation. It was considered a means of determining directions during unfavourable weather conditions rather than a navigational tool. It was only in 1269, with the modifications made by Petrus Peregrinus that the magnetic compass began to be used. He provided a container in which the needle was pivoted so that it was unaffected by the movement of the ship and the wind. He also provided a sighting device to align the compass in a specific direction and a graduated circle to allow measurement in the sighted direction.(Ricker 2011).

While the compass helped in providing the direction, seamen still needed help in determining the course of the route. For this purpose, till the 13th century, sailors relied more on Rutters, which were Handbooks for sailors giving directions based on geographical information collected by navigators and pilots, also known as Peripluses. They gave information about harbours, market ports and landmarks. There have been references made by the Greeks to 'drawn peripli' which modern scholars refer as sea charts(Bagrow 2009).Once commerce increased in the Mediterranean, the handbooks became more descriptive and accurate. In Italy these handbooks were called 'Portolani' which gave sailing directions in terms of compass directions and distances, and sometimes they were also accompanied by drawings of harbours and the coastlines.

As maritime traffic in the Mediterranean Sea increased in the 13th century, accompanied by improvements in compass and sailing handbooks, the importance and usage of maps in sailing slowly began to emerge. In the late 13th century, sailing charts of the Mediterranean Sea were developed in Italy, most of which are undated. The earliest dated nautical chart still in existence is Petrus Visconte's Loxodromic chart of 1311 (Putnam 2013). It is assumed that Visconte's chart led to the advent of nautical cartography (Bagrow 2009). The nautical charts of those times mostly emerged in the famous ports of Italy, and were based on the information collected in the Portolani, thus making them known as Portolan Charts. However these charts could not represent all the information of the Portolani handbooks, which is why these charts were only used as supplements. Nonetheless, these charts spawned a new era in mapmaking in Europe as these maps were more accurate than the other European maps of those times. Various scholars have tried to study how these maps were made so accurately, but because of the need for secrecy among rival sailors and traders of those times, not many of such maps have survived. By perusing over the existing maps and using mathematic computer softwares on these maps it has been shown that these maps were made with the help of the magnetic compass, since a deviation was observed in these maps from the true north (Rehmeyer 2014). Many authors have also concluded that the Portolan charts were not based on map projections (Tobler 1966), however they contained rhumb lines radiating from a number of crossing points distributed regularly over the map. The early portolan charts were compiled using rough estimate of linear distances between various points.

Initially they were drawn on vellum and embellished with a frame and a scale. By 1375 compass roses were also added to these maps. The printing of these charts began by 1477 and engraved on copper by 1560 (Putnam 2013).

The medieval portolan charts can be classified into two categories according to their characteristics. The Italian portolan charts mostly depicted areas of the Mediterranean and the western European region. The Catalan Portolan charts on the other hand extended to northern Europe, up to northern Scandinavia and as far east as China. Since the Catalan charts showed larger areas, they were circular in shape. In the 14th and 15th century the Catalan portolan charts also depicted the Atlantic islands and the west coast of Africa(Campbell 1987).

By the end of the medieval period with the help of the mariners compass and the portolan charts, sailors were brave enough to transverse further. The charts beckoned the age of explorations, which ultimately led to the portal charts being superseded by more modern charts. Mainly because as the sailors ventured out further into the sea and visited distant places, the portolan chart was unsuitable to depict such a large space (Rehmeyer 2014).

DEVELOPMENTS IN THE RENAISSANCE PERIOD

With the Age of Exploration, as voyages had become longer, sailors started realizing that there was a deviation between the magnetic north and the true north. The earliest mention of the variation of the compass from the true north was on the first voyage of Columbus in 1492. With the growing use of the pole star for navigation, there was further proof that the celestial and compass observations did not coincide (Ash 2007). The cartographers had to sacrifice the internal consistency of their charts in order to correct the discrepancy between the celestial and compass observations. The variation of the compass was first marked on a map in 1532 and on a printed chart in 1595, but the placing of magnetic compasses on charts did not become customary until about fifty years ago(Putnam 2013).

With the introduction of the quadrant and the astrolabe in navigation, astronomical observations of latitudes were facilitated. Thus locating oneself on the earth using astronomical observations were taken to be more accurate than rough estimation through measuring distances as it was done using Portolan charts. Nautical cartographers realized the growing importance of the latitudes in ocean navigation and reflected it in the charts. They started including the scale of latitudes such as Portuguese charts of the 1500s. These were graduated, with equidistant straight parallel lines, intersecting the other lines at right angles. These maps were known as 'Plane Charts' (Ash 2007).

By the early 16th century the usage of latitudinal scales in the carts was a regular feature. The parallel meridians were a cause of difficulty among the cartographers, who were struggling to represent the spherical nature of earth. In 1569, a Flemish cartographer, Gerhard Mercator, published his famous Universal Map. The map had meridians and parallels as straight lines intersecting at right angles; it was the first depiction of the world using an isogonal projection. After examining the Mercator chart in 1590, Edward Wright, an English mathematician, worked out the mathematical solution which would allow for the Mercator projection to be used in navigation. He was able to develop the correct principles on which such a chart should be constructed, and published in 1599 his treatise "the Correction of Certain Errors in Navigation'. It took nearly a century to bring this chart into use (Putnam 2013). The Mercator projection maintains the parallel grids of latitudes and longitudes, but the distance between the latitudes increased further towards the poles. This was useful in navigation because now the rhumb lines would be straight lines because of the preservation of the linear distance ratios for every degree of latitude (Ash 2007).

Though the Mercator projection is one of the widely used projections for navigation even today, it suffers from basic shortcoming such as the distortions of the coastlines towards the poles. Thus they were not of much use to navigators in the high latitudes. To do away with this shortcoming, English explorers started experimenting with new projections. English cartographer John Dee claimed to have invented the Polar projection in the latter half of the 16th century, calling it the "Paradoxall compass" (Ash 2007). Instead of taking the equator as a point of reference, the polar projection took the poles as the point of reference with latitudes being shown as concentric circles and meridians as radii of the circles.

In 1772, Johann Heinrich Lambert, a French mathematician introduced 7 new projections among which the modified Mercator projection which was later named Transverse Mercator and the Lambert Conformal projections are still being utilized in nautical charts.

The 16th and 17th century saw an increase in mathematical complexity in nautical cartography. While maps were getting more elaborate and accurate, developments of other navigational tools also took place which assisted in determining one's location and speed. During the 16th century, the chip log was invented and used as a crude form of calculating the speed of the ship. In 1730's, John Hadley and Thomas Godfrey, both independently invented the sextant, which was a sophisticated tool used to determine the angle between the horizon and the sun, moon, or stars. The sextant much like the nautical charts is still a common feature of modern ships.

By the end of the 17th century, ascertaining the speed and latitude became common place among sailors but steering off course was still a common phenomena. This was due to the lack of a practical method to determine the longitude. Various astronomers, physicist and mathematicians tried to solve the "longitude' problems. The trick to solving the longitude problem lay in being able to keep accurate time aboard a ship while simultaneously keeping track of the correct time at the port of origin (Sobel 1998). This was accomplished by the invention of the sea going Chronometer by the British clock-maker John Harrison, in 1764. This was tested by James Cook, while circumnavigating the globe in 1779.

Apart from improvements in map making and innovations, nautical cartography was also aided by the formation of several navigation organizations all around the world to promote safe and productive sailing. The first of such organizations were the Royal Greenwich Observatory in England established by King Charles as early as 1675. The United Nations Navy put up an important role in the development of navigational technology in 1798. The government of various countries started setting up offices with the sole purpose of surveys, producing and publishing nautical charts. The Dutch set up a post for correcting and publishing charts as early as 1633 and the French followed suit in 1720. In 1795, the Hydrological Office was established in London. Following similar lines US coast and Geodetic survey was found in 1807 which mainly monitored nautical survey along the coastline, harbors, outlying islands and fishing bank of the U.S. and the US Hydrographic Office was established in 1866 (Patnam 1908).

With the setting up of various organization and effective instrumentation and mathematical modeling, mapping became more uniform and organized.

DEVELOPMENTS IN THE MODERN PERIOD

The 20th century witnessed the two major wars which brought about wide spread destruction and misery, but this is also the century that saw some of the best breakthrough in technology and science. This ultimately has spearheaded cartography in general and nautical cartography to a whole new height.

World War 1 and to a greater extent World War 2 brought several changes and progress in cartography mainly through technological breakthrough which directly affected nautical charting. During the initial years of the world war one, countries with paramount defense consideration like Britain and France made much exploration in cartography while others such as United States it was mainly the civilian organizations like National Ocean Services which were responsible for nautical mapping tasks. Great Britain became the primary maritime power of Europe during the world war one where development in charting of the maritime routes and betterment of navigational facilities place. This era saw a great deal of Ordinance surveys which nullified the civil commitments and focused mainly on the war. The hydrographic department of Britain was solely responsible for providing charts to the royal and Merchant navy acting as assistance both at war and trade. Gaining worldwide position by inter-war period it mainly produced 'Admiralty charts' which covered the ocean areas and main ports at different scales. These charts largely acted as scientific instruments giving details of underwater surface, radio data and tidal variations. The British Hydrographic department also generated special 'Operational charts' for the royal navy during the war period. At the end of the two wars, through the production of 'Map Charts' and 'Beach Charts' they traced all the sea-borne invasions. Another important innovation by British Nautical cartographers was the 'boat chart' which became standard navigation equipment for the life boats. The charts were simple showing prevailing winds and ocean currents of different oceans with appropriate navigation instructions at the back. This chart was very effective and saved many lives collectively from submarine warfare and normal marine navigational hazards. Another prominent European power to come up with developments in nautical cartography was France. Beautemps-Beaupre was an important figure in marine cartographic developments as he tried out several new methods of hydrographic surveying. The skill of the French hydrographic office mainly reflected in the compilation of foreign charts for both military and civil purposes and this finally led to the establishment of International chart under the guidelines of the International Hydrographic Organization. Though progress in nautical cartography was steady during the initial years of the 20th century in France, there was a slag during the war period owing to limited bathymetric information and multiplication of systematic surveying resulting in profusion of charts. Apart from these two European nations others like Germany and Russia hardly revealed their nautical knowledge and this is reflected in the lack of literatures available pertaining to these countries. Followed by Britain and France, USA also took long strides in development of nautical cartography. By 1922 two scientists Hoyt Taylor and Leo C. Young first traced out the use of radar. The British around 1935 also carried on with some work on radar and ultimately with the combined effort of the two nations, the microwave radar became practical and roughly by the end of World War 2 it became available for use commercially. America also developed hyperbolic radio aids during World War 2, Loran A and Omega for hydrographic surveying, off-shore facilities positioning and general navigation. Other important electronic systems like Navy Navigation Satellite system popularly known as NAVSAT was introduced after the Second World War for safe navigation by surface vessels, aircrafts and submarines. Later it was replaced by more accurate and widely available Global Positioning System (GPS).

In 1921 the International Hydrographic Bureau was established largely to help standardize datum and nautical charts around the world which led to smooth navigation around the globe. This organization by 1970 was renamed as the International Hydrographic Organization. The United Nations Convention established the International Maritime Organization mainly to focus on safety of navigation and its effect on environment. While these organizations were busy in mapping and charting the vast oceans, advent of computers influenced cartography on a large scale. Following the impact of computer technology on cartography, the working group of International Cartographic Association defines modern cartography as " A holistic representation and intellectual abstraction of geographical reality, intended to be communicated for a purpose or purposes, transferring relevant geographical data into an end product which is visual, digital or tactile''(Kumar 2006). At present the computer plays the most important and regulating factor in updating the topographic and hydrographic detail for the preparation of nautical charts. High resolution satellite images, digital photos, bathymetric data collected through GPS results in more accurate charting of the oceans around the world. Present Nautical cartography has several elements which are important for chart construction. Mainly Geographical Information System (Geomedia Professional, SPAN, ARC/INFO, MGE, MapInfo, ILWIS, IDRIS, CARIS GIS), Remote sensing (EASI/PACE, Image Analyst, ERDAS imagine, Er Mapper, TNTMips), Computer Aided Drafting System (Auto Cad, Micro station, Arc Cad) and Mapping Systems (ACE (from PCI Geomatic) Map composer (from ERDAS) Map publisher (from INTERGRAPH) Arc plot (from ESRI)) comprises of the above mentioned elements. The recent development in modern cartography has proved their capabilities to produce nautical charts in analogue form and electronic navigational chart in the form of electronic navigational chart database (ENCDB) for requirement of safety and automated navigation(Kumar 2006) The world scenario portrays the widespread use of modern cartographic tools for both oceans and land management applications. Frequent use of digital photogrammetry along with image processing of remote sensing data jointly caters to the mapping requirement of coastal and hydrographic management applications. Several International hydrographic offices are largely utilizing modern cartographic tools for generation of both paper chart database and ENC database mainly because of the benefits of data integration from various sources and more accuracy with projections and final chart production.

DEVELOPMENTS AND CONTRIBUTIONS OF INDIAN CARTOGRAPHERS

Although India's ancient maritime tradition pre-dates Greek, Roman and Carthaginian exploits in the Mediterranean, not enough is known about it mainly because of lack of documentation (Prakash 2013). To know the country's ancient maritime activities and sea-faring skills one had to accept accounts authored by Western historians who mainly mentioned about sailing being influenced by the monsoon winds in the Indian Ocean. Systematic maritime cartographic expeditions in the waters of Indian oceans started with the advent of British rule in the sub-continent. Most of the work to map the ocean waters and open seas for safe navigation was exercised by the Hydrographic Department of the country. Being one of the oldest surveying organizations of India it has worked under different names in different periods. One can trace the history of Indian Hydrographic Department as early as the 17th century. The Masters of the East India Company's ships provided vital information on depths and Sailing Directions, which formed the basis for the publication of earlier Indian charts (Saran & Sinha 2011). To promote systematic and safe maritime activities and navigation, the East India Company established a fully fledged marine survey department in the year 1770. This was followed by the Marine Survey of India which was established in Calcutta headed by the then surveyor-in-charge A.D Taylor. One of the earliest Indian Marine surveyors, Captain John McCluer surveyed a considerable part of the Indian coasts and his work is thus entitled as among the best cartographic charting commenced in these waters. In this context another hydrographer, Captain Daniel Ross of the Indian Navy otherwise known as the father of Indian surveys deserves special mention as he did a detailed scientific survey of the south Indian oceans, clarifying the sea routes and boosting up trade. These surveys though made more than a century and a half ago, with inferior instruments, and at a time when the science of hydrography was in its infancy, show surprising accuracy and attention to detail.

Till the early years of 1950s the result of the surveys were forwarded from the Indian Hydrographic Department to the British hydrographic department who in turn undertook the responsibility of publishing the nautical charts. Later keeping in view the maritime interest of the country, the hydrographic office was established in India to undertake the task of mapping. The first office was set up in Birpur, Dehradun on 1st June 1954, getting fully nationalized in 1955. Right after the nationalization of the Indian Hydrographic Department, India became the member of the International Hydrographic Organization (IHO) in the year 1956, which was an intergovernmental body of hydrographers with the main aim to standardize navigational charts and publications so as to promote safe and less ambiguous marine activities around the world. This showcased the first participation of Independent India in an international platform in the context of nautical cartography. After this the Indian office of the hydrographic department was shifted to Rajpur Road in Dehradun on 29th March 1957. This organization did not only work for the navy but also was the sole national authority for the production of nautical charts and publications which were important for the development for the country.

The first step to improve knowledge about the open waters and carry out survey was to allot proper survey ships which again saw improvements along the course of time. The first range of ships appointed to carry the surveys was named investigators. The fifth in this line carried out the major surveying duties in the post independence period. However, keeping in view, the task that lay ahead for revision of surveys of the entire Indian coastline, measuring approximately 6000 nautical miles including several major and minor ports and to meet the urgent requirement of shipping, *Rohilkhand,* a minesweeper, was converted to carry out surveying duties from 1952(Singh 2005). In 1953 the frigate[1] Sutlej was converted into a survey ship and was sent to join the services in place of Rohilkhand. 1956 saw another frigate joining the services named Jamuna. The surveying techniques became more sophisticated replacing the old traditional methods and the first hydrographic ship built in India named Darshak equipped with eco-sounders and helicopters for aerial photography was commissioned in 1964. Apart from the survey ships, shore based mobile survey units and air borne survey systems were introduced in the department by late 1990s.

A revolutionary change in nautical cartography in India came with the introduction of electronic navigational charts which largely replaced the conventional paper charts. This was primarily possible because of the advancement in mapping technologies in the context of general cartography like geographical information system, satellite imageries and remote sensing. The Electronic Navigational Charting programme of India started with a vision to gain a greater appreciation and understanding of the use of electronic charts when operating in its waters. Beside this the purpose was to develop an information system and demonstrate to the world that India is capable of producing full coverage of its National Chart series digitally and as per the specifications laid down by IHO/IMO(Kumar 2006). Thus with a group of experienced cartographers and hydrographers equipped with extensive bathymetric and hydrographic data, an attempt to develop ENCs started in 1997 and India finally attained full ENC coverage by 2002. Over the period of time, the ENCs produced by the IHO covered the entire Indian coastline and open waters beyond that, starting from Gulf of Kutch, Bombay Port, Kerala Coast, Tamil Nadu Coast and finally Andhra Coast. At present India is distributing its ENCs worldwide which are compatible to most of the electronic chart display and information system of the world.

CONCLUSION

The lure of the sea, and mans drive to conquer land and water led to many innovations, contributing to the growth of cartography. Evolving from maps drawn on calf skin to electronic navigational charts which could track the movement of ships, nautical cartography has made huge leaps from 1300 A.D to present day. It has taken a new dimension from being only a navigational supplement to sailors to a necessity on board for every sailing vessel. In recent times, with cooperation among various countries nautical cartography was able to advance much faster than in the medieval period. Nautical cartography promoted secure and accurate voyages in open seas. Thus it can be concluded that it was not only technological advancements that were responsible for the development in nautical cartography but also the establishment of various maritime bodies and organizations and cooperation among them and the countries, for the sole purpose of safe sailing.

REFERENCE

1. Ash, Eric H. (2007). Navigation Techniques and Practice in the Renaissance, In David Woodard (Ed.) The History of Cartography Volume 3, Chicago: University of Chicago Press
2. Bagrow, Leo. (2009). *History of Cartography,* ed. R.A Skelton, London: Transaction Publishers

3. Balchin (1987). United Kingdom Geographers in the Second World War: A Report. *The Geographical Journal*, Vol 153,(2): pp. 159-180

4. Bourgoin (1988). The French state and Nautical Cartogrpahy. *International Hydrographic Review*, Vol 15, No 2.

5. Bowditch, Nathaniel (1995). *The American Practical Navigator*, Maryland : National Imagery and Mapping Agency.

6. Campbell, Tony. (1987). Portolan Charts from the Late Thirteenth Century to 1500, In J.B. Harley and David Woodward (Eds.) The History of Cartography, Volume I, Chicago: University of Chicago Press

7. Cloud John (2002).American Cartographic Transformation during the Cold War. *Cartographic and Geographic Information Science*. Vol 29(3). pp. 261-282

8. H. H. Ricker III,H.H (2005). The Discovery of the Magnetic Compass and Its Use in Navigation. *The General Science Journal*. www.gsjournal. net/old/science/ricker4 .

9. Harley J.B. (1988).Silences and Secrecy: the Hidden Agenda of Cartography in early Modern Europe. *Imago Mundi*, Vol 40: pp. 57-76

10. ICSM .Fundamentals of Mapping", Anzlic Committee on Surveying and Mapping, viewed on 05.10.2015, Web Access (http://www.icsm.gov.au/mapping/maps_charts.html)

11. International Hydrographic Organization. Regulation of the IHO for International (INT) Charts and Chart Specifications of IHO.Edition 4.4.0, 2013. Monaco, International Hydrographic Bureau press.

12. Kumar Rajesh (2006). Indian Electronic Navigational charts: A Digital Journey. *Co-Ordinates*, Nov 2006. http://mycoordinates.org/indian-electronic-navigational-charts-a-digital-journey/

13. Paselk ,Richard A (2008). Medieval Tools of Navigation. In Robert Bork and Andrea Kann (Ed.), An Overview, in The Art, Science, and Technology of Medieval Travel, Hampshire: Ashgate

14. Putnam, G.R (1908). *Nautical Charts* ,New York : John Wiley and Sons

15. Rehmeyer, Julie (2014). The Mapmaker's Mystery. *Discover*, June 2014

16. Saran &Sinha (2011). India's Maritime stakes and Challenges in India Ocean.*Scholars Voice: a new way of thinking*. Vol 2, No 1: pp. 1-12

17. Singh & Kumar (2005). Indian Electronic Navigational Charts (ENCs) Programme: Marching Towards self reliance. http://www.cartesia.org/geodoc/icc2005/pdf/oral/TEMA13/Session%203/U.K.%20SINGH.pdf

18. Singh RB (2006).Advent of Modern Cartography in Nautical Charting. *Co-Ordinates*, April 2006, http://mycoordinates.org/advent-of-modern-cartography-in-nautical-charting/

19. Sobel, Dava (1998). A Brief History of Early Navigation. *John Hopkins APL Technical Digest*, Vol 19, No 1.

20. Tobler, W.R (1966). Medieval Distortions: The Projections of Ancient Maps. *Association of American Geographers,* Vol 55, No 2, pp 351-360

THE KEY TO THE PAST – THE MONUMENTS WITH A CASE STUDY OF DELHI

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ABSTRACT

The objective of the study is to establish the link between different historical phases and events. Historical events can be depicted spatio-temporally with the support of Geospatial technology. In this study, the capital city Delhi has been focused to visualize its past scene. Delhi has witnessed succession of different powers, their glory and then the ruins. Present day Delhi is carefully preserving its history in many folds. Monuments standing today have a fossilized seal of the history. The shadowy corners of the past scene of Delhi have been enlightened with the help of Geospatial Technology.

Cartography is a method to represent the real world in a communicable way. Historical Cartography is an approach to connect the past to the present considering the fact that present is the key to the past

***Keywords**: Historical Cartography, Delhi, Monuments, Evolution, 3D Visualization*

INTRODUCTION

Cartography is a method to represent the real world in a communicable way. The essence of cartography is communication. Cartography acts as a powerful medium of visualization. As early cartographers explained the world centuries ago by discovering previously unknown physical spaces, it is now a necessity to tell the stories of the spaces of humanity. One new role of cartography is to contribute to an understanding of those spaces that we still do not fully understand and to analyse how these can be visualised.[1]

Historical cartography includes almost all other varieties of cartography because we all live inside the chronos "time-space envelope". Historical cartography is not defined by the mildewed smell or the spotted look of old maps, or even by the medium (stone, wood, vellum, palm leaves, paper, mylar) on which the maps were rendered.[2] Wm. Faulkner reminds us "the past is never dead; it is not even past".Maps of "then" are available to us in the "now" and it is for us cartographers and geographers to comprehend the change these maps show as we plan for the "nows" to come.[3]

Historical Cartography is an approach to connect the past to the present considering the fact that present is the key to the past.[4] Monument is symbolic to history and in manifolds it provides layers of information. It is a reflection of the structural and architectural pattern signifying the then socio-cultural influence. We can explore the 'silent witness of time' to sketch up the old scene in a new canvas.

Delhi City in its long past has witnessed succession of different powers, their glory and then the ruins. Present day Delhi is carefully preserving its history in manifolds. More than 200 protected monuments are standing today with a fossilized seal of the history. Lights can be thrown to the shadowy corners of Delhi to enlighten the past scene with the help of Geospatial Technology.

Mapping of Monuments is an ideal way to explore the thrust area of history. Representation of data includes historical monuments and other associated features like old roads, connecting routes, the places associated with the then life. With a proper overview and understanding of the then set up the story can be recreated to visualize our past. Immense power of cartography not only have the potential to make a better tomorrow with proper visualization, but it also nourishes the opportunity to explore our past to establish the links between different events of 'then' and to preserve properly for future appraisal. The power of visualization is immense to be utilized to replicate the reality whether it is for our future or to look back to our past.

SCOPE OF WORK

Madan Mohan in his paper titled 'Historical Information System for Surveying Monuments and Spatial Data Modelling for Conservation of Cultural Heritage in Delhi', primarily concerned with the historical ancient seven cities, historical ancient forts, and historical ancient and modern monuments along with the World's cultural heritage sites in Delhi.

Different approaches have been adopted for better visualization of the monuments. The technical aspects associated with mapping of heritage monuments and comparison with historical drawing has been analysed by the scholarsin the paper titled '3D Digitization and mapping of heritage monuments and comparison with historical drawings.'[5]

It has a good scope of mapping of monuments to develop an information system with an special emphasize to illustrate the historicity of existing

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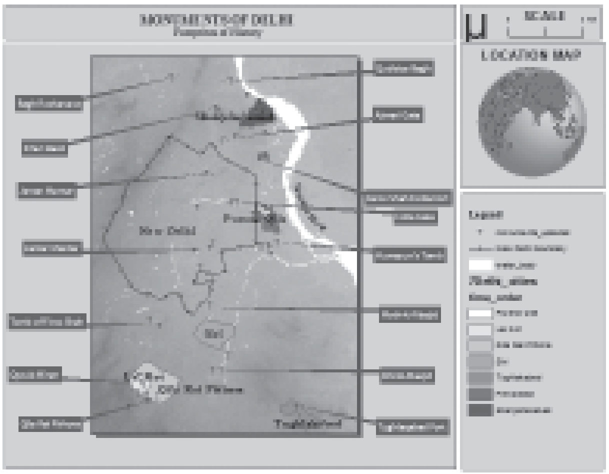
Table 1
List of Monuments in Delhi (selected)

SL. No.	Description	Location	District	Coordinates
N-DL-1	Bastion, where a wall of Jahanpanahmeets the wall of Rai Pithora fort.	Adchini	Delhi	28°37'56"N77°13'09"E
N-DL-10	Lal Gumbad	Chirag Delhi inJahanpanah	Delhi	28°32'24"N77°12'49"E
N-DL-100	Gates and walls of Mubarakpur, Kotla in village Mubarakpur	village Mubarakpur, Kotla	Delhi	
N-DL-101	Moti-ki-Masjid (Moth Ki Masjid)	Behind South Extension Part II.	Delhi	28°33'45"N77°13'04"E
N-DL-102	Inchla Wali Gunti	villageMubarakpur, Kotla	Delhi	28°37'56"N77°13'10"E
N-DL-103	Kala Gumbad	village Mubarakpur, Kotla	Delhi	28°34'12"N77°13'08"E
N-DL-104	Tombs of Bade-Khan, and Mubarakpur Kotla, Kotla	village Mubarakpur, Kotla	Delhi	28°34'23"N77°13'12"E
N-DL-105	Tombs of Chote Khan, Mubarakpur	Kotla	Delhi	28°34'23"N77°13'14"E
N-DL-106	Tomb of Mubarak Shah in Mubarakpur, Kotla. Built 1434 A.D.	village Mubarakpur, Kotla	Delhi	28°34'22"N77°13'22"E
N-DL-107	Mosque attached to Mubarak Shah Tomb	village Mubarakpur, Kotla	Delhi	28°34'20"N77°13'20"E
N-DL-108	Tomb of Bhura Khan	village Mubarakpur, Kotla	Delhi	28°34'20"N77°13'15"E
N-DL-109	Tin Burji Walla Gumbad	Mohammed Pur village II, 304	Delhi	28°33'58"N77°11'18"E
N-DL-11	Tomb of Bahlul Lodi. Built 1451 - 1488 A.D.	Chirag Delhi, inJahanpanah	Delhi	28°32'19"N77°13'35"E
N-DL-110	Unnamed tomb	Mohammed Pur village , 305	Delhi	28°37'56"N77°13'10"E
N-DL-111	Baoli. Built 1451 - 1526 A.D.	Munirka II. 318.	Delhi	28°33'24"N77°10'12"E
N-DL-112	Munda Gumbad	Hauz Khas	Delhi	28°33'24"N77°11'30"E
N-DL-113	Unnamed Mosque from 15th century A.D.	Munirka 314.	Delhi	28°37'56"N77°13'10"E
N-DL-114	Unnamed Tomb	Munirka 313.	Delhi	
N-DL-115	Unnamed Tomb	Munirka 315.	Delhi	
N-DL-116	Unnamed Tomb	Munirka 316.	Delhi	
N-DL-117	Unnamed Tomb	Munirka 317.	Delhi	
N-DL-118	i. Unnamed Mosque	Munirka 321&	Delhi	
N-DL-119	Wajir pur- ki-Gumbad	Munirka 312.	Delhi	28°33'46"N77°10'30"E
N-DL-12	Ajmeri Gate	Bazar Ajmeri Gate	Delhi	28°38'46"N77°13'26"E
N-DL-120	The Afsah-walla-ki-Masjid (Assarwala mosque) situated outside the west gate of Humayun's tomb with its dalans and paved court bounded on the east by Humayun's tomb on the west by Abadi Arab Sarai on the north by road and Khasra No. 252 and on the south by Abadi Arab Sarai	Nizammudin	Delhi	28°35'34"N77°14'52"E
N-DL-121	Bara Khamba (Barakhamba) outside north entrance to shrine	Nizammudin	Delhi	28°35'33"N77°14'33"E

Source : en.wikipedia.org, List of Monuments of National Importance in Delhi.



Map 1 : showing Monuments of Delhi

ancient historical cities and monuments;?to examine the impact of urbanisation on historical and cultural heritage sites; and ?to suggest the suitable strategies for conservation of historical monuments and cultural heritage sites.[6]

OBJECTIVE

"all history must be treated geographically and all geography must be treated historically."

—Herodotus

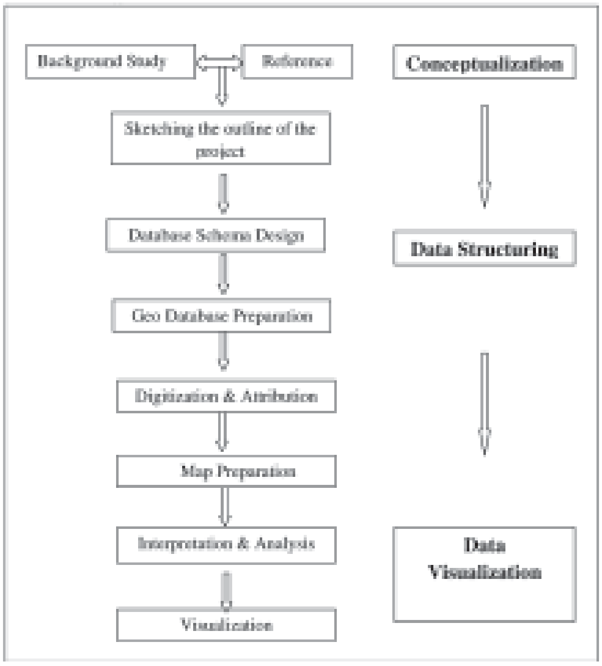


Fig. 1 : Methodology & Workflow

Historical events can be depicted spatio-temporally with the support of Geospatial technology. In this study, the capital city Delhi has been focused to visualize its past scene. In the wide span of history Delhi attracted people from different corners and developed as 'a complex agglomeration of built fabric'.[7] Underlying mound and standing ramparts of the city guide to visualize and stitch the past scenes together to understand the sequential 'built and rebuilt' event with the following objectives:

- to establish the link between different historical phases and events.
- Visualization of architectural style creating '3D impression' to symbolize the structural specialty.
- to recreate the story of the past for knowledge sharing and awareness among the people for better preservation and management in future.

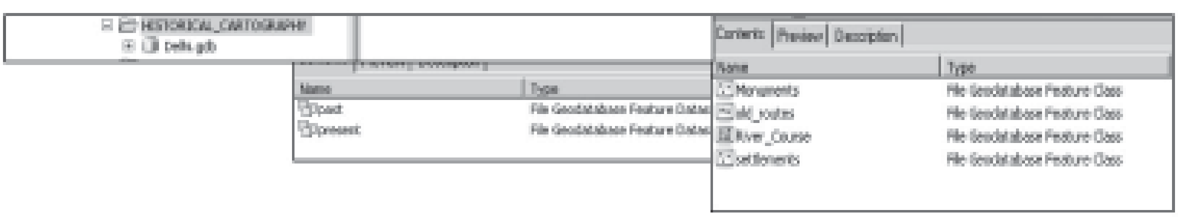
METHODOLOGY & DATABASE

The methodology adopted for this study, has been illustrated in Fig1. For replicating the past scenario through the mean of cartography, proper understanding of 'the then' set up is required firstly. Delhi is one of the ancient historical and greatest cultural cities of the World .The high rise buildings now stand check-by-jowl with Delhi's 1,300 historical monuments.[8] In the process of analyzing the monuments from a perspective of its historicity, the 'now' & 'then' setup has been visualized with the help of digital cartography and Geographical Information System. The study is based on secondary source of data which has been collected from different study and research materials and authenticated data of different publications of Archaeological Survey of India and some physical observation and verification.

In this study mappable data has been derived from secondary sources. A geodatabase schema has been designed (Fig 2) specifically for the purpose to store, manipulate, analysis and retrieval of data. The data has been structured using Geographical Information System with the support of ArcGIS 10.1 environment.

DISCUSSION AND ANALYSIS

Total work has been executed in 3 different phases (Fig 1) – 1. Conceptualization, 2. Data Structuring and 3.Visualization. This study is initiated with thorough literature review to understand the background process and to visualize 'the then' setup. In the next



stage the conceptualized information has been transformed into map able information with the help of proper structuring of the data. Visualization of data from different perspective is the output of the final stage.

Conceptualization

Delhi witnessed a lot of changes over the ages and the monuments standing in the city are the sole representative of the past. The architectural forms and styles reflect how the influence of time has left its the signature over the monuments. Delhi has started its story long back when Pandavas used to live in Indraprastha (the site of Purana Qila) and has witnessed succession of different powers, glory and then the ruins. Present day Delhi has carefully preserving its history in manifolds. Due to the advantageous location of Delhi, it was explored and conquered repeatedly by different powers and clans. They ruled Delhi in different stages and left their signature on the landscape of Delhi. The monuments of Delhi has covered a wide range in the time scale starting from the age of Pandavas to Present. Map1 is illustrating the change in position of Delhi City as it was perceived to gain the strategic control of rulers of Delhi of different times.

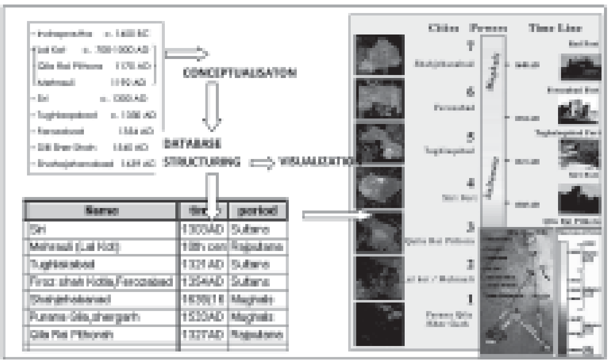
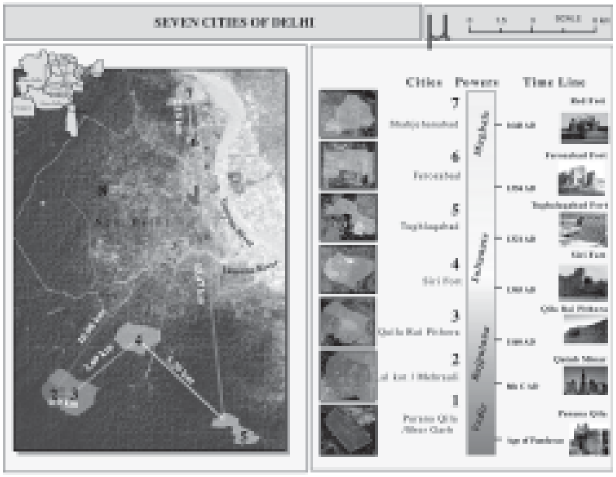


Fig 3 : Work Phases – Conceptualization, structuring & Visualization

In Fig 3 illustrates the work flow in 3 different work phases with an example of walled cities which are still standing today with a historical time stamp and considered as 'protected' city remnants. Mapping of Monuments include those 'Old' cities considering the fact that in accordance with the change in power in Delhi Masnad, the location of cities have been changed with the influence of change in administrative power and control & will & strategy of the then rulers of Delhi (Map 2).

The Purana Qila is presumed to be in the place of 'Pandavas' and it treated as the 'first city of Delhi'. the Purana Qila standing today, was the creation of Sher Shah when he wrested Delhi from Humayun in 1540,the second Mughal king.It was originally being built by Humayun as his capital Dinpanah. Sher Shah



Map 2 : Showing 7 Cities and their Remnants

razed Dinpanah to the ground and started building his own capital introducing ornate elements in architecture and named it Shergarh Delhi was won back by Humayun not very many years later in 1555 and he completed parts of the Purana Qila left unfinished by Sher Shah.The ruins of Humayun and Sher Shah's creations 'Dinpanah and Shergarh' are standing on the plinth of 'Indrapet' of Pandavas with the layers of history as Purana Qila today.

In 10^{th} century AD , Tomar king Anangpal built the first Rajputana city 'Lal Kot' In 1160 AD, the Chauhan rulers took over Delhi from Tomars, along with it the fort city of Lal Kot, the first extant city of Delhi. Thereafter Prithviraj Chauhan whose capital was Ajmer in Rajasthan, enlarged the Lal Kot, which had large rubble walls and ramparts, and renamed it Qila (Fort) of Rai Pithora or Qila Rai Pithora. The combined fort extended to six and a half km, and city existed with the fort, while older Lal Kot served as the citadel. In 1192, his general Qutubuddin Aibak defeated Prithviraj Chauhan in the Second Battle of Tarain, ending their dynasty. This in turn established Muslim rule in India, with his Mamluk dynasty also known as Slave dynasty, the first Sultanate of Delhi. However, Aibak didn't extend or change the fort structure, it remained same through his early successors as well.[8]

Alau'd-Din Khilji started to build his city **'Siri'** in 1303 AD. The 'Slave' dynasty of Qutubuddin was followed by the line of Khilji rulers . Among the six rulers of the Khilji dynasty, Allauddin Khilji is the most well - known -who extended his dominion down southern India too, and created the fourth city of Delhi, Siri.The Saljuqian influences are the most remarkable feature in the buildings from this period.This came about as craftsmen from the Saljuqian dynasty in west Asia reeling under Mongol invasions took refuge in the Delhi court and contributed to its architecture. A large reservoir called Hauz Khas was another accomplishment of city of Siri. A madrasa (college) was also created here

Table 2
Backgrond Database Created in the Phase of 'Data Structuring'

Name	initiated	period1	King_patro	Next_Ruler	time2	period2	time_order
Tughlakabad	Ghiyathu'd-Din Tughluq	Sultans	Ghiyathu'd-Din Tughluq	Ghiyathu'd-Din Tughluq	1321AD	Sultans	5
Siri	Alau'd-Din Khilji	Sultans	Alau'd-Din Khilji	Alau'd-Din Khilji	1303AD	Sultaiyat	4
Shahjehabanad	Shah Jahan	Mughals	Shah Jahan	Shah Jahan	1649AD	Mughals	7
Qila Rai Pithorah	Rai Pithura	Rajputanas	Muhammad-bin Tughluq	Muhammad-bin Tughluq	1327AD	Sultaiyat	3
Purana Qila,shergarh	Pandavas (Indrapat)	Vedic	Humayun	Humayun	1533AD	Mughals	1
Mehrauli (Lal Kot)	Anagpal	Rajputanas	Anagpal	Anagpal	10th c	Rajputanas	2
Firoz shah Kotla,Ferozabad	Firuz Shah Tughluq	Sultans	Firuz Shah Tughluq	Firuz Shah Tughluq	1354AD	Sultans	6

Table 2 Succession of Powers

Name	initiated	period1	King_patro	Next_Ruler	time2	period2
Siri	Alau'd-Din Khilji	Sultans	Alau'd-Din Khilji	Alau'd-Din Khilji	1303AD	Sultaiyat
Mehrauli (Lal Kot)	Anagpal	Rajputanas	Anagpal	Anagpal	10th c	Rajputanas
Tughlakabad	Ghiyathu'd-Din Tughluq	Sultans	Ghiyathu'd-Din Tughluq	Ghiyathu'd-Din Tughluq	1321AD	Sultans
Firoz shah Kotla,Ferozabad	Firuz Shah Tughluq	Sultans	Firuz Shah Tughluq	Firuz Shah Tughluq	1354AD	Sultans
Shahjehabanad	Shah Jahan	Mughals	Shah Jahan	Shah Jahan	1649AD	Mughals
Purana Qila,shergarh	Pandavas (Indrapat)	Vedic	Humayun	Humayun	1533AD	Mughals
Qila Rai Pithorah	Rai Pithura	Rajputanas	Muhammad-bin Tughluq	Muhammad-bin Tughluq	1327AD	Sultaiyat

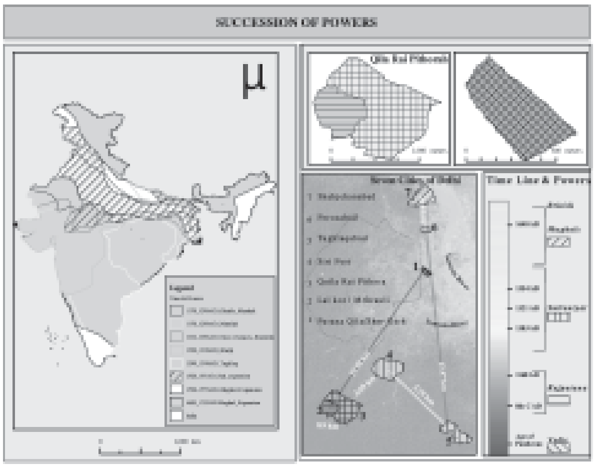
by later rulers. Hauz Khas today is a complex of chic boutiques against the ruins of an ancient fort while Siri is represented by stretches of thick stone walls.

In this sultaniyat age the fifth city has been built up at **Tughlaqabad** in 1321. In the 1320s Ghiasuddin Tughlak , a Turk Governor who had his strong hold in the western provinces invaded Delhi, and won it from Nasiruddin Mohammed. Tughlak, known as a headstrong tormenter, created the third city of Tughlakabad. He created a fort here (the splendid ruins still remain) with high fortifications.

Mohammad Tughlak, descendant of Ghiasuddin Tughlak, went on to capture much of India. He also raised a city, 'Jahanpanah', which largely comprised a walled enclosure between Qila Rai Pithora and Siri.

One of the Tughlak rulers, Firoze Tughlak created the '**Firozabad or Kotla Firoze Shah'** next to the river Yamuna. This was a large enclosure of high walls, containing palaces, pillared halls, mosques, a pigeon tower and a water tank. On the top of his palace, Firoze planted an Ashokan pillar from 1500 years ago. He also built several hunting lodges in and around Delhi, as well as mosques, some of which still remain. Apart from raising new buildings, Firoze Shah also repaired old ones,such as Sultan Ghori's tomb,Qutub Minar,Suraj Kund and Hauz Khas.

Humayun's son Akbar is known as one of the greatest Mughal emperors . However, he concentrated his construction feats in Agra and the later abandoned city Fatehpur Sikri. It was his grandson Shahjehan, The man who gave the Taj Mahal to the world, who created the city of '**Shahjehanabad'**, the seventh city of Delhi - in the area that is now known as Old Delhi. The Jama Masjid and the Red Fort are two excellent examples of the architectural splendour of the 17th century.



Map 3 : Succession of Powers

Data Structuring

All the '7 old cities' of Delhi witnessed the rise & fall of power through a periodical stretch of time. Successions of Powers, Strategic deviation in the ruler's perception have left signatures on those remains of history. These monuments are the silent witness of history which can be unraveled with an attempt to fit the historical sequences properly in the extended time frame. In Table 2 showing glimpse of a data base which has been designed to cover up all the historic information attached to Delhi cities with a support of relevant fields. The database is filled up with the fields like 'initiated'(initiated by the ruler), 'time1' (time when it has been plinth) , 'period' (the power rules over at the time of initiation), 'time order' (based on sequential development), 'Next_Ruler' (who contributed further in later ages of development of the pre existing city or its remnants), 'time2' (later age of development by the 'Next_Ruler').Map2 has been prepared considering four fields namely 'initiated', 'time1', 'period', 'time order'.Map2 is showing the 'early age' time stamp on the Delhi Cities with an overview of the change in political power scenario.

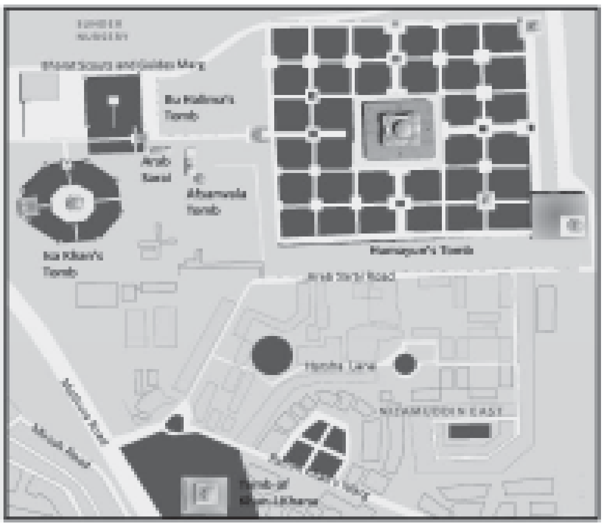
Data Visualization

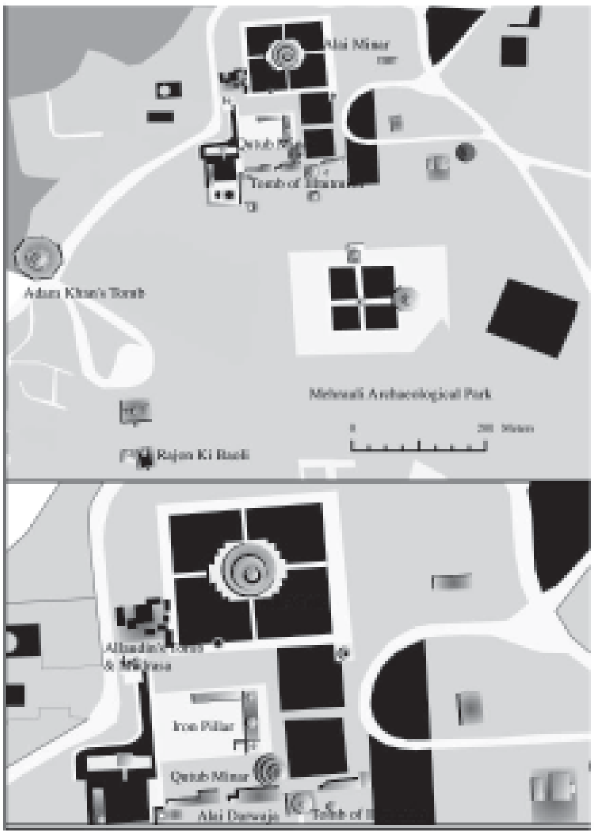
Living in the age of 'neocartography' & 'geovisualization' it is regardless to ignore the fact that 'Neocartography should be a chance to broaden the discipline by embracing revived interest in maps. This should be an inclusive approach that includes all aspects of visualizing geospatial information regardless their diverse labels – be it *Geovisualisation*, *GIScience*, or the very traditional understanding of cartography'.[9]

'Monument' is a special type of structure that was explicitly created to commemorate a person or an important event, sometimes it acts as a 'key to the past' and sometimes it reflects the 'art and architectural aspirations' of the founder.

Map is the reflection & representation of the real world. 'Monument' which is structurally, artistically different from the general land use and landmarks, in the mapping approach its structural uniqueness should be taken care of without compromising its speciality.

Immense power of visualization can be utilized in case of historical mapping with an emphasize to the architectural form of the features to be mapped. In this study Delhi Monuments are mapped from different perspective to represent its spatio-temporal distribution, historical aspects etc. Beside that the 'structural speciality' has been attempted to visualize creating '3D impression' of the structures to make it more reflective of the reality.





Map 4 : Humayun's Tomb (Left), Qutub Minar (Right)

Bird's Eye view combined with symbology and Annotation creates a realistic representation of The historical monuments as it has been depicted in Map 4.

CONCLUSION

This research area has promising future to explore our history in a better and communicable way. The present era of geo-visualization when we are emphasizing to plan our future, there is really a requirement to look back to our past for better understanding. Geo Spatial Technology will play a significant role to connect the past with the present through flash backs. The scope of the study is not only limited to the visualization of the past rather it emphasizes the necessity for future protective measures to be taken. It will help people to understand the unrecognized corners of our city environs. General awareness regarding the importance of those abandoned 'past structures' will make people more sensible towards the conservation. In a true way those 'Protected' labels will stand meaningfully to those monuments only after the mass awareness will come from each and every label. The Past story is retold and re-sketched with a concern to preserve and protect these 'silent witness of the history'- the Monuments.

Note

1. Benjamin Hennig (2012). From Geovisualisation to Neocartography: Maps in a digital world
2. *D.G. Dickason (2011). The Future of Historical Cartography*
3. W. Faulkner (1951). Requiem for a Nun. New York: Random House.
4. Sir Charles Lyell. (1830) *Principles of Geology* .

5. F. Fiorillo, F. Remondino , S. Barba , A. Santoriello , C.B. De Vita , A. Casellato
6. Dr. Madan Mohan (2004)
7. Madan Mohan(2004)
8. Madan Mohan(2004)
9. Tracy, (2000)

REFERENCES

1. R Nath – Monuments of Delhi- A Historical Study.
2. Surendranath Sen – Delhi and its Monuments
3. Narayani Gupta& Laura Sykes- Delhi ,Its Monuments and History
4. Rakhshanda Jalil-Invisible City
5. Archaeological Survey of India- Monuments of Delhi
6. Madan Mohan, Historical Information System for Surveying Monuments and Spatial Data
7. Modeling for Conservation of Cultural Heritage in Delhi, 2004
8. Benjamin Hennig (2012). From Geovisualisation to Neo Cartography: Maps in a Digital World
9. D.G. Dickason (2011). The Future of Historical Cartography

CARTOGRAPHY: AN INVESTIGATIVE CONTRIVANCE OF BRITISH COLONIAL EXPANSION IN INDIA- SOME VISUAL IMPRINTS

Twisha SINGH[1]

ABSTRACT

Though the era of modernisation is often equated to the British control of India that had also produced a vast body of systematic knowledge of Indian culture and society, yet the interest of the colonial rulers was paramount in the cartographic representations of that period. Cartography during the early British expansion was reflective of the colonial ambitions in India, ie. conquest and expansion, administration and extortion to serve the interest of the imperial powers. Hence embedded in the cartography of that period were certain interests, biases, inclusions, omissions that effective portrayed power structures in the context of continuously changing space-place relations in India.

The paper is an attempt to trace the development of cartography in colonial India involving a series of innovations in mapping technologies including the early mapping efforts, introduction of surveying and production of maps as investigative tools for fostering imperialist ideologies. With the inauguration of the journey of British rule in India in the aftermath of the Battle of Plassey (1757), marked the era of surveying in India and field survey methods evolved as a precursor to scientific map making.

The early mapping efforts under British imperialism include the Bengal Atlas and the Map of Hindoostan (1788) by Sir James Rennell (Surveyor General of Bengal) that was compiled from the evidences of various route surveys. However, with the beginning of scientific surveying and mapping in the early 19th century, the British began to confront numerous problems on measurements as also newer and newer territories were converted into the British Empire in India.

Though right from the beginning, colonised spaces in India had been envisaged and conceived as revenue generating ones, modern surveying unfolded gradually different purposes of the imperial hegemony. These include military surveys that were necessary for the advancement of troops into newer areas, to mark routes for supply and encampments as well as for military fortifications. Survey methods like the plane table, triangulation etc thus started during this period. The other surveys simultaneously introduced during this period include the topographical survey (Colin Mackenzie); the trigonometrical survey (William Lambton, Everest) and the revenue survey.

The topographical surveys were just not related to territoriality or fixing up boundaries and placing inventories of terrain, people and places; but in reality represented a collection of the statistics of people and resources that could be administered effectively, exploited and also could be placed under surveillance for effective control. In similar lines was the Great Trigonometrical Survey with the rhetoric of accuracy that came more into prominence with the obsession of precision by Everest.

Colonial mapping thus was based on the early surveys introduced by the British in India. Some of the early maps were highly colourful representations of the Indian subcontinent with different colours portraying the colonial hegemony. The choice of colours conveyed different messages. For instance, the pink and red spaces reflected the territories permanently administered by British while the native states and territories were coloured yellow. Sometimes an intense red or bright pink were administered that reflected British expansion and supremacy almost overshadowing the pale yellow of politically weaker Indian princely states.

Nevertheless, the initial attempts of mapping India and the imposition of imperialist tendencies had serious problems. The accuracy, scale, map projection compatibility are some of these. More importantly strong interests in certain regions dominated mapping exercises; while other areas and pockets were left as blanks.

Keywords: *Cartography; Imperialist; Surveying; Trigonometrical; Surveillance*

INTRODUCTION

British imperialism in India started a very ambitious project in the Indian sub-continent marked by conquest, administration, rule and consolidation, resulting in the formation of a vast region historically known as the "Indian Empire". This necissated the production of substantial knowledge base of the land, resources and people of this sub-continent and hence started off the imperial efforts of surveying and mapping of the Indian subcontinent by the British. A series of surveying and mapping operations therefore were initiated by the British during the 19th century

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as newer and newer territories came under the colonial rule. At each step of this enormous effort, the tools and techniques of cartography employed by the Britishers were refined and rejuvenated resulting in increasing efficiencies in capturing data and information. The ultimate output was in the form of a vast body of information and knowledge of the land and people of India and that of its culture and society. Cartography during the British expansion was reflective of the colonial ambitions in India, ie. conquest and expansion, administration and extortion to serve the interest of the imperial powers. Hence embedded in the cartography of that period were certain interests, biases, inclusions, omissions that effectively portrayed power structures in the context of continuously changing space-place relations in India. Nonetheless, such pioneering efforts made India prominent in the world map and also contributed to the important source materials for historical writings of that period.

OBJECTIVES

Of the various "investigative modalities" outlined by Bernard Cohn (1988) through which the British generated knowledge about the Indian society, cartographic knowledge and representation assumes tremendous significance. The paper is an attempt to trace the development of cartography in colonial India involving a series of innovations in mapping technologies including the early mapping efforts, introduction of surveying (topographical, military, trigonometrical and revenue) and production of maps as investigative tools for fostering imperialist ideologies. The aim here is also to reflect on the British cartographic efforts that portrayed development of the underdeveloped thereby emphasizing and justifying the need for colonial rule in India. The role of colours and symbolisation used in mapping has also been explored so as to relfect the contested spaces and power structures of the British Empire in India.

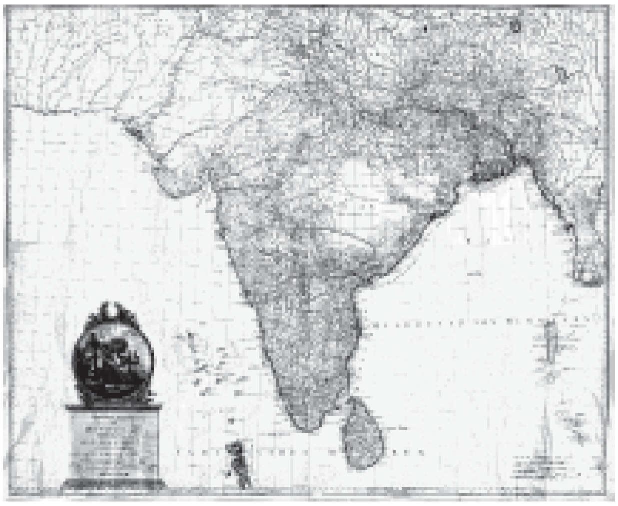
DISCUSSIONS

With the inauguration of the journey of British rule in India in the aftermath of the Battle of Plassey (1757), marked the era of surveying in India and survey methods resulting in the generation of factual data, evolved as a precursor to scientific map making. Scientific surveying and mapping in India developed in consonance with central idea of expansion and consolidation of the British territories in India. Thus the Survey of India was set up with this objective in 1767 and became famous due to the pioneering gigantic survey known as the Great Trigonometrical Survey under William Lambton and George Everest.

The Early Cartographic Efforts

The early mapping efforts under British imperialism include the Bengal Atlas and the Map of Hindoostan (1788) by Sir James Rennell (Surveyor General of Bengal) that was compiled from the evidences of various route surveys, though the first modern map of India predates the Map of Hindoostan and was prepared by a French Geographer – D. Anville. This map is based on the knowledge of travellers. However, Renell's name figures in the history of modern cartography of India as the forerunner of modern survey methods and he is popularly known as "The Father of Indian Survey". His application of surveying techniques in Bengal and Bihar (measurements of the actual distance by the chain method and point observations of latitude and longitudes) laid the rudiments of the first modern map of India. Though the Map of Hindoostan was first published in 1782, there were three subsequent editions followed by the final production in 1788 titled as "Memoir of a Map of Hindoostan". With each subsequent attempt of this map, Renell included additional information than the earlier one. However, with the beginning of scientific surveying and mapping in the early 19^{th} century, the British began to confront numerous problems on measurements as also newer and newer territories were converted into the British Empire in India. Also, a cartographic representation embodied the incorporation of scales comparing the map with the ground realities. This needed the fixing of boundaries and filling up of the empty inner spaces of the map. These posed considerable challenges to the early mapping efforts in India.

British surveyors also confronted difficult ground situations in terms of the heat and humidity, torrential rainfall, forests and wild animals, snakes, diseases, pests, hazards and hostile local inhabitants and other such hinderances. But this did not deter them from their war of expansion, consolidation and rule. The indigeneous systems operating in different parts of the country and also available through historical texts ans reports were translated and used. Thus historical information of the land and the people, tenure systems etc was repackaged during the colonial rule and used with scientific rationality, later to be replaced by the Europen systems. This was particularly true of land measurements. In a nutshell, the British were capable of using every bit of inofrmation availble in that period to enhance their attempts of cartography and map making.



Neueste Karte von Hindostan (after James Rennell)

In outlining the divisions of the Map of Hindoostan, that were then under the company possessions Rennell even presented the company receipts and disbursements from Bengal, Bombay and Madras indicating also the total net revenue in India Rennell's cartographic exercise hence needs to be read as a statement of political intensions, and as yet an unaccomplished task – the task of conquest and the establishment of a "revenue state" which like all other endeavours needed to be reckoned in terms of the costs and benefits. The topographical surveys were just not related to territoriality or fixing up boundaries and placing inventories of terrain, people and places; but in reality represented a collection of the statistics of people and resources that could be administered effectively, exploited and also could be placed under surveillance for effective control. For this purpose Renell had also gathered information from the Ain-i-Akbari by Abul Fazal, translated by Gladwin and History of Nadir Shah by Frazer and hence worked on the administrative units / revenue generating units. Thus the 'Subhas' of Akhbar were further divided into 'circas' and 'purgunnahs'. Thus right from the early efforts of mapping colonised spaces were predominately perceived as revenue generating ones (U Kalpagam, 1995).

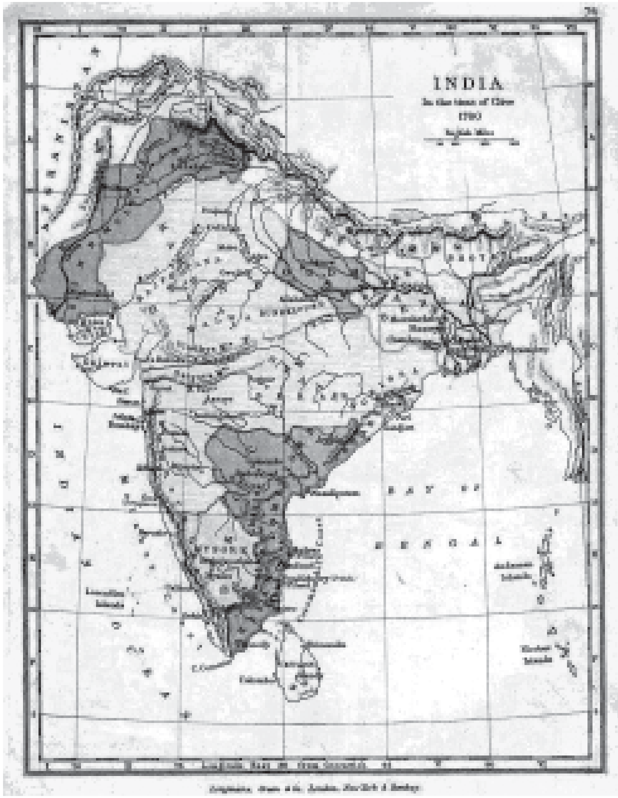
Early 19th century marked the beginning of the scientific surveying and mapping in India. The British cartographers confronted certain problems as the task of mapping an alien territory was not easy and there existed several technical problems. Also, the British confronted cerain methodological problems particularly the choice between the western techniques and the existing indigenous methods. The British ambition of colonial expansion was expressed in three steps. The first was defining the territory, followed by fixing of the boundaries and then making the inventory of the land and the people within the delimited boundary. The topographical surveys therefore started the survellience of science and statistics of the land and people of the British territory in India and the name of Colin Mackenzie stands out as the forerunner of such scientific investigations. The topographical surveys of Colin Mackenzie therefore incorporated three major aims. The first one was the incorporation of the objectives of scientific enquiries, the second was the collection of the tropical specimens and finally the collection of the data / statistics of the land and the people who could be effectively governed and exploited. Thus when Mackenzie was appointed as the Surveyor of Mysore, it was made clear to him that such surveys should go beyond geometrical and geographical aspects and should be extended to a "statistical account of the whole country" (Phillimore 1950:91).

Though right from the beginning, colonised spaces in India had been envisaged and conceived as revenue generating ones, modern surveying

gradually unfolded different purposes of the imperial hegemony.

These include military surveys that were necessary for the advancement of troops into newer areas, to mark routes for supply and encampments as well as for military fortifications.

Survey instruments and methods like the plane table,



theodolite, triangulation etc thus started during this period. The other surveys simultaneously introduced during this period include the topographical survey (Colin Mackenzie); military surveys; the trigonometrical survey (William Lambton, Everest) and the revenue survey.

Topographical Surveys

Scientific basis for data generation resulting in the amalgamation of science, statistics and survellience resulted form the famous Survey of Mysore by Colin Mackenzie. This included a mathematical part (consisting of geographical and geometrical components) as well as a physical survey part. In the intial phase delimitation of the boundaries was done with scientific precision. In addition, a series of primary and secondary stations was located throughout the Mysore state. This served as the foundation stone for the entire country for locating each and every geographical / administrative entity arrording to their correct bearings to be preserved for reference and verification at a later point of date. However, the British still could not overcome the idea of an additional agricultural survey in addition to the topographical survey. Apart from scientific facts, Mackenzie also collected several evidences for recontructing history as part of his mapping endeavour. The final maps were produced in 1808 in the form of an Atlas of south India and hence, the Mysore exploration became a model for future mapping based on scientific surveys in the country under the British; and similar surveys became a regular part of the Brith hegemony in India.

Military Surveys

The Madras Military Institution also started the military surveys for the movement and location of troops as part of the colonial expansion. All through this period surveys became based on instruments such as the plane table and the theodolite enabling large scale mapping and also incorporating more precision in such exercises. The militarisation of geographic knowledge exemplifies how cartography was used as an investigative contrivance perfectly suited to the British colonial interests in India. "The survey by planetable superceded or supplemented Mackenzie's system of theodolite traverse according to the nature of the ground. The surveys were on a large scale of four miles to an inch" (U kalpagam, 1995). Though the Madras Military Institution was closed in 1816, yet in the history of cartography, it made a valuable contribution to the factual base of southern India. Military surveys initiated by the British were ultimately linked with the trigonometrical survey, the acquired over riding importance over other surveys due to pursuance by Everest.

The Great Trigonometrical Survey

Furthering the control over the Indian Empire and promoting the British imperialist agenda in India can be seen in the refinements in surveying beyond the traveller's analogue in India. The trigonometrical surveys ushered in further precision and accuracy since these were based on lines of latitudes and longitudes using trigonometrical calculations based on the Central Meridian or Greenwich. The triangulation method preceded the trigonometrical surveys and Lambton's and Everest's name stand out in this respect. This method "entailed fixing a base point and then carrying forward a series of triangles in different directions, the base lineswere to be done by actual measurement. This was considered a superior way of unambiguously fixing places" (Kalpagam, 1995). The actual work of the great trigonometrical surveywas commenced on 10th April, 1802 by the measurement of a base line near Madras (Prithvish Nag, 2016). Almost the entirety of peninsular India (south of the Krishna river) was covered through traingles by William Lambton in between 1802 1nd 1815. In 1822 George Everest joined the trigonometrical survey and extended the triangulation method in western India. The Great Trigonometrical Survey thus formed the basis of advanced or scientific cartography in India based on instrumentation. "William Lambton, the prime mover of the Great Trigonometrical Survey, had a special theodolite (a surveying instrument with a rotating telescope for measuring horizontal and vertical angles) shipped to India from Britain. At one point the ship that carried this great theodolite was actually captured by the French, who graciously repacked it and sent it on". (Ian J. Barrow, 2003). Lambton's effort was taken forward by Sir George Everest and then by Andrew Scott Waugh followed by James Walker. The first completion of this project took place in Walker's time in 1871.

Surveyor's Pocket Compass

The imperialist agenda is also clear in Barrow's description "It's surprising but true that cartography in the 19th century in India was actually the most advanced in the world. Other nations, such as Britain, were not mapped to the extent that India was". Surveys were not only scientific but efforts were made to make them as intensive as possible. "The Astronometrical Observation at Madras was selected as the origin to begin work with the primary reference station. After connecting both the sides of the

The Great Trigonometrical Survey: Map of India

enlightened patron because of its rigorous and scientific nature…. This rhetoric of scientific progress and improvement was a significant factor contributing to the character of colonial rule in India during the nineteenth century. The survey not only helped the state gather information and knowledge, it also —and this was its greatest advantage over route surveys— added legitimacy to colonial rule by making it seem that this form of science in India would not only result in India's progress but would also improve geodesy." (Ian J. Barrow, Making History, Drawing Territory, 2003, p. 83-84).

In addition, the British also followed a protectionist policy of all data recording stations / bench marks initiated and in 1866 by imperial order, it was decided that all stations of Great Trigonometrical Survey should be placed under the official protection of district magistrates and visited periodically. Thus the Great Trigonometrical Survey resulted in the provision of scientific data for the whole country that enhanced cartographic exercises in India and provided a rationale for other surveys as well.

Revenue Surveys

The revenue surveys were the heart of the British interest in India as they provided information on the size of the landholdings, productive potentials and the nature of ownership. However, a number of problems confronted the British in conducting the revenue surveys. The foremost of this was the conflict between the various indigenous method employed in the country during that period. Introduction of the European method therefore provided a challenge before the colonial administrators. Indigenous methods of revenue surveys incorporating land measurements were used in the Bengal Presidency. The British decided to introduce a permanent settlement i.e. decisions made in 1793 to form a permanent assessment for all times to come. The permanent settlement was also decided for the

Johnson's "Hindoostan" Map - 1864

1902 map of India, then a colony within the British Empire

A map of the British Indian Empire in 1909 during the partition of Bengal (1905–1911), showing British India

peninsula as mentioned above, Lambton concentrated himself to the measurement of an arc of meridian. The series measured for this purpose is known as the **"Great Arc Series"** (Prithvish Nag, 2016).

Ian Barrow states: "there was a sense among surveyors and the East India Company's high bureaucracy that trigonometrical mapping would enhance the reputation of the Company as an

Madras presidency. But this posed considerable problems as small landholdings prevailed in many parts of the country necessitating a different method of assessment. Alexander Read embarked on the task of revenue settlement in the south following the defeat of Tipu Sultan. Read's method entailed detailed survey based on the ryots for a couple of years and also incorporated field measurements by 'amins' working under the British officers and the Indian supervisors. Read's method was corrected by Thomas Munro (one of Read's assistants) and he became famous on this count. Both the contributions of Read and Munro resulted in revenue assessment and collection far more efficient for the British who were alien and had to familiarize themselves with the indigenous systems and practices. This resulted in effective exploitation by the colonial rulers and maximum extraction for land ensued in due course of time. At a later date to extend the perfectionist theory and in order to bring permanence in the revenue surveys as well, the British connected the revenue surveys with the triangulation method and with the trigonometrical surveys.

CONCLUSION

Colonial mapping thus was based on the early surveys introduced by the British in India. As more and more knowledge was being generated, more refinements were introduced in the surveying techniques so as to capture more information of the land and the people for purposes of revenue generation, taxation, governance and territorial expansion. The British mapping technologies and in particular, the early mapping efforts shows the "development of underdevelopment" by the colonial regime, thereby placing the requirement of unstructuring British cartography in India in the present paper. The messages that were conveyed through the maps were also very specific as some of the early maps embodied colonial hegemony and supremacy in that they were colourful representations of the Indian subcontinent. "The choice of colours conveyed different messages. For instance, the pink and red spaces reflected the territories permanently administered by British while the native states and territories were coloured yellow. Sometimes an intense red or bright pink were administered that reflected British expansion and supremacy, while the pale colours were used for representing the politically weaker princely states. The belief that the persuasive and convincing capacity of cartographic representations could help structure of nationality and imperial identity, promoted the systematic production of maps first under the East India Company and later under the British Government in India. Maps emphasized the colonial shaping and logical re-organisation of territory to make it politically coherent and administratively manageable, portraying the development and modernisation of this colony through networks of communication, railways, roads and urban growth. From the perspective of Government, maps were essentially administrative goals and key instruments of colonial control and domination, symbols of power and propaganda, manipulation and subjection" (Arundhati Virmani, March 2013).

Nonetheless, the story colonial cartography exemplifies that in the quest of domination and rule, the British confronted indomitable problems in gathering knowledge about a country that was almost unknown and alien. Not only this, but a country that was abound in diverse topography, high mountains, forests, wildlife, heat, humidity, torrential rainfall, pockets infested with malaria and other such problems quite unanticipated by people from temperate habitations.Yet, scientific progression in map making continued through topographical, revenue and military surveys and specially the triangulation method that was introduced in India at an early date. This ultimately paved the road of a rich legacy of modern map making based on scientific rationality in the subcontinent, later to be easily taken forward by the Indian cartographers. The British tradition of map making is so embeded in the subcontinent that it continued for decades in India, even after independence, until the recent inroads of digital technology and modern mapmaking.

REFERENCES

1. Barrow Ian J. (2003): *Making History, Drawing Territory: British Mapping in India, c.1756-1905,* Oxford University Press, India, ISBN-10: 0195665465, pp. 225.
2. Kalpagam U. (1995): *"Cartography in Colonial India"* Economic and Political Weekly", July 29, 1995, pp. PE87-PE98.
3. Markham Clement R. (1871): *A Memoir on Indian Surveys* W.H. Allen and Company, London.
4. Mukherji Chandra (1983): *From Graven Images: Patterns of Modern Materialism,* Cambridge University Press, New York.
5. Nag Prithvish (2016): *Indian Geospatial Infrastructure,* Bharati Prakashan Varanasi, ISBN -978-93-80550-83-1, pp. 220
6. Nag Prithvish (2003): **"***The Great Arc*"; Department of Science and Technology, Government of India, New Delhi.
7. Virmani Arundhati (2013): *"Asthetics in Cartography: A More Democratic Access to Information?"* Part of an occasional series on 'The Political Aesthetics of Power and Protest,' the subject of a one-day workshop held at the University of Warwick 2012 pp. 1-5.

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CARTOGRAPHY: A HISTORICAL REVISIT "TECHNOLOGICAL INTERFACES FOR ENHANCED PERFORMANCE IN THE FIELD OF CARTOGRAPHY"

Yatish KUMAR[1]

ABSTRACT

In this paper, I engage with the historical perspective of cartography. Modern era has begun with technological revolution. It has made cartographical process more advanced and technical efficient. Cartography is the art and science of making maps. The oldest known maps are preserved on Babylonian clay tablets about 2300 B.C ago. The historical investigation of cartography trends highlights changing pattern in mapping analysis. Modern epoch has been witness to the technical advancement in modern geography.

Geographical information system (GIS) and remote sensing are the two important sub-branches of geography in the contemporary period. Remote sensing is one of the most unique and powerful techniques for geographical representation. Consequently, Lillesand and Kiefer (2004) have describes remote sensing is the science and art of obtaining information about and object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Another technical approached called Geographical Information System (GIS) is a computer based approach for capturing, storing, querying, analyzing and displaying geographic data. In this regards, Geographical information system (GIS) software emerged commercially as a new information processing technology offering unique capabilities of automating, managing, and analysing a variety of spatial data. With the assist of geographical information system and remote sensing the representation of geographical data became finer and more scientific. Integration of GIS with other technologies such as Global Positioning System (GPS) and the efficient internet has introduced new application to investigate the geographic data.

Keywords: Cartography, Geographical Information Systems (GIS), Remote Sensing, Global Positioning System (GPS)

INTRODUCTION

Cartography has been influenced by development of information and communication technologies and geographical thinking. "Cartography was originally an instinctive science, which today has entered a new, revolutionary period in its development. In the modern approach, mapping is understood as the ability to create a knowledge frame of an environment in space"[1]. Today, geographic information systems (GIS) support a wide range of spatial venture; however, creation of maps remains the independent and dominant conception. Cartography is the process of creating maps. It involves gathering of geographical information, storage, processing, and editing of this information, and the presentation of the data in map shape. Cartography will be significantly influenced by the development of information technologies. It seems that it will be above all a service for cartographic visualization of geospatial data processed by GIS technologies. Any study or subject has its own historical importance. Historical analysis of a subject shows their process and development of functional activity. In this context Smith (1996) argued that "history is not and cannot be based on direct experience but only on knowledge by description". According to this paradigm, revolution in electronic technology is rapidly affecting the way cartographers think and work. The use of computers to store, retrieve, display and reproduce geographical data in the form of maps as opposed to enabling more sophisticated forms of analysis. It has been an important feature of computer cartography and GIS since the 1960s. *'Mapping can be considered as a series of transformations from raw data, to cartographic data, and finally to a graphic model of the real world. In this process, map design is a decision process through which a solution or design plan must be adopte[2]'*. Cartography is the making and study of maps in all their aspects. Currently the revolution in electronic technology is rapidly affecting the way cartographers think and work, what gets mapped, and how maps are used (Robinson, et al 1953).

"Cartography is an age-old activity, with the first drawings dating back to 24,000 BC (south Moravia, Czech Republic) or 12,000 BC (the Ukraine). Although there is some doubt over the accuracy of these European assertions, there is more agreement over the Chinese, cadastral map from 2000 BC and Catal

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Huyuk city in Anatolia, Turkey, dating back to 7200 BC. Cartography was originally an instinctive science, which today has entered a new, revolutionary period in its development"[3]. In the modern approach, cartography is influenced by the latest technological advances, in which GIS are strongly linked with spatial information infrastructures (SDIs) and various information and communication technologies (ICT) to provide services to millions of users[4].

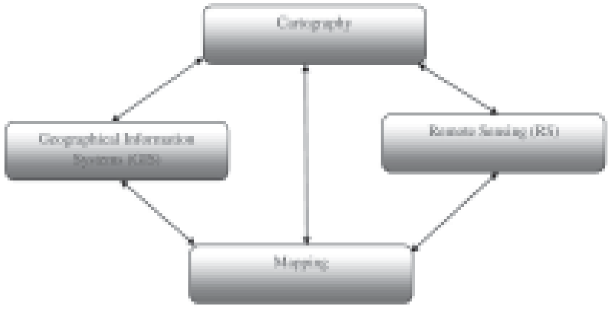

Fig. 1 : Functioning Elements of Modern Cartography

The Impact of Changing Technology

In the modern era, the development of cartography as a science working it down even to small areas and attempting to create visual representations of land on a wide scale. Cartography is the art and science of creating maps. It involves gathering of geographical information, storage, processing, and editing of this information, and the presentation of the data in map form. Furthermore "Beginning in the 1960s, electronic sensor systems were increasingly used for collection and storage of the images, and satellites were developed as an alternative to aircraft platforms"[5].

Aerial Photography

A photograph taken from the air with the camera axis pointing downwards at the time of exposure is known as an aerial photography. These photographs are of immense value particularly for mapping and interpreting the earth surface feature. In the modern time this technique of photography is most popular in various fields. Especially, cartographers widely used these photographs for mapping analysis. Literature based evidences shows, "*aerial photography started approximately in 1858, when the famous photographer Gaspard Tournachon obtained the first aerial photographs from a balloon near Paris. Since then, aerial photography has advanced, primarily during times of war, to first include color-infrared (color-IR) films (for camouflage detection) and later sophisticated digital cameras. Aerial photography and other remote sensing data are being used successfully in agriculture, forestry, land use planning, fire detection, wetlands mapping, beach erosion control, and many other applications*"[6].

Global Positioning Systems (GPS)

'The launch of the low-Earth orbit satellite, Sputnik 1, by the USSR (Soviet Union) on October 4, 1957 may possibly mark the beginning of Global Positioning System (GPS) technology'[7]. The Global Positioning System (GPS) is a constellation of twenty-four satellites, orbiting approximately 20 200 km above sea level, that enable receivers to compute their position anywhere on the earth with remarkable accuracy[8]. The use of Global Positioning Systems (GPS) is a recent phenomenon in modern cartography. The global positioning system (GPS) is a satellite- based navigation and surveying system for determining the precise position and time utilizing the radio signals from the satellites, in real time or in post-processing mode. In the recent time, Global positioning system (GPS) based ground control points (GCP) are used for improving the plannimetric accuracy of the satellite images and generating value added products to facilitate cartographic mapping[9].

Remote Sensing and Digital Cartography.

Remote sensing is a multi-disciplinary activity which deals with the inventory, monitoring and assessment of natural resources through the analysis of data obtained by observation from a remote platform. The growing interest in remote sensing methods may be seen as one of the consequences of the mounting awareness of environmental problems and the increasing realization that these often complex problems are in many respects regional or global in nature. Remote sensing data is being extensively used for natural resource mapping, monitoring and management. Remote sensing today is used in many fields, such as ecology, geography, hydrology, oceanography, meteorology and land use management.

Stages of Remote Sensing

- Origin of electromagnetic energy
- Interaction of energy with the earth's surface
- Transmission of energy from the source to the surface of the earth and its interaction with the intervening atmosphere
- Preprocessing of the data for generation of the data products.
- Data processing and interpretation.

Thus, the remote sensing system consists of a sensor to collect the radiation, and a platform, which can be satellite, rocket, aircraft, balloon, automobiles or even a ground based stand on which a sensor can be mounted.

Application of Remote Sensing

Land cover mapping is one the most important and typical applications of remote sensing data. Among the present and proposed uses of remote sensing are the following: mapping, identification and inventorying of crops and forest vegetation, detection of stress symptoms in crops and forest vegetation, study of soil salinity, detection of forest fires, land use inventorying, urban data acquisition, monitoring of changes in wildlife habitat conditions, detection of water pollution (including oil slicks, algae concentrations, sediment and thermal pollution), detection of air pollution sources and of some pollutants, monitoring of snow fields, glaciers, sea ice and polar ice, monitoring of desert areas and exploration of marine resources[10].

Geographical Information System (GIS) and Digital Cartography

Geographical information systems (GIS) can be considered as the modern form of the geography discipline's spatial tradition, which has been identified as one of four traditions of geography. GIS is now well recognized as a science and can be considered as a relatively new and emerging area[11].

Table 1
Classification of GIS Based Activities

1.	Spatial Data Inputs	• Data entry: create new database system, use existing data files.
		• Data Editing
		• Geometric Transformation
2.	Attribute Data Management	• Data Entry and Verification
		• Digitization and Editing
		• Management of Data Files
3.	Display of Data	• Display the Geographic features through, Maps, Charts and Tables
4.	Data Exploration	• Attribute Data Query
		• Spatial Data Query
		• Geographic Visualization
5.	Data Analysis	• Vector Data Analysis
		• Raster Data Analysis
		• Terrain Mapping and Analysis
		• Spatial Interpolation
		• Network Analysis
6.	GIS Modeling	• Binary Models
		• Index Modeling
		• Regression Models

In the context of GIS, as a technology predicated on geographic data, cartography as a term is now used more to cover the visualization and reproduction aspects, starting from processed data and excluding the earlier stages of building databases and carrying out analysis[12].

Thus, GIS is a computer program or application that is utilized to view and handle data about geographic locations and spatial correlations among others. According to Walford, (1999) GIS is used in two different ways: first, to refer to an integrated system of computer hardware, software, digital geographical data and other forms of IT; and, secondly, to denote a specific application of such a system within a particular organisational context. The evolution of geography information system (GIS) has been intimately connected with the development of communication and information technology. Basaraner, (2016) stated that the analytical cartography has grown in the 1960s from Tobler's concept of 'solving cartographic problems' into a broader and deeper scientific specialization that includes the development and expansion of analytical/mathematical spatial theory and model building.

Applications of Geographical Information System (GIS)

In the early 1980s geographical information system (GIs) software emerged commercially as a new information processing technology offering unique capabilities of automating, managing, and analysing a variety of spatial data[14]. Added to this, both Satellite and airborne remote sensing is now firmly established as a major source of geographic information.

One of the major changes observed is that the cartographers are losing the control they exercised in the past. When the printed map was the sole product, cartographers controlled every bit of information. Users could extract from a map only what cartographers chose to include. With digital technology, the situation is entirely different. Users can select the information they want to include in visualization[15].

CONCLUDING REMARKS

To conclude, I would like to make a few observations. First, during the digital transition phase in spatial data handling, management and use, no uniform consensus was established for the role and the scope of cartographic discipline in spatial arena[16]. Secondly, significant progress in technological expansion has been made cartographic analysis more efficient and effective. Maps play a crucial role in GIS, and geographic information systems are important in modern cartography. The purpose of this paper is to discuss the historical and technological aspects of the modern cartography. The recent technological interventions provide a digital approach to the subject and made it more proficient.

REFERENCES

1 Konecny, M. (2011): "Review: Cartography: Challenges and Potential in the Virtual Geographic Environments Era", *Annals of GIS*, Vol 17, No 3, pp 135-146.

2 Xiao, N., and Armstrong, M. P. (2012): "Towards a Multi Objective View of Cartographic Design", *Cartography and Geographic Information Science*, Vol 39, No 2, pp 76-87.

3 Konecny, M. (2011): "Review: Cartography: Challenges and Potential in the Virtual Geographic Environments Era", *Annals of GIS*, Vol 17, No 3, pp 135-146.

4 Konecny, M. (2011): "Review: Cartography: Challenges and Potential in the Virtual Geographic Environments Era", *Annals of GIS*, Vol. 17, No. 3, pp. 135-146.

5 Klemas, V. (2012): "Airborne Remote Sensing of Coastal Features and Processes: An Overview", *Journal of Coastal Research*, Vol. 29, No. 2, pp. 239-255.

6 Klemas, V. (2012): "Airborne Remote Sensing of Coastal Features and Processes: An Overview", *Journal of Coastal Research*, Vol. 29, No. 2, pp. 239-255.

7 Kumar, S., and Moore, K. B. (2002): "The Evolution of Global Positioning System (GPS) Technology. *Journal of science Education and Technology*", Vol. 11, No. 1, pp. 59-80

8 Nord, G. D., Jobon, D., and Nord, J. (1997): "The Mathematics of the Global Positioning System. *The Mathematics Teacher*", Vol. 90, No. 6, pp. 455-460.

9 Rao, S. S., Murthy, Y. K., and Ammineedu, E. (2004): "Value Addition to the Cartographic Potential of Satellite Data Using Global Positioning System", Journal of Indian Geophysical Union, Vol 8, No 2, pp. 135-141.

10. Dyring, E. (1973): "The Principles of Remote Sensing", *Royal Swedish Academy of Scienc*e", Ambio, Vol 2, No 3, pp. 57-69.

11 Srivastava, S. K. (2013): "Threshold Concepts in Geographical Information Systems: a Step towards Conceptual Understanding", *Journal of Geography in Higher Education*, Vol. 37, No 3, pp. 367-384.

12. Basaraner, M. (2016): "Revisiting Cartography: Towards Identifying and Developing a Modern and Comprehensive Framework", *Geocarto International*, *Vol 31*, No 1, pp. 71-91.

13. Basaraner, M. (2016): "Revisiting Cartography: Towards Identifying and Developing a Modern and Comprehensive Framework", *Geocarto International*, *Vol 31*, No 1, pp. 71-91.

14. Jankowski, P. (1995): "Integrating Geographical Information Systems and Multiple Criteria Decision-Making Methods", *International Journal of Geographical Information Systems*, Vol 9, No 3, pp. 251-273.

15. Robinson, A.H. et.al (1995): "Element of Cartography", John Wiley & Sons Inc, pp. 6-7.

16. Basaraner, M. (2016): "Revisiting Cartography: Towards Identifying and Developing a Modern and Comprehensive Framework", *Geocarto International*, Vol 31, No1, pp. 71-91.

INTEGRATING WEB GIS USING OPEN SOURCE TOOLS FOR NATURAL RESOURCE INVENTORIES: A CASE STUDY OF CHHATARPUR AND SAGAR DISTRICT, M.P. (INDIA)

Randhir Singh REDHU[1], Rajeev Preet SINGH[1]

ABSTRACT

There is a growing needs for cost effective web based GIS for easy and fast spatial information dissemination which helps in decision making for various natural resources based applications. This paper presents a case study of an efficient approach to customize and integrate a complete open source web geographic information system (GIS) that offers fast and globally reachable way to process and represent spatial information through maps and statistics.

Components integrated in the Web application include a spatial database PostgreSQL/PostGIS, a GIS processing engine QGIS, a GIS map server GeoServer, a web server Apache Tomcat and front-end technologies OpenLayers. Open source and unclassified published satellite imagery, aerial magnetic, geology, geomorphology, drainage data layers are utilized. Structural zones delineated from the remote sensing images and aero-magnetic maps indicate favourable targets for minerals exploration in the study area.

With all the components of the GIS integrated in to system, an individual not specialised in the use of a GIS can view, retrieve, query and analyse spatial information.

Keywords: *Web GIS, Open Source, Integration, GeoServer, GeoDatabase, OpenLayers.*

INTRODUCTION

Web GIS refers to application that process and present spatial data through a web browser. Users can query, analyze and download data through the web browser's interface. It is widely used by both public and private organizations because it is a relatively inexpensive way of disseminating spatial data and basic GIS functionality through the web or an intranet. Web GIS enables sharing of geospatial information by anyone, anywhere, anytime and for any purpose whereas Geographic Information System helps in effective management of spatial data[1]. Web-based GIS systems developed by integrating GIS and ORDBMS allow the user to operate the system without having to understand the underlying intricacies of GIS and ORDBMS technologies[2]. Moreover, it would allow sharing of spatial information and technical expertise among varied users.

With the advent of GIS software, interpretation of spatial data has become easy and increasingly simple to understand. But, everyone does not have access to commercial software due to their high cost and steep learning curve. Many organisations are interested to distribute maps and processing tools without time and location restriction to users. Internet has made its way to many government organizations as well as students, researchers etc. The ability to easily disseminate information has made the internet a viable distribution platform[3]. Hence, an attempt has been made with an objective of developing open source web application to share natural resource information through internet.

This paper describes steps and methodologies of integrating Web GIS application using Open Source tools for natural resource inventories as part of search of favourable targets for atomic minerals exploration in the study area. This application is developed by integrating the GeoSever[4] map server, Tomcat Apache[5] web server, OpenLayer[6] web browser Client, Geoexplorer[7] map composer, PostGIS[8] and PostgreSQL[9] object-relational data-base by adopting web based client/server environment. The application described here aims at providing a web-based platform for collaboration and data sharing between specialists, planning agencies, citizens, and private entities[10].

Study area is located in Chhatarpur and Sagar districts of Madhya Pradesh lying between north latitudes 24°00′: 25°20′ and east longitude 79°00′: 80°30′. In this part volcano-sedimentary sequence of Bijawar un-conformably overlie Bundelkhand granite gneiss complex in north and west and is in turn un-conformably overlain by Vindhyan Super Group of rocks in the south.

OBJECTIVE

In the present study, a framework for Web GIS for natural resource inventories focuses on development of open source web application for natural resource management in a web environment enabling use of spatial data even by non-experts, without the need for dedicated commercial GIS software. For this

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study, the natural resources data of Chhatarpur and Sagar district of M.P. have been taken to develop the Web GIS database. Open source Web GIS tools used in this application emphasize on creation of geo-database of spatial information in the study area intended to publish on Web application. This will help in extending the benefit of GIS and Web technology for retrieval of information and making spatial queries of minerals and other resources available to delineate mineral exploration targets based on parameters chosen by the end-user of the system. Integrated WebGIS [11] application facilitate tools to the individual not specialised in the use of GIS technologies to view, customize retrieve, query and analyse spatial information.

APPLICATION DESIGN

The system design selected is based on the choice of the Web client and web map server for the Web-GIS. The Web Client provides the interface that allows the users to visualize, navigate and analyze the geospatial data via the Web. The web map server provides interface for sharing, editing and publishing of geospatial data. Free open source software (FOSS) namely; OpenLayer web clients and GeoServer web map server were selected for this application. The selection of the Web client was based on the certain criteria such as quality of navigation tools provided, capabilities of query and measurement tools, capabilities for scale management and search functionality, ease of interface customization, plugins and functions compatibility, programming languages supported, established community of users and developers, support for the OGC-compliant services, WMS/WFS and data interoperability[4].

Application Architecture and Function

To integrate a subsystems of WebGIS; OpenGeo Suite 4.7.1[12] which includes PostgreSQL9.4, PostGis 2.2, Qgis 2.8, Geoserver 2.6, Apache Tomcat 9 and Openlayers 3 is used since it has a robust and flexible architecture that enables to reliably manage and publish geospatial data. PostgreSQL and PostGIS control the maintenance of a spatial and attribute database. QGIS, a Desktop GIS application is used for creation, edition and analysis of geospatial data. GeoServer is used as server side software which reacts to requests from a web browser through OpenLayers and generates geographical web objects dynamically. GeoWebCache[13] a simple caching engine is used to speed up repetitive requests. OpenLayers toolkit is loaded into the web browser for creating queries to the Geoserver through GeoWebCache. (Fig. 1)

WebGIS Engine

GeoServer is an open source software server written in Java and is the reference implementation of the

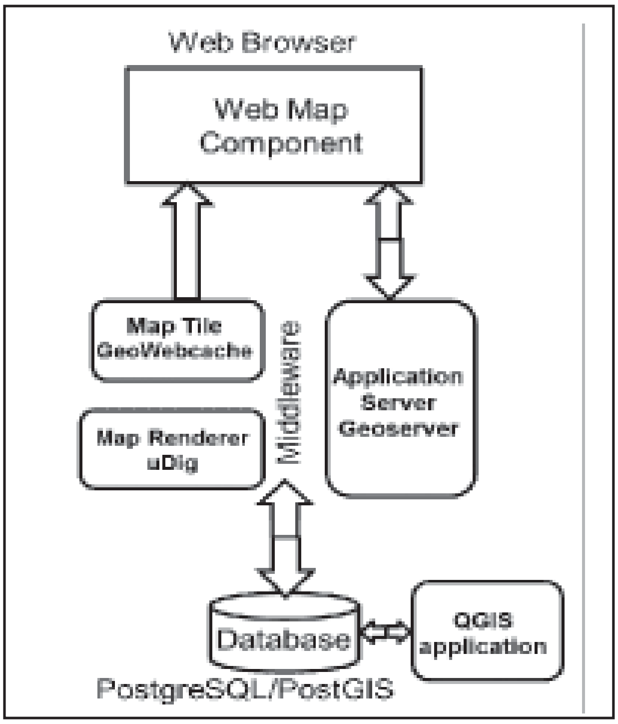

Fig. 1 Web Application Design

OGC Web Feature Service (WFS), Web Coverage Servise (WCS) and Web map services (WMS) that allows users to share and edit geospatial data. It is designed for interoperability to publish data from any major spatial data source using open standards. GeoServer; the GIS engine forms a core component of our application that listens for specific request (by clients). These requests could be for different services e.g. getMap request etc. A GIS server loads a dataset and renders it, cut image into tiles and sends it back to the requesting client. Format of image tiles is specifically selected due to its size.

Data Preparation and Editing

QGIS Desktop GIS provides useful tools for spatial analysis, geoprocessing, geometry, and data management is used in preparing and editing spatial data for the web application. In the first step vector and raster data is generated with the help of QGIS and collected some other from data repositories or from the web are Landsat Imageries, district resource maps and natural earth etc. Map themes namely; geology, landuse, uranium anomalies, drainage, roads, lineaments and boreholes are generated as shape files in QGIS environment and exported to PostgerSQL databse tables in geometry column. These database tables were imported in uDIG Desktop Internet GIS [14] for designing and editing of web map theme styles. uDIG provides tool to create and edit layer styles from range of options including size, color, opacity, filters, and much more. Geospatial layers of each theme were styled as per application requirements using change style function to generate

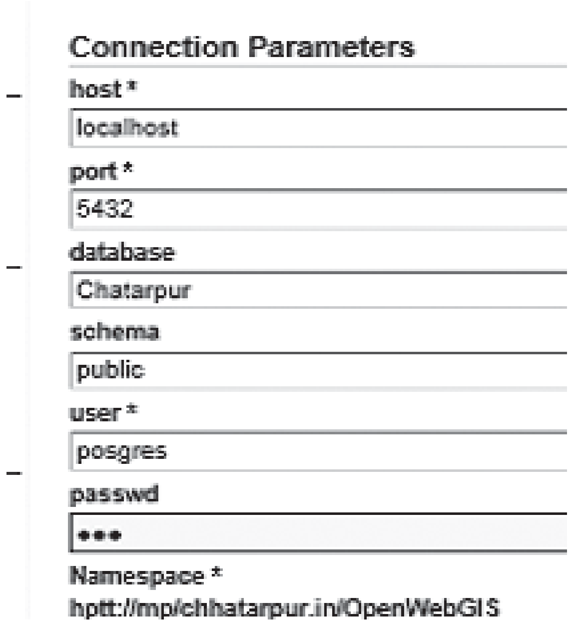

Fig. 2 PostGIS Connection

xml of the layers style codes. The generated xml of style codes are copied and added to GeoServer as layer style. GeoServer stores data layer styles in the data-store and publishes through the web browser client.

Interaction of Geoserver with PostgreSQL/ PostGIS

PostgreSQL high-performance object-relational database management system with PostGIS spatial extension has the capabilities to deal with huge amount of raster as well as vector database. The spatial data of shape files and geotiff files are imported into postgreSQL and stored as raster and geometry database tables respectively; in this way PostgreSQL becomes an indispensable system component from which the web GIS loads data to be displayed as maps. These tables are called by GeoServer using the PostGIS connection (Fig. 2). Each PostgreSQL table has been provided with a geometry or raster columns in which every record has its spatial description. In this way the tables become "spatial tables"[15]. The Geometry Column provides spatial information that has been created by PostGIS automatically with PostGIS Pgshape Loader. For loading spatial tables in GeoServer it is enough to specify in "add datastore" by select PostGIS data source and by specify connection parameters such as viz. (1) host: (2) port; (3) name of the database containing the spatial table to be loaded; (4) name of the schema; (5) user; (6) and password (Fig. 2)

Maps Composition and Publication

Maps were composed and published with GeoExplorer web application. GeoExplorer assemble maps through GeoServer and integrate with hosted maps such as Google Maps and OpenStreetMap. GeoExplorer deployed with GeoServer and PostGIS converts spatial files into PostGIS tables, and then serve that data through GeoServer to map window. Map composition involves loading all the layers you wish to publish, determining layer order, and determining map extent and positioning. Once this is accomplished, maps are saved in a format that makes it easy to embed in any web page. Tools chosen in this embedded map are zoom in/out, selection, attribution, measure, attribute table, query, analysis and layer list.

Compiled Web applications can also be distributed as web archives (WAR files) that are compressed files of web maps that make it easy to handle and distribute spatial data of large area extent.

Building Complete Application

OpenLayer, a JavaScript library allows for putting a dynamic map in any web page. For building new application a new file is created called "webGIS.html" and contents of embedded map code are pasted in it. This file is saved in apps directory. Web application build in OpenLayer can also be distributed as web archives (WAR files). Web archives are the compressed files of web maps that make it easy to handle and distribute spatial data of large area extent.

Web Components Implementation and Testing

The major components of the application portal are categorized into Selection Tools, Navigation Tools, Analysis Tools, Query Tools, Measure Tools. Legend Tools, Search Tools and Layer Manager. Top frame of the web page shows Selection Tools: select rectangle or polygon; Analysis Tools: select within, nearest point, buffer, count features, extract selected features and calculate line length; Query Tools: layer and filter; Attribute Table Tool: displays attributes, Measure Tool: distance, area, remove measurement; About Tool: displays description of the web portal. Various navigation tools: zoom in, zoom out, selective zoom, pan, home and print map tools are included on left side frame of the portal. Legend, layer detail, toggle full screen, search and info tools are the part of right side frame(Fig. 3).

Features on the map can be identified by a click of mouse on the feature, a popup window showing the detail of the selected feature will flash on the screen. Distance and area measuring tool have been included as part of spatial map analysis, that displays measurements of the selected area or length in pop-up window. Query tools perform selections in layers and queries are expressed in filter field using the notation accepted by the Filtrex library. Users can perform queries by selecting a layer from dropdown

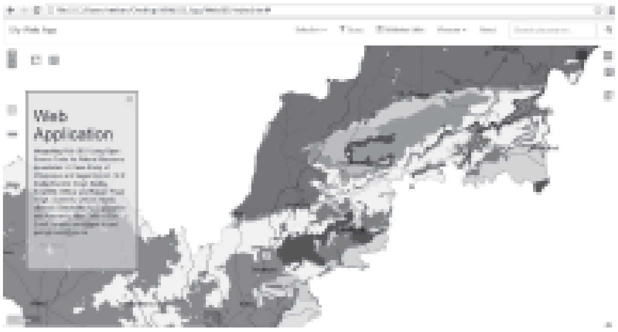

Fig. 3 OpenLayer Based WebGIS Interface.

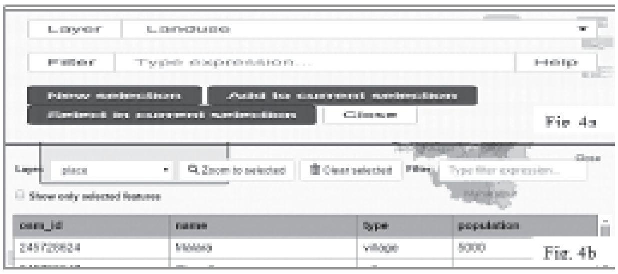

Fig. 4. (a) Query tool; 4 (b) Attribute Table Tool

list and then entering search criteria in filter field box (Fig. 4a). As a result map is highlighted and zoomed in browser window. Attribute table tool displays the layer attributes in a tabular format. Attributes of the layer can be viewed in table by selecting the layer from dropdown list in the field (Fig. 4b). The automatic geo-location of mouse cursor enable user to see the attributes corresponding to the map location when mouse cursor moves (Fig. 4c).

After compiling and deploying the application, testing for each component of the WebGIS framework was performed on both database and application coding levels by running implemented widgets. GeoServer and other software's mentioned herein were installed on local server and this webGIS application was integrated and tested on local server.

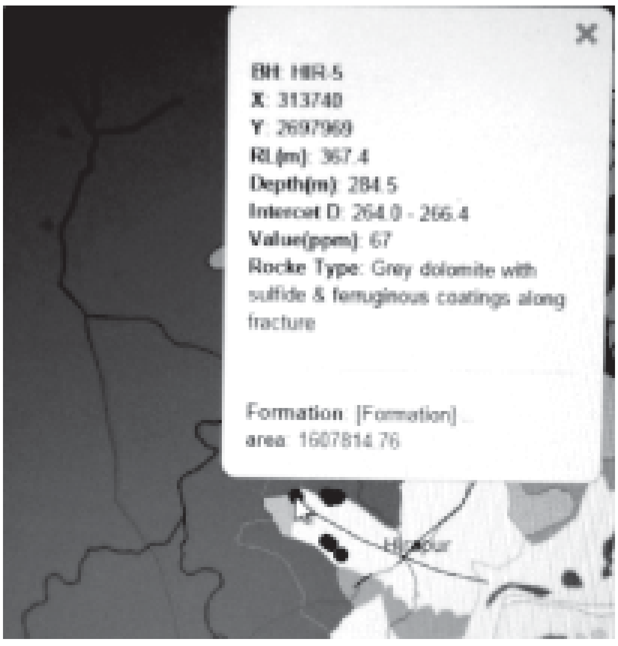

Fig. 4 (c) Auto Identify Tool

RESULTS AND DISCUSSION

This work presents the steps of building the cost effective infrastructure for the growing needs of collaborative efforts in the context of affective management of natural resources. Geospatial web service technologies have been adopted to build the platform for users to efficiently explore large amount of spatial data. This approach is adopted to develop WebGIS application using open source tools and standards for spatial data visualization, analysis, querying and finally generation of maps. This intuitive user interface allows the GIS experts and novice alike, to access the spatial information customized for specific applications. This can also be useful for management in their decision making process.

Acknowledgement

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REFERENCES

1. Julius M. Bangati (2010): "Web Based Geographic Information System", juley.bangati@gmail.com
2. Puyam S. Singh et.al.,(2012):" Development of a Web Based GIS Application for Spatial Natural Resources Information System Using Effective Open Source Software and Standards", Journal of Geographic Information System, pp 261-266.
3. Sampath Kumar P. and Vivek Kumar Gautam (2014): "Open Source Tools Facilitate Image Georeferencing over Internet India", Geospatial Digest, April 2014.
4. GeoServer:http://geoserver.org
5. Apache Tomcat: //tomcat.apache.org
6. OpenLayer: http://openlayer.org/
7. GeoExplorer:hptt://girona-geoserver-workshop-readthred.org
8. PostGIS: http://postgis.refractions.net/
9. PostgreSQL: www.postgresql.org/
10. Anis Zouagui et. Al. (2005): " Implementation of information system to respond to a nuclear

emergency affecting agriculture and food products - Case of Morocco , International experts meeting on assessment and prognosis in response to a nuclear or radiological emergency" (CN-236) IAEA, Vienna.

11. WebGIS: gis.stackexchange.com
12. OpenGeo Suite:boyndlessgeo.com
13. GeoWebcache:http://docs.geoserver.org/stable/en/user/geowebcache/index.html
14. uDIG Internet GIS: ://udig.refractions.net/files/docs/latest/1.3.../gis_application_tutorials.html
15. Ming Husiang Tsou (2004) Integrating Web Based GIS Image Processing Tools Environmental Inventories and Natural Resource Management, Journal of Geographical Systems.

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Miscellaneous

AGRICULTURAL PRODUCTIVITY AND PATTERN OF CROP DIVERSIFICATION IN BANKURA DISTRICT, WEST BENGAL

Md Azfar MONDAL[1]

ABSTRACT

The present study reveals the agricultural diversification and productivity of Bankura District, West Bengal with the help of crop diversification method by Ayyar and Crop Yield and Crop Concentration Indices Ranking Co-Efficient Technique of Jashbir Singh. The analysis indicates that in the high diversification area people are much more dependent on agriculture in subsistent level.Therefore, they are not confined to one crop to prevent against economic risk. So, that if market price deteriorates, they are not severely affected.

Keywords: *Crop Diversification, Crop Yield Index, Crop Concentration Index, Productive Zone, Agricultural Productivity, Agricultural Efficiency*

INTRODUCTION

The measurement of production and inputs required for the production of a certain output is known as agricultural productivity. Agricultural productivity is a function of the interplay of physical and cultural variables and it manifests itself through per hectare productivity and total production. Agricultural productivity also depends on attributes of the farmers towards work and their aspirations for a better standard of living. The measurement of agricultural productivity helps in knowing the areas that are performing rather less efficiency in comparison to neighboring areas. (Husain, 2005) Crop diversification means the growing of several crops in any holding of land in an agricultural year. It largely depends on geo-climatic, socio-economic conditions and technological developments in the region. Crop diversification provides a relationship between the areal strength of the crop grown in a region. It helps to know the contemporary competition among the crops in any area and the scope of crop rotation and effect of growing several crops, total population and per hectare productivity. In this study, we try to understand how crop diversification and productivity is used to show the efficiency of land as well as trends towards specialization in Bankura district, an agricultural based district of West Bengal.

OBJECTIVES

The main objectives of this study are to identify block wise agricultural diversification pattern and to analyze the productivity with crop yield and crop concentration index.

STUDY AREA

Bankura district is located in between the latitude of 22Ú 38 ìN to 23Ú 38 ì N latitude and 86Ú 36 ì E to 87Ú 46 ì E longitude (Map no- 1). It is an agricultural district. The district is broadly divided into three physiographic divisions namely the western hilly and undulating terrain, the middle undulating tract and the eastern alluvial plain (Banerjee, 1968). The western part is a part of Chhotonagpur plateau and very tough for agriculture due to the rugged terrain, very poor irrigation facilities and ground water unavailability. The middle part is much better than the western part in terms of land, ground water availability, soil, which favours good agriculture. The eastern parts are very good for agriculture due to the availability of the irrigation from canal and ground water sources, younger alluvial soil, technological inputs etc. The irrigation facility was not good in this district prior to the two multipurpose river valley projects like D.V.C (1953) and Kangsabati (1956). The *Bandh* on Damodar River at Durgapur nearer to the block Borjora has immensely helped to develop the district by irrigation and for very good agriculture. In addition, it saves the district from floods. The Kangsabati Dam (1956) at the river Kangsabati and Kumari near Mukutmonipur of Khatrablocks of this district has immensely helped the district due to irrigation especially at the southern Dwarakeshwar River of this district. After the initiation of the two projects, the agriculture of this district has utterly changed. In recent times (2015), the district's ground water lifting has reached extreme points especially at the eastern part. It is for the purpose of irrigation around the whole season, which has helped to grow several crops and improved production.

Soil

The greater part of this district consists of a rolling country composed of lateritic and alluvium. To the

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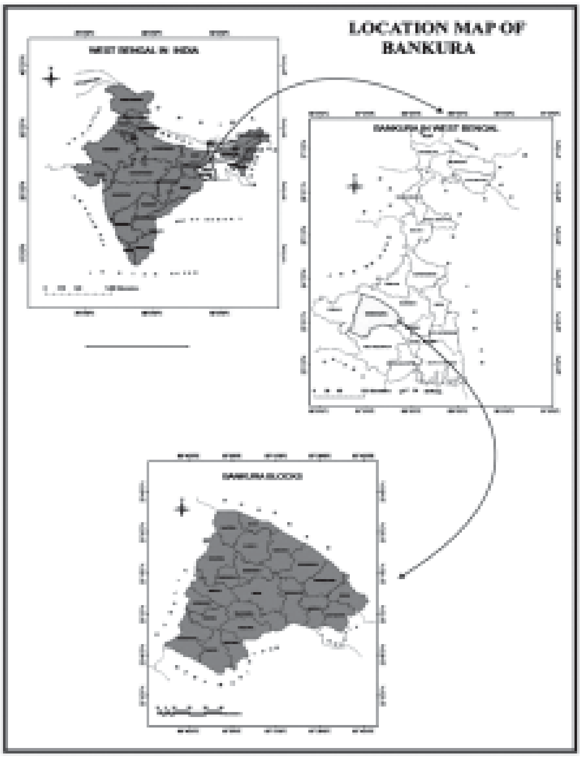


Map 1

east, there is a wide plain of recent alluvium, while gneisses and schist of Achaean age are found to the extreme west, which forms the eastern boundary of similar rocks in Chhotonagpur. (Banerjee, 1968) The block Indas and kotulpur are covered with recent alluvium. Some parts of the blocks like Patrasayer, Sonamukhi, Jaipur, Bishnupur Taldangra, Simlapal, Sarenga covers with older alluvium. The lateritic soil is predominant in the middle undulating tract of the district. The southwestern part is covered with red gravelly soil; the western part is covered with red and yellow soil and the extreme western part is covered with red sandy soil. (District Planning Map Series, Bankura, NATMO).

Climate

Southwest monsoon climate prevails in this district. The western part is much drier than the eastern part. In the early March to June, maximum temperature rises to 45^0c in the western part. The westerly winds die down around sunset and allow cool winds to blow from the south. Nor'wester is frequent during the pre-monsoon period and helps to mitigate the excessive heat. (O'Malley, 1908), Average rainfall during the monsoonal months (June- September) is in between 125-150 cm. After the month of September, the rainfall decreases in this district. Winters are pleasant with temperatures dropping down to below 27 °C (81 °F) in December. The winter is generally dry (Dec to February). In addition, the minimum temperature drops below to 7^o c at some parts of western, southwestern Bankura. (O'Malley, 1908)

Primary Agricultural Products

Rice is the main and most important crops in this district. The second important crop is potato and the third important crops are mustard, sesame seed, wheat, etc., and the marginal important crops are jute, sugarcane, vegetables, flowers, etc. Rice grows here in *Aus* (autumn), *Aman* (winter), *Boro* (summer) seasons. Rice is of numerous varieties like *Swarna Masuri, Minicate, Chhatrish, Govindabhog, Nagra, Joya, Ratna etc.*

DATABASE AND METHODOLOGY

The present study is based mainly on secondary data collected from district statistical handbook of Bankura -2010-2011, published by Govt. of West Bengal. To determine the pattern of crop diversification, Ayyar's (Ayyar, 1969) method has applied. He took into account only those cop which occupies at least one percent of the total cropped area of the particular region.

Percentage of total harvested area under 'n' crops

Crop diversification = Number of 'n' crops

Where 'n' crops are those, which occupy individually at least one percent or more than the total cropped area. After calculating all of the blocks of this district the choropleth map to show the diversification of crops has been prepared. In this case, we have used the Shade Method of *Jenks, 1967 i.e*. Natural Breaks Method for better arrangements. (Jenks, George F. (1967)

To show the agricultural productivity, four crops, namely paddy, wheat, potato and mustard have been selected. Crop yield and crop concentration indices ranking coefficient techniques of Jasbir Singh (Singh and Dhillon, 2006) have been applied for this purpose.

The crop yield and concentration indices ranking coefficient procedure is as follows:

Yi=Yae/Yar100,

Where, Yi= the crop yield index

Yae= the average yield per hectare of crop in "a" in the component enumeration unit.

Yar=the average yield of the crop 'a' in the entire region or country

Ci= Pae/Par100,

Where, Ci = the crop concentration index.

Pae = the percentage strength of crop "a" in the total harvested area in the component enumeration unit

Par= the percentage strength of crop "a" in the total harvested area in the entire region.

The crop yield and concentration indices ranking coefficient for crop a=crop yield index ranking of crop a+ crop concentration index ranking of crops a/2.

At last, for drawing of choropleth maps the ranks of crops yield and concentration indices of four-crop yield are added and then divided by four. And average ranks of crop yield and concentration are grouped into four categories namely (I) high productive zone (II) moderate productive zone (III) low productive zone (V) very low productive zone. For shading of the map, the equal interval method has been applied.

Here all of the maps have prepared on ARC GIS10.1 and TNT MIMS PRO-GIS software platform.

PATTERN OF DIVERSIFICATION

The pattern of crop diversification depends on the region's soil, rainfall, irrigational facility, accessibility to the arable land and the technology deployed by the cultivators. Using Ayyar's method of crop diversification, the district has been divided into five areas; very high diversification, high diversification, moderate diversification, low diversification and very low diversification. (Map no 2)

Areas of Very High Level Crop Diversification

In Bankura district, some blocks like Jaypur, Patrasayer, Sonamukhi, Onda and Taldangra have very high diversification of crops. Diversification index value is 14.29 or less. In this areas fertile soil, rainfall, irrigation facility by both the projects like Kangsabati, and D.V.C, favor the blocks for a very high level of crop diversification. Here various types of crops like Aus, Aman, Boro paddy, potato, wheat, mustard, sesame seed, vegetables, sugarcane, jute grows in very good percentage. In these areas, the people mainly depend on agriculture. At riverside of the block Patrasayer, Sonamukhi, Onda, people are Bangladeshi in origin and they are immigrants. They are hard workers, engaged in agriculture at the riverside, and cultivate different types of crops in different seasons. They have immensely helped these blocks in raising the level of crop diversification.

Areas of High-Level Crop Diversification

The following blocks like Indas, Barjora, Bishnupur, and Sarenga have a high level of crop diversification. Crop diversification Index Value is 14.30-16.67 in these areas. The main crops in these blocks are Aus, Aman, Boro, Potato, Mustard, Sesame seed and marginally, crops like vegetables, jute, flower, etc. Some areas of these blocks especially at the riverside of Indas, Barjora, Onda and Taldangra have a greater variety of crops growth. The newer alluvium and older alluvium soil, good irrigation facility, use of modern equipment favors the growth of multiple crops in any season. In these areas people mainly depend on agriculture.

Areas of Moderate Level Crop Diversification

The blocks like Kotulpur, Bankura-II, Indpur, Raipur have a moderate level of crop diversification. Diversification index value is 16.68-25.00. In this case, the situation is different for every block. The Kotulpur block has very good irrigation facility, very fertile alluvial soil and high level of technological inputs. In spite of these facilities the farmers of Kotulpur block are choosing moderate levels of crop diversification. The main causes behind this fact are that the farmer of these areas cultivates crops commercially. In addition, they are concentrating on potato cultivation. On the other hand, some people have alternate occupations like a small business, small-scale industries and services. Blocks Bankura II and Indpur and Raipur have moderate levels of crop diversification due to low irrigation facility, undulating terrain, infertile laterite soil and low levels of technological inputs. In this block mainly the Aman paddy, mustard, sesame crops grow. The people of these areas have alternative jobs. They are not fully dependent on agriculture. In the paddy cutting season at the eastern part of this district and the other districts like Hooghly, Burdwan, many people of low-income group migrate as agricultural laborers.

Areas of Low Level Crop Diversification

The index value under these categories is 25.01-50.00. Five blocks belong in this category. The blocks like Simlapal, Khatra, Ranibandh, Gangajalghati, Bankura-have infertile red gravelly soil, red and yellow soil prevails, low irrigation facility, low ground water availability retard these blocks from high diversification of crops. For the people of these areas, agriculture is not the main occupation. They have alternatives occupations. The poor Bauri, Adivasi Santal people migrate to the eastern part of the district as agricultural laborers during the paddy sowing and cutting season.

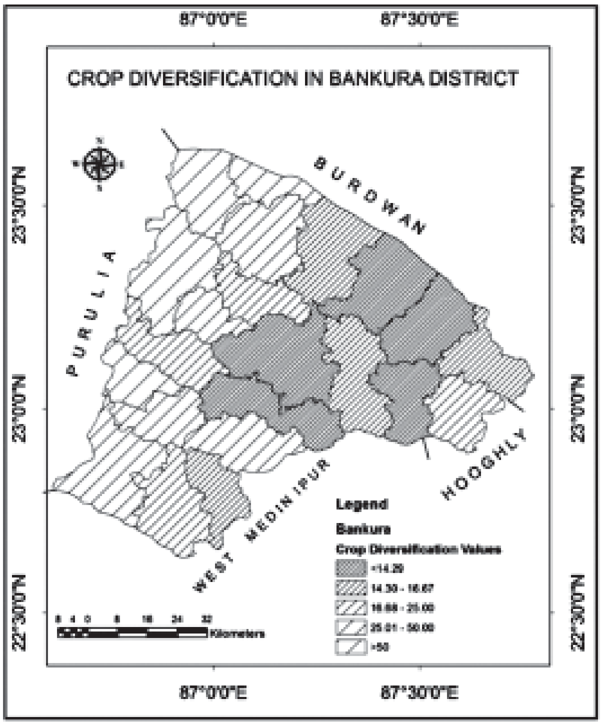
Areas of Very Low Level Crop Diversification

The diversification index value in these areas is >50.00. Very low irrigation, rugged terrain, red and yellow soil are unfavorable factors resulting in a very low level of crop diversification. The blocks like Mejia, Saltora, Chhatna and Hirbandh belong to this category. These are areas of monoculture. Only once the *Aman* paddy is the main crops. Even *a man* is uncertain when rainfall fails in the monsoon season. Here the people are very poor and have an alternative occupation. Many people of Mejia block are engaged in coal fields and the people of the block Chhatna, Saltora and Hirbandh are migratory in the Bankura town, Purulia and many people of Hirbandh block migrate to the eastern part at paddy sowing and cutting season as agricultural laborers (Map 2).

Table 1
Crop Diversification

Degree of Diversification	*Diversification Value*	*No. of Blocks*	*Name of C.D. Blocks*
Very high	14.29 or less	5	Patrasayer , Sonamukhi, Jaypur, Onda and Taldangra
High	14.30-16.67	4	Indas, Barjora, Bishnupur, Sarenga
Moderate	14.68-25.00	4	Kotulpur, Bankura-II, Indpur, Raipur
Low	25.01-50.00	5	G.Ghati,Bankura-I, Simlapal, Khatra, Ranibandh
Very low	>50	4	Saltora, Mejia, Chhatna, Hirbandh

Source: compiled by the author.



Map 2

Table 2
Agricultural Efficiency

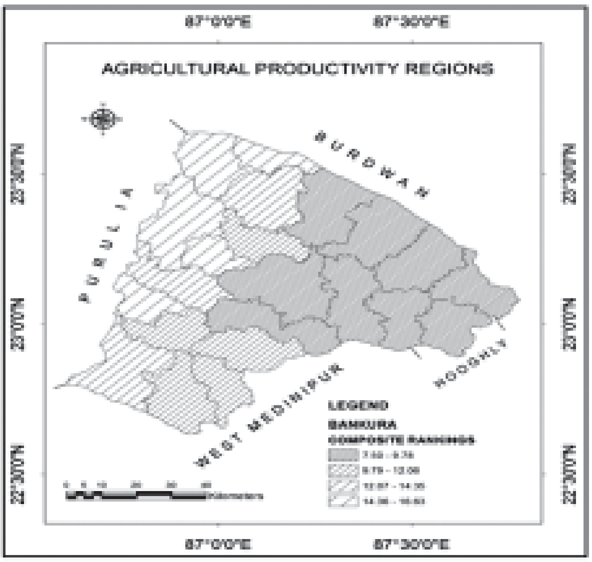
Degree of productivity	*Composite Range*	*No. of Blocks*	*Name of Blocks*
Very high	14.29 or less	5	Patrasayer , Sonamukhi, Jaypur, Onda and Taldangra
High	7.50-7.78	9	Indas, Kotulpur, Patrasayer, Sonamukhi, Jaypur, Barjora, Bishnur,Onda, Taldangra
Moderate	9.79-12.06	5	Bankura-II, Simlapal, Khatra, Sarenga, Raipur
Low	12.07-14.35	3	G.Ghati, Indpur, Ranibandh
Very low	14.36-16.63	6	Mejia, Saltora, Chhatna, Bankura-I, Hirbandh

Source : District Statistical Handbook 2010-2011 and compiled by the author

Table 3
Agricultural Productivity Status

Sl. No.	C.D. Blocks	Paddy yi	Paddy ci	Wheat yi	Wheat ci	Potato yi	Potato ci	Mustard yi	Mustard ci
1	Bankura 1	44.53	111.00	0.00	0.00	109.73	92.32	0.00	0.00
2	Bankura 2	111.10	109.86	161.50	37.84	134.50	39.23	96.24	32.10
3	Chhatna	45.72	117.50	0.00	0.00	0.00	0.00	0.00	0.00
4	Saltora	30.18	117.50	0.00	0.00	0.00	0.00	0.00	0.00
5	Mejia	0.00	117.50	0.00	0.00	0.00	0.00	0.00	0.00
6	G.Ghati	91.20	111.90	0.00	0.00	0.00	0.00	129.55	126.26
7	Barjora	120.70	96.91	175.41	174.77	112.76	25.54	173.49	242.18
8	Onda	144.46	90.64	160.09	275.68	119.29	106.01	103.80	212.47
9	Indpur	47.73	99.66	95.08	378.38	74.26	22.04	56.49	256.23
10	Khatra	54.32	99.79	87.96	273.87	125.67	2.50	99.14	314.85
11	Hirbandh	51.49	117.18	0.00	0.00	103.20	1.50	115.07	4.77
12	Ranibandh	43.08	104.85	69.31	19.82	85.22	9.35	116.84	196.02
13	Taldangra	159.14	90.29	141.11	176.58	121.83	125.04	116.68	89.39
14	Simlapal	53.11	101.95	132.14	3.60	137.75	195.16	82.24	31.83
15	Raipur	139.12	91.72	115.79	109.91	138.26	87.31	86.42	166.58
16	Sarenga	93.70	83.99	130.86	204.50	110.85	170.12	110.72	91.25
17	Bishnupur	152.54	95.30	171.76	30.63	147.51	126.71	135.67	127.59
18	Joypur	163.17	84.76	159.26	205.41	124.82	358.43	141.14	31.03
19	Kotulpur	186.75	63.08	129.38	29.73	147.57	495.33	139.53	19.36
20	Sonamukhi	136.50	92.56	139.70	181.08	151.44	136.23	149.03	83.82
21	Patrasayer	173.96	96.36	130.92	88.29	131.74	149.92	168.66	91.78
22	Indas	158.50	105.72	199.71	11.71	123.60	56.43	179.28	80.90

Source: compiled by author.



Map 3

ANALYSIS OF AGRICULTURAL PRODUCTIVITY REGIONS

The total nine blocks like Indas, Kotulpur, Patrasayer, Jaypur, Sonamukhi, Barjora, Onda, Bishnupur and Taldanra have been identified as high productive regions. In these areas very good irrigation both from canal and ground water lifting through the process of tube well, deep tube-well, shallow etc. High use of fertilizers, technological inputs are available for very good production. Second important area of production are blocks like Bankura-II, Simlapal, Khatra, Sarenga, Raipur. These areas are poorer than the previous one with respect to soil, irrigation facilities, technological inputs, fertilizer and pesticides uses etc. These blocks have moderate levels of crop production. Blocks like Gangajalghati, Indpur, Ranibandh belong to the categories of low crop production. In addition, blocks like Mejia, Saltora, Chhatna, Bankura-I and Hirbandh are in the categories of very low crop production. These are the areas of low irrigation, infertile red and yellow soil, red and gravelly soil, low level of modern inputs like the fertilizers, pesticides. Due the uncertainty and vagaries of monsoon rainfall, the production is frequently hampered in these areas. (Table 2, 3), (Map 3)

CONCLUSION

From the preceding discussion, we may sum up the following points

1. In high diversification areas people are more dependent on agriculture than low level of crop diversification;
2. In areas of higher levels of crop diversification, several crops are grown. As a result, the people do not lose much when market price deteriorates in any time of a year.
3. In low diversification areas people sometimes concentrate on high level productive crops like potato. Kotulpur block for example, is in this category.
4. The high productivity zone has benefited areas in terms of good irrigation and other necessary inputs of agriculture.
5. Irrigation is the main hindrance of this district for crop production and diversification too.

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REFERENCES

1. Husain, M, (2005) 'Systematic Agricultural Geography' Rawat Publications, New Delhi, Pp-244-245
2. Banerjee, A.K., (1968), 'The West Bengal District Gazetteers" State Editor, Govt. of West Bengal, Kolkata- 1, pp-13-14,36.
3. O'Malley, L.S.S., (1908), ICS, Bankura, Bengal District Gazetteers, Government of West Bengal, Kolkata-1, pp-1-20
4. Ibid-pp-1-20
5. District Planning Map Series, Bankura (1996), National Atlas & Thematic Mapping Organization (NATMO), Department of Science and Technology, Govt. Of India, Calcutta-64
6. Singh, J. and Dhillon, S.S.(2006) 'Agricultural Geography,' 3rd edition, Tata Mc Graw Hill Publishing Company Limited, New Delhi,Pp-274-286
7. District Statistical Handbook – (2010-2011) Bureau of Applied Economics And Statistics Government Of West Bengal, Bankura
8. Ayyar, N.P.,(1969): 'Crop Regions of Madhya Pradesh: A Study In Methodology,'Geographical Review Of India, XXXI, (I) pp-1-19
9. Jenks, George F. (1967). "The Data Model Concept in Statistical Mapping," International Yearbook of Cartography 7: 186–190.

ROLE OF GIS AND REMOTE SENSING AND OPEN SOURCE TECHNOLOGY IN DISASTER MANAGEMENT AND PLANNING:
A CASE STUDY IN COASTAL KERALA

Chanchal Kumar TRIPATHI[1]

ABSTRACT

Disaster is an unpleasant event that occurs with little or no warning which results in economic disruption; loss of property and loss of life. The word's root is from astrology, which implies that when the stars are in a bad position, a bad event is about to happen. Natural disasters have their greatest impact at local levels, especially on the livelihood of poor people.

Keywords: - *Remote Sensing, GIS, GPS, Decentralized Planning, Vulnerability, IDW Interpolation, Open Source.*

INTRODUCTION

Disaster Management

Disaster management can be defined as the discipline of applying science, technology, planning and management to deal with extreme events that can injure or kill large numbers of people and cause extensive damage to property. In India, post-disaster activities are given more importance as compared to the developed countries where huge funds are spent in the pre-disaster preparedness and mitigation activities which considerably reduces the impact of a disaster.

Crisis Informatics

Crisis Informatics is an emerging field showcasing the application of information and communication technology (ICT) in Disaster Management. GIS, Remotely Sensed data, GPS and other databases can be integrated to develop a better crisis management and support system. Geographic information system (GIS) is an effective tool in disaster management activities like preparedness, mitigation and disaster response.

GIS in Different Stages of Disaster Managment

Fig. 1: Different Disaster Management Stages

High Resolution Satellite Imagery in Disaster Management

Use of high resolution imagery is imperative in Disaster Management. It provides vital information to disaster managers for decentralized planning. Satellite images taken after a catastrophe reveals the existing state of the area as blocked roads, vulnerable areas, alternative evacuation routes, the settlements that need immediate attention can be located and emergency relief can be re-directed to the area. Pre-disaster and post disaster images can be used for change detection and the damage assessment can be done more effectively and quickly.

STUDY AREA

The study area is the 8 coastal wards of old name Alleppey, now change name Alappuzha Municipality in Alappuzha district in Central Kerala. The area stretches up to 5.41 sq.km and lies between $9^0$27'46''and $9^0$31'19'' North latitude, $76^0$18'41'' and $76^0$20'05'' East longitudes.

Alappuzha is a Land Mark between the broad Arabian Sea and a network of rivers flowing into it. Alleppey is called the Venice of the East. Thus, the sobriquet found its place in the world Tourism Map. The presence of a port and a pier, criss-cross roads and numerous bridges across them, a long and unbroken sea coast makes it to be called so.

Topography

The district is a sandy strip of land intercepted by lagoons, rivers and canals. There are neither mountains nor hills in the district except some scattered hillocks lying between Bharanikkavu and Chngannur blocks in the eastern part of the district and no area under forest in this district.

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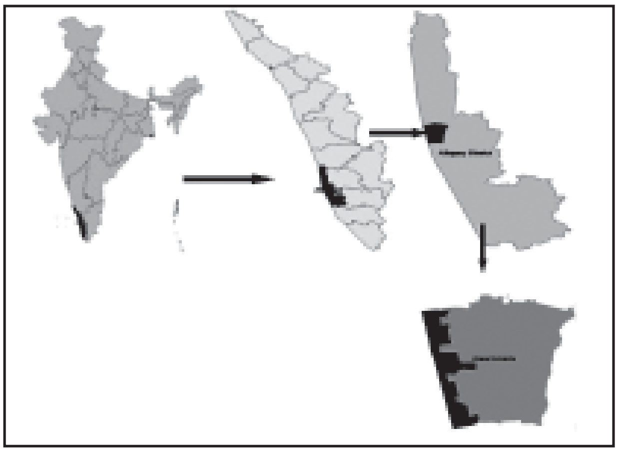

Fig. 2 : Study Area

METHODOLOGY

Fuse Image using (cartosat-1 +Liss-III) image of 2.5 meter resolution was used as the base map to develop disaster preparedness and response mapping system for the coastal wards of the municipality. The high resolution satellite imagery was geo-referenced using the WGS84 coordinates and the Image-image referencing of Cadastry and the satellite image was carried out using Quantum GIS. Different point, line and polygon shape files were generated using QGIS. Different thematic layers extracted from the satellite image include the location of individual households, roads and land use. The individual parcels were extracted from the Cadastre.

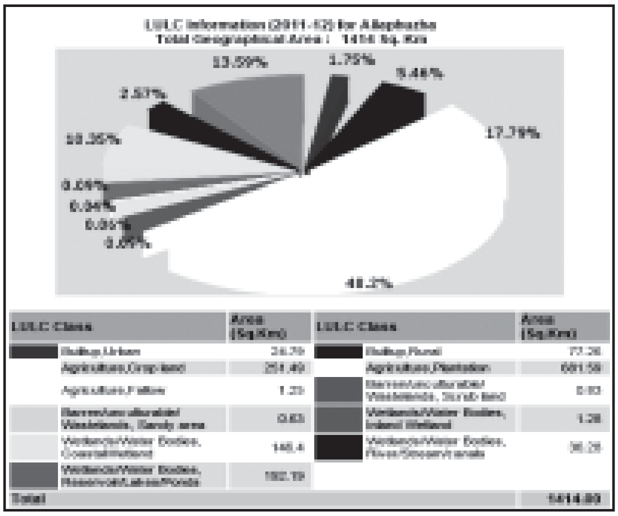

Fig. 3 : Land Use /Land Cover of Area

Inverse Distance Weighting (IDW) Interpolation Technique:-

- IDW weights the value of each point by its distance to the cell being analyzed and averages the values.
- IDW assumes that unknown value is influenced more by nearby than far away points, but we can control how rapid that decay is "Influence diminishes with distance."

"To predict a value of any unmeasured location, IDW will use the measured values surrounding the prediction location. Those measured values closest to the prediction location will have more influence on the predicted value than those farther away. It weights the points closer to the prediction location greater than those farther away, hence the name inverse distance weighted.

Settlement Vulnerability Mapping

The study area was divided into grids of the 12.5m interval. Different vulnerability ranks were assigned to these grids depending on criteria like presence or absence of settlements in a grid, road connectivity to a grid, coastal proximity of the grids and the proximity to inland water bodies. These ranked grids were intersected into the centroids of the grids and based on the IDW interpolation technique using the raster model was developed in GIS.

Remote Sensing data has been successfully used to map the Indian coast for Regulation of the Coastal Zone on 1:10,000 scale demarcating High Tide Line (HTL) and Low Tide Line (LTL) in Coastal Regulation Zone (CRZ) using RS data. Usefulness of RS data has also been demonstrated for mapping in Fig. 4.

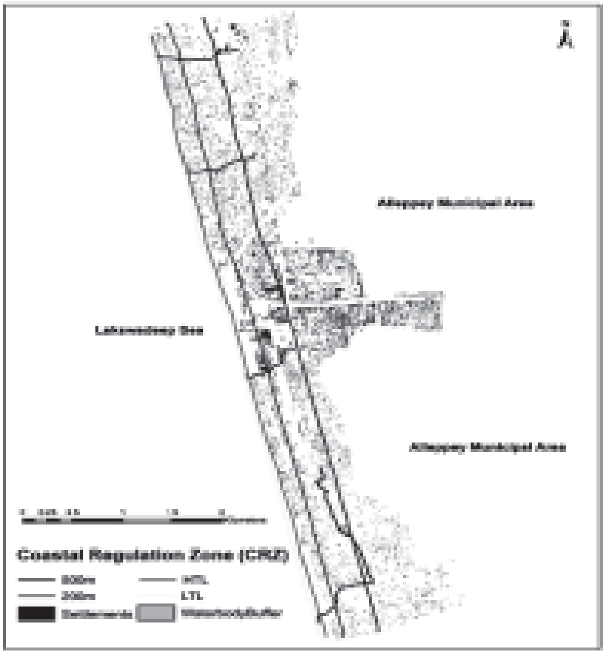

Fig. 4 Map Layout Data Source from Open Source Google Earth and Q-GIS

Advantages of Open Source GIS in Disaster Management

Open Source GIS could be used for community level disaster preparedness, activities like setting up an evacuation route, organizing mock drills and making the people aware of the area they live in. The objective is to bridge the gap between several levels of local administration and common people through an

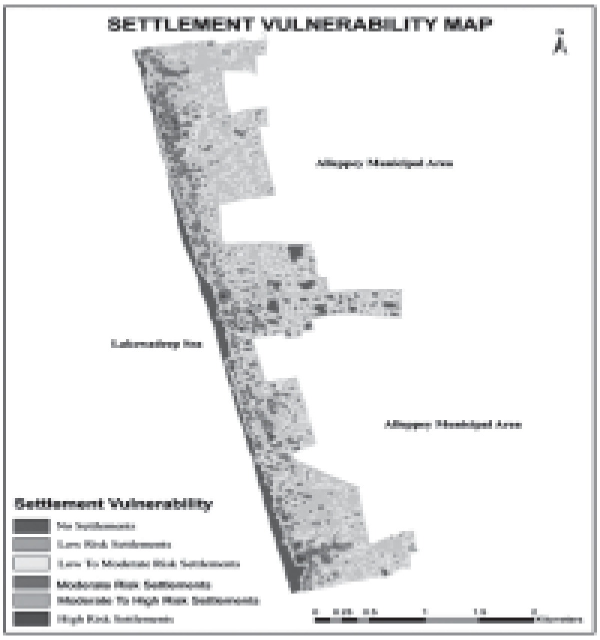

Fig. 5 Map Layout Data Source from Open Source Google Earth and Q-GIS

extensive knowledge workshop that ensured public participation. The local knowledge on disasters is highly important. Open Source GIS helps in taking technology to the common people.

CONCLUSION

This study gives an idea of the advantage of using high resolution satellite imagery and GIS in disaster management. The present study emphasizes the purpose of assessment of an area during a coastal disaster like tsunami or storm surges with special preferences given to early evacuation routing and community preparedness.Use of Open Source GIS is a cost effective method for local level community preparedness and public participatory geographic information sharing.This system can be used for generating community preparedness plans, thus empowering the people to think and act spatially, thereby having a proper understanding of the area they live in and the risk they are exposed to. The quality and timeliness of response services during a disaster can be improved using this system. Disaster management plans are to be integrated within the mainstream planning and development activities of local authorities. GIS needs to be deliberately infused into these activities for a better disaster resilient society.

REFERENCES

1. J.A. Dixon, L.F. Scura and van 't Hof, "Valuation of a Marine Resource." In Biodiversity Conservation: Problems and Politics, eds. C. Perrings, K.-G. Mäler, C. Folke, C.S. Holling and B.-O. Jansson, Kluwer Academic Press, Dordrecht (The Netherlands), 1994.

2. F.J. Edwards, "Climate and Oceanography." In Key Environments: Red Sea, eds. A.J. Edwards and S.M. Head, Pergamon Press, Oxford (UK), pp. 45-69, 1987.

3. F.F.M. Freire, "The Application of Geographic Information System to the Coral Reef of Southern Okinawa." In 22nd Asian Conference on Remote Sensing, Singapore, 5-9 November 2001. Available online at: http://www.crisp.nus.edu.sg/~acrs2001/pdf/194freire.pdf,(Accessed: 17/01/2002).

4. E.P. Green, P.J. Mumby, A.J. Edwards and C.D. Clark, "A Review of Remote Sensing for the Assessment and Management of Tropical Coastal Resources," Coastal Management, Vol. 24, pp. 1-40, 1996.

5. http://bhuvan.nrsc.gov.in/data/download/index.php

6. E.J. Hochberg and M.J. Atkinson, "Capabilities of Remote Sensors to Classify Coral, Algae, and Sand as Pure and Mixed Spectra," Remote Sensing of Environment, Vol. 85, No. 2, pp. 174-189, 2003.

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EXPLORATIONS OF GRADUATE LEVEL EDUCATION : SOME REFLECTIONS FROM GEOGRAPHY

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ABSTRACT

The number of enrolments of students to acquire higher education at college level is growing rapidly in various disciplines such as science, commerce, arts, engineering, medical, and management and so on. The present paper highlights some reflections on the factors responsible for the selection of the 'Geography' as an optional subject, the educational background of the student at undergraduate level in pass and honours courses in the state of Haryana. It has been observed that thesubject attracts the students inthe statemore in quantity but the acquired level of geographic knowledge (quality) of students at different level of the degree classes is low and sometimes below the expectations. It has been identified that the many students have higher priority to take admission in science, commerce, technical and professional course but opt geography as a subject when they do not get entry in these career oriented professional courses. Opting the geography by chance (not by choice) has no interest in the subject and only pile up the numbers of graduates and creates pressure at university level. The geography teachers should come forward to improve the status of the subject by modification and improvement of the curriculum/syllabus according the needs and demands of the hour.

Keywords: *Science, Geographic Knowledge, Under graduate, Professional Courses*

INTRODUCTION

In India, Education system seems failed to offer exposure to students to convert them on scientific understanding and productive thinkers. Large number of students who are passing out every year became part of anon-ending unemployed populous. Means of education are considered to conducive to spread the fruits of development and rise in living status of citizens but in Indian it is lookinglost somewhere between the journeys

As being theteachers of geography, all we know that most of the students who have opted geography, are those who were failed to opt other more beneficial streams or subjects. This concern has been earlier expressed by Lahiri-Dutt (2005) and Sarfaraz Alam (2014). Priority for opting an option is directly linked with the ability of the discipline to offer the livelihood to the students at lateral stage, or we can consider it helpfulness of the subject to find ways to earn livelihood after degree.

In 2006, the then prime minister of India, expressed his concern in a statement "I share the concern being expressed by many of our scientists that our best minds are not turning to science, and those who do, do not remain in science. I am told that less than 3% of school children want to pursue a career in science. We must find ways of making these disciplines more attractive to children. We have to improve the quality of teaching of science and mathematics at the school level. Countries like China and South Korea are far ahead of us in investing in science and technology. We need to do much more in this vital area if we have to keep pace with the evolving global economy of the future."(Dr. Manmohan Singh, 2006)

Prime Minister Narendra Modi has suggested a series of structural reforms in education, ranging from schools to Universities with emphasis of skill development along with formal education. (TOI, 31 March 2016). This will incline more attraction of students towards technical education instead of general education and if we geographer have to face more complex situation in future if continues in same traditional ways.

Geography teaching and research in India has been facing innumerable internal and external challenges. Internal challenges pertain to feeble to response and preparedness to incorporate appropriate changes in teaching curriculum at school, college and university levels in light of changing nature of discipline globally and its relevance in addressing the contemporary issues both at global and local levels. It is too well known that the school and university curricula have at best incorporate superficial changes in last few decades. It is thus outmoded and perhaps unattractive to the discerning and creative young minds in school and colleges. (Sachindanand Sinha, 2014)

Geography is not different from other science or social science subjects here.There are so many concerns have been expressed by esteemed thinkers about the future of geography in India at varies level of teaching at many forums like NAGI, state level associations and other institutions, publicationsand symposiums. Few cited above are making reflections of a complex situation. We are failed to turn our students into

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curious minded scientific thinkers. Geography became just an optional exam to find a degree from universities. There is an urgent need to rediscover (Indian) geography in respect of its relevance for society. There is a need of hour to change in geography curriculum by adding modern scientific and skilful knowledge to save its status among other growing disciplines in present world of academia.

STUDY AREA

The state of Haryana is selected as the study area for the present piece of research work. The state is located in fertile north-western plain of India, surrounded by Punjab, Uttar Pradesh, Rajasthan, Himachal Pradesh and Uttrakhand (Fig.1). At present, there are 22 districts in the state. The state was came in existence on 1st November, 1966 after reorganisation of Punjab on linguistic basis. Agriculture based state have shown notable progress in all spheres of development and counted in economically between advanced states of India. A total number of 120 samples have been collected from the colleges in the state of Haryana.

Fig.1

OBJECTIVES OF THE STUDY

The research paper is an attempt to find out the some relevant factors affecting the students at the time making their choices to opt the geography for building their career. An attempt is also being made to elaborate the problems occur in this process and difficulty faced by the subject at college level. The following objectives have been taken into consideration for the present research work.

1. To study the educational background of the students opting the geography as a subject at under-graduation level.
2. To find out the factor affecting the students for making the choices for the subject selection at under-graduation level.
3. To examine the role of various agencies for guidance in the selection of the geography as subject at under-graduation level.
4. To find out the level of elementary knowledge of geography among the entrant students of geography at under-graduate level.
5. To make suggestion about qualitative measures to enhance geography teaching at graduation level by improving syllabus and curriculum.

DATA BASE AND METHODOLOGY

The present study is based on empirical and qualitative primary data collected from the students of geography in the colleges. The analytical explanations have been done byusing quantitative techniques to analyse data collectedfromthe universe. A field survey has been conducted with a randomly selected sample size of 120 students from different undergraduate classesin the colleges of the state. Various appropriate statistical techniques have been used to analyse the collected data and to draw the inferences. On the bases of the results and conclusion on the study, someimperative suggestions are made to improve the educational level of achievers in particular and civic societyin the state of Haryana.

RESULTS AND DISCUSSION

As we have discussed earlier, students who were failed to get any chance somewhere in science, management, technical or vocational education, applied for humanities and there they were preferred highly demanded subjects like mathematics, economics, english and after losing chance there, they seen opportunity by opting geography.

Educational Background of the Students

The background of these students is imperative and students who came from science streams have prefer for B.Sc. in Physics, chemistry, biosciences before they were chosen geography as an option. At the other hand students with commerce background has a negligible presence in geography that indicate, that students of commerce background may be preferring subjects like Bachelor of Business Administration and economics due to their similarity in nature with commerce. Students from social science who opted geography at school level have larger share among the geography students.

Table 1
Educational Background of the Geography Students

(In per cent)

Previous Background	*Total*	*Rural*	*Urban*
Science	30.00	26.67	3.33
Humanities	60.00	53.33	6.67
Commerce	3.33	3.33	0.00
Others	6.67	5.00	1.67
Number of Observations	120	88.33	11.67

Source: Based on Primary Data.

Table 1 shown that major share of geography students comes from rural area whether they belong to any stream at earlier stage. Near about 30 percent of surveyed student were came to geography from science background, 66percent from humanities and a negligible share from commerce stream with 3.3 percent figure, which is also lower than 5 percent students from other fields came to opt geography.Students who came from social sciences has previously has studied geography at the school level and a minor amount of students from social science has never taken geography as optional subject at school level.Majority of students come from rural background who are opting geography. Possibly, urban students have better option because better guidance and exposure for the professional courses. Majority of students who were admitted and opted geography were not aware about honours course in geography.

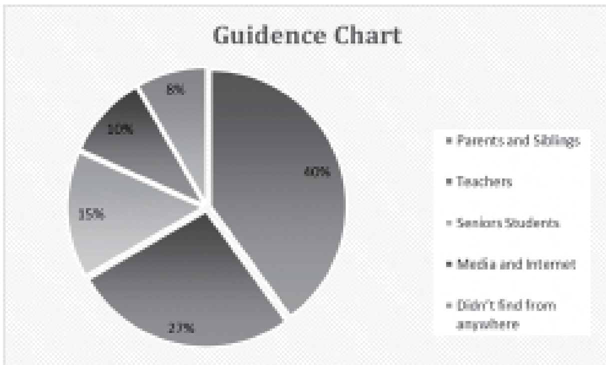
Table 2, reflects that most of the students who were taken geography have some reasons behind their selection. In fact sometimes when our discussions happened about student's subject choice or selection, we generally ignore things those are easily recognisable. Here in this list, being practical subject, became the strongest reason of choice (25%) followed by importance of geography in career building due to its large share in competitive exams and a notable number of students choose because geography bring us aware about our surrounding, our atmosphere (21%).. All this seem as advantage comes to our door by chance and notby our efforts behind their selection of subject. Students opted geography because, they were familiars with subject at school level, followed by students, who were inspired by their interest in subject. A small portion of the students accept that their teachers of geography were good than other subject teachers (3.3%) and it led them to keep continue in geographysubject. If we want to improve number of students and qualitative students in geography we must have to increase this figure to a notable percentage against minimal current one.

Table 2
Reasons of Selection of Geography

S. No.	*Reason of Selection of Geography as a Subject*	*Percentage*
1.	Interest in subject	13.33
2.	Due to Geography's part in career building andcompetition exams	20.00
3.	Geographywas an option at school level	16.67
4.	School geography teacher was good than other teachers	3.33
5.	Practical score more marks than other subjects	25.00
6.	Geography aware us about our environment	21.67

Source: Based on Primary Data,

When students were asked about the source of guidance or inspiration to opt geography, it reflects a complex picture shown in diagram 1., here family members are on top to provide advice or suggestion to the students in selection of optional subjects and if we go through, brothers and sisters are more active as well as efficient instead of parents, possibly, due to low-level of education of parents in rural areas. Teachers of geography both at their previous School and at colleges where they were seeking admission, were active in advising new comers as being at third place followed by media and internet sources. Although media and internet sources are known as the modern power houses of information but here it seems



Source: Based on Primary Data.

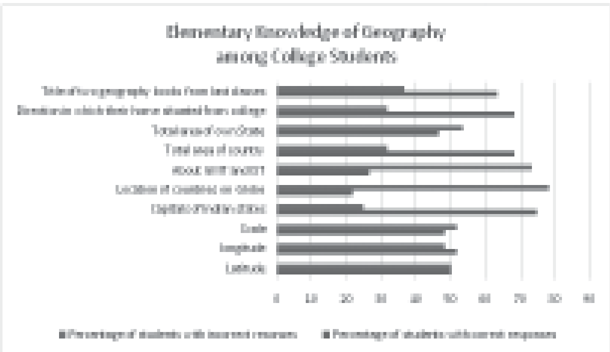
Fig. 2

We lag behind in these means. A small portion but a notable part of 8.33 percent did not find any guidance in form of advice/suggestion/inspiration from anywhere and were takes geography with uncertainty of decision. Selection of subject is really a tough task for the students comes after school education, especially for students coming from rural areas. They prefer to guidance from easiest source available nearby, whether they find at home, school or where they are seeking admission (College/ University).

Elementary Knowledge of Geography among Students

The undergraduate geography departments in colleges are now getting students who lack even the basic knowledge of geography. To understand the level of basic understanding of the students admitted to the geography about basics of geography, some basic questions were designed in survey including knowledge of latitude, longitude, capitals and their locations, locations on globe, total area of the country and Haryana state, direction of their home place from their institution and about the title of any two books they have studied in last class.

It given a concerning outcome as our failure to reproduce scientific and basic understanding of geographical knowledge among students. Half among the surveyed students are not familiar with latitudes (50%), longitudes (48.3%) and scale (51.6%) reflecting from Fig.3. Furthermore 25% students are not aware about the location and capitals of the Indian states on map and while talking about globe, location of countries, and 78% failed to respond right answer. Most of students were not aware about countries location between continents, asked countries were Brazil, Japan, Korea, Germany, Spain, Austria, Peru, chilli, Canada, Singapore, Mauritius etc.



Source: Based on Primary Data

Fig. 3

While answering questioning about GMT and IST in survey, 73 percent were unknown to GMT and IST. One third were unknown to the total national area and when their native state was considered, this figure was raised up to 53 percent. Situation seems better when knowledge of direction was considered and 68.3 percent students told exact direction of their homes/villages/colonies from college where survey conducted. 63 percent students were remembered the title of the books they have considered in their last class to prepare geography. All this representing an uninviting picture of our future.If we continued same, survival will be next to discuss. We need to change our curriculum and syllabi to make geography more interesting for students and to strengthen its relevance for our society.

It is unnecessary to highlight that newly entrant students securing admission at undergraduate level are expected to be aware these basic concepts and facts about geography.Because these are the bases ofall complex geographical concepts. Lack of understanding these concepts among the students is obstructive to teach complex concepts of geography whether it is spatial patterns, organizations or associations. Failing to response are directly linked with the weakness of school curricula, syllabus or anymore and out of our reach to amend.It may be in the absence of the paper regarding world geography and examples from different countries about geographical phenomena in which led students to inefficient to answer about local and worldwide locations. When a teacher told students about countries, locations and people, an imagination takes place in student's minds immediately, furthermore it bring students curios to know about new. But the current state of the geographical illiteracy seen in this study looking hampering the teaching of geography at this stage.

One thing is also worth to notehere, the study of geography in the state of Haryanais clubbed under civics at high school and at senior secondary levelit is surprisingly falling under subjects have minimallyavailable from a long time contrary to highly acceptable by students at graduation level. It bring quantity of the students without background and basic knowledge of geography.As a result, undergraduate geography departments are receiving a substantial proportion of students who have not studied geography at higher secondary stage.

CONCLUSION

Study reveals that at the under graduate level of study, students we are receiving are not of sort that is required and geography departments arelag behind the pace in attracting enough number of qualitative students. We are receivingmajority of students among opportunity losers from other disciplines, probable science and tech subjects, mostly from rural areas without proper guidance and facilities. It is bad luck of geography departments and teachers, that they did not have basic knowledge of geography required at the time of entry to a student of the under graduate level. We are constantly revising our syllabi and curriculum but still having some gaps and it is need of time to bridge them in accordance with requirements of academia and society."These challenges could be met by reorienting geography curricula for undergraduate classes.

The incorporation of relevant and useful themes in syllabi together with their rational sequencing and adoption of innovative teaching techniques could make the subject intellectually appealing and rewarding for students, teachers and society" (Sarfraz, 2014) It's time to rethinking about the status of the subject in Haryana state. Depicting picture in this article we find, is an alarming conditions and may be worse more in future if we did not step up forward. We must accept these challenge to bring positive changes in course of development of geography at every level of teaching. There are lot of opportunities in the field of GIS, Remote sensing, town and country planning, forestry and environment, agro planning, disaster management and private industry but geographers share there is counted negligible. It is worth to mention that most of employee in ESRI among 3000+ employees are from geographical background and in European countries geographers are getting enough placements in jobs related to surveys, land records, GIS-RS, town and country planning etc. but in India we are failed to do all this. We are failed to find opportunity for geographers to find livelihood after receiving a degree with geography subject. Geographers must take the advantages of the innovations and technology of the current pace. We need to re-frame our curricula and syllabi in accordance with pace of time. We need to bridge gap between school and college level geography, further from college to universities. There is a serious lack of availability of a stage for state geographers to be united and to decide the future of geography in state of Haryana. A united forum of school, college and university teachers should be formed to mitigate the problems raised from time to time.

Suggestions and Policy Imperatives

Professional subjects such as electronics orelectrical technology, food processing and management, textile designing, fashion designing,tourism,health and beauty,information technology, computer science, management sciences, Automobiles, disaster management, policy making are meant for higher studies have now become quite popular now the days. In the past few years, the enrolment percentage of students opting for these vocational courses have increased considerably because of their employment assistive nature. A job after degree is became necessity to earn livelihood.All this conditions are indicating us to cast our curriculum and syllabi in accordance with requirement of industries and HR agencies to fulfil student's requirements to finding better opportunities to earn livelihood.

No doubt, curriculum and syllabi development is a continual progressive process which incorporate the changing requirements of the society and learners specifically. Sometimes due to various factors it lag behind the tuning of time and harm academia to society, where students suffer most. Syllabus development is vigorous process. Updated state of the syllabus reflects the dynamicity in the teaching of subject at the particular departments. On the other hand an up to date syllabi help students to achieve more in accordance with social requirements. Efforts have been made by individual departments and at UGC level but results are not up to mark accordance with expectations.

"If the geographers have to cope with the challenges of the twenty first century, they have to change curriculum; information and communication technology should be included and geographical enquiry has to be concerned with the lowest order of the data available. In general, geographers have to be ready for technological socks of the twenty first century" (P. Nag. 2008).

Limited success is a complex phenomenon and have a need of in-depth examination but it have so many complexities in itself. Development of syllabus for subject is multi-dimensional. It depends on ongoing research in the discipline and allied areas, social contexts and requirements, availability of infrastructure, the focus of the mother departments, the specialization and competence of teaching staff available, and the level of understanding/talent of students. Consequently, a syllabus developed without taking into considerations these factors, even an evidently progressive syllabus becomes a burden on students and teachers. It is not an easy task to strike a balance between all these aspects but it is necessary to accommodate all these to run with pace of time to survive with recognition.

It is, therefore, proposed that the following principles for curriculum development may be taken into consideration for reorienting undergraduate geography curriculum.

- Curriculum and syllabi should be revised and well-designed fulfil the gaps between the school and college education, further it should be sequentially arranged and equally distributed for all semester to make the learning process interesting and rational for learners.
- The syllabus should be revised to up-to-date regularly, relevant to the contemporary needs of all sections of the society and students and enriched with local and global current trends including local geographical traits of the state of Haryana.
- Syllabus should be more attractive and interesting for students, first and second semester students may be offered physical geography with basic cartography in practical papers. It may be helpful in developing their interest and scientific understanding towards geography.
- Third and fourth semester students may offered

Advance Geography of India consisting a portion about geography of Haryana state followed by Regional planning in next semester. In practical in these semesters, survey and field reports writing and their presentations, should be preferred. It will enhance their national and surrounding geographical knowledge and help them to meet with problems and prospects of the society where they are living.

- In Fifth and Sixth semester students may offered Disaster management and Applied GIS-Remote Sensing to enhance their ability to link geography with livelihood. In practical paper students may be offered Computer aided Cartography, GIS-Remote Sensing, Case studies, Disaster mitigating etc. to equip them with modern tools of geography.
- A field survey may be offered every year, either once in two semesters and should be focused to conduct physical, agricultural, industrial, socio-economic surveys with recent tools and techniques of information and communication technologies.
- The syllabus should articulate to develop interests of students in geography. We need to teach those concepts, theories, models and laws of geography and allied disciplines with the help of new techniques like projectors, smart class rooms, presentations and internet resources. Factual and old-fashioned syllabus bring boringness of students towards the discipline which resultant decline in their student profiles.
- We need to introduce more and moreoptional papers, if not possible in every semester, once in a year. It will liberalise students willing to read what they want and what that is more relevant to the needs of society and their livelihood.
- More colleges may be offered honours courses in geography to attractbrilliant students to prepare a better nursery of geographers for future to make distinction from other subjects in academia and society.
- In honours courses we may offer specialisation from fourth semester in GIS Remote sensing, Planning, Urban and Rural planning, Disaster management, Environment consultancy etc., to make geography career oriented like other tech subjects are.
- In honours courses we may offer industrial apprentice/internship in last semester in GIS, Remote sensing, Planning, disaster management, Environmental consultancy to build up our students skilful modern professionals geographers.
- Advanced study methods and techniques should be followed, information technology and communication technology should be included.

REFERENCES

Ahmad, A. (1997): "Fifty Years of Indian Geography" in Kapur, Anu, ed. (2002). Indian Geography: Voices of Concern. New Delhi, Concept Publishing Company: 366-376

Alam, S. (2010): "Recent Trends in School Geography in India", Journal of Geography, 109 (6): 243-250

Alam, S. (2014): "Reorienting Undergraduate Geography Curricula" Trans. Inst. Indian Geographers, (36): 33-43

Banerjee-Guha, S. (2004): "Space, Society, and Geography: Investigating the Crisis of Postmodern Urban Space" in BanerjeeGuha, Swapna (ed.) Space, Society and Geography. Jaipur/New Delhi: Rawat Publications: 61-82

Lahiri-Dutt, K. (2005): "Geography as a Marginal Social Science", Economic and Political Weekly, (February 12): 689-691

National Council of Educational Research and Training (2000): National Curriculum Framework for School Education. New Delhi

National Council of Educational Research and Training (2005): National Curriculum Framework 2005, Higher Secondary Stage. New Delhi: NCERT

Nag, P. (2008) "geography in 21st century: managing data infrastructure" in Dutt, Mishra & Chatterjee (Ed) Explorations in applied geography; Prentice hall of India Private limited, New Delhi, 56-70.

Singh, S (2009): "Geography in India: Some Reflections", Transaction Institute of Indian Geographers, 31(2): 109-120

Sharma, H.S (2008) "Repositioning Geographical Research: Environment, Development and Sustainability, Annals of the National Association of the Geographers of India: 28(1): 1-21

Web References

Press Information Bureau, Government of India (August 28, 2006): "PM announces setting up of National Institute of Science Education and Research at Bhubaneswar"http://pib. nic.in/newsite/erelease.aspx?relid=20345 accessed on Sep 20, 2016

Times of India (March 31, 2016) "From schools to universities, Modi plans overhaul of education" http://timesofindia.indiatimes.com/india/From-schools-to-universities-Modi-plans-overhaul-of-education/articleshow/51624993.cms accessed on Sep 20, 2016.

A MICRO LEVEL ANALYSIS OF THE CHANGING USES OF LAND IN THIRUVANANTHAPURAM DISTRICT, KERALA

Charutha REGHUNATHAN[1] & R. ANILKUMAR[2]

ABSTRACT

Population growth and land use are dependent and the varying interests of the population are evident from the land use of a region. Thiruvananthapuram, being the state capital and the seat of administrative activities along with the added advantage of being an important IT center, the influence of population is considerably increasing. The work tries to analyze the varying interests of the population in terms of usage of a particular piece of land. In the course of this study, land use underwent substantial changes in the district and during the period, conversions between different types of land uses took place frequently. The major factors causing these changes are identified as population growth, increasing construction activities and government policies.

INTRODUCTION

The changing population and its effect on land are always an important topic of discussion. The change in the lifestyle of people directly affects the use of land and this plays a vital role in regional, economic and social development. A comparative picture of the population characteristics over a period of time can also explain the development process of a geographic locality (Kerala State Planning Board, 2009) as land uses observed in an area are primarily the result of human actions on land. Understanding these actions and the social forces that drive them is crucial to understanding, modeling and predicting local, regional as well as global environmental change and also for managing and responding to such change (Fazal Shahab, 2000). Information regarding the existing land use patterns and changes through time is an important prerequisite for better land utilization. In this context, the variations in population concentrations and the resultant land use were analyzed in each physiographic division of Thiruvananthapuram district.

STUDY AREA

Thiruvananthapuram district lies in the southern part of Kerala (Figure 1) extending between the north latitudes 8° 17' 25" to 8° 51' 46" and east longitudes 76° 40' 25" to 77° 17' 6" with 2192 sq.km area. The altitude of the area varies from MSL to 1900 mts. The main rivers are Neyyar, Karamana Ar and Vamanapuram Ar. The important backwaters are Veli kayal, Kadinamkulam kayal, Anjengo kayal and Edava-Nadayara Kayal, and there is also a fresh water lake at Vellayani. The population of the district is 3,307,284 (2011 census). It is the second most populous district in Kerala and is the densest district with 1506 persons/sq.km (2011 census).

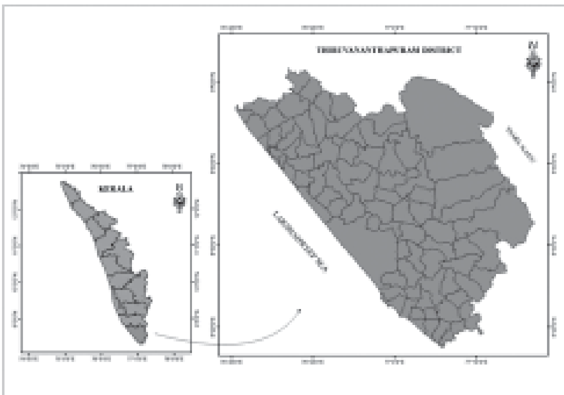


Fig. 1 : Study Area

MATERIAL AND METHODS

Data Used

The demographic details from 1971 to 2011 were collected from Census publications. The investigation also used two sets of data for analyzing land use changes which include historical documents (published maps and texts) and remote sensing data. Land use/Land cover of 1966-67 was extracted from SOI topographic maps of 1966-67 (1:50000), that of 1991 was mainly obtained from Landsat TM imageries of 1991 and data of 2001 and 2011 were extracted from Indian Remote Sensing (IRS) LISS III images. Visual interpretation techniques were incorporated for the work. For the preparation of recent land use/cover maps, field verifications were made as well as Google Earth images were consulted. This provided a platform for the detailed analysis of land use changes. Arc GIS 9.3 software was used for editing, labeling, projecting demographic and land use and for the preparation of land use matrices.

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Data Processing

The processing of the compiled data was in the following sequence: the scanned topographic maps of 1966-67, which was used as the base map, was geo-referenced and all the other maps and images were registered in the same projection and coordinate system (WGS 1984). Subsequently, visual interpretation and digitization of the maps and images were made and a series of land use maps belonging to four different time periods viz., 1966-67, 1991, 2001, 2011 were prepared. The land use/ cover of the study area was classified into twelve types, namely, a settlement with mixed trees, airport, built-up land, paddy field, forest, forest plantation, grassland, sandy area, scrub forest, scrub land, wasteland and water bodies. The panchayat wise demographic attributes were incorporated and three divisions based on physiography namely highland, midland and lowland were delimited with the help of contours. Finally, the land use change matrices were prepared.

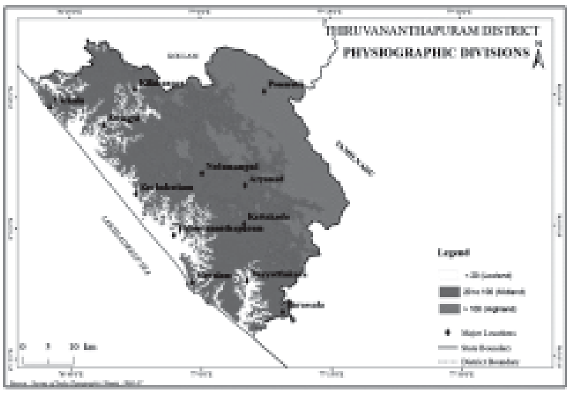

Fig. 2 : Physiographic Divsions

RESULTS AND DISCUSSIONS

Population Variation in the Physiographic Divisions

The study of population based on physiographic division showed that majority of the population preferred to live in lowland regions. During 1971, about 54.82 percent population residing in this zone (Table 1) increased to 55.42 percent in 1981. As per 2011 census, 55.25 percent of the population resided in lowland. The proportion of population residing in midland shows only minute variations. In 1971, 39.58 percent people resided in this zone, increased to 39.21 percent in 1981. 40.05 percent of total population of district stay in this zone as per 2011 census. Decrease in population concentration can be witnessed in highland region. About 6.58 percent of the population in 1971 resided in this zone. According to the 2011 census, 4.69 percent the population of the district resides in this zone. Thus, the present investigation showed that lowland region remained the zone of high population concentration in Thiruvananthapuram district followed by midland region while population percentage is seen to be decreasing in the highland region.

Table 1
Population Concentration in Different Physiographic Division of Thiruvananthapuram District, 1971 to 2011

Physiographic divisions	1971			1981			1991			2001			2011		
	Persons	Male	Female	Persons	Male	Female	Persons	Male	Female	Persons	Male	Female	Persons	Male	Female
Highland	6.58	6.643	6.52	5.35	5.37	5.34	5.20	5.20	5.20	5.017	4.978	5.05	4.69	4.63	4.752
Midland	38.58	38.68	38.48	39.21	39.35	39.08	39.94	40.01	39.87	43.09	43.15	43.03	40.05	40.07	40.022
Lowland	54.82	54.66	54.98	55.42	55.27	55.57	54.85	54.78	54.91	51.89	51.87	51.91	55.25	55.29	55.21
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

The decade wise growth rate revealed that during 1971-81, the growth rate of midland was high with 20 percent followed by lowland (19.10 %) (Table 2). Highland region showed negative growth rate (-3.94%). During 2001-11, except lowland (8.68%), the other two physiographic divisions recorded negative growth rates.

The study revealed that the lowland regions are the zone of preference of population, but the overall growth rate of population for the forty years shows that both the midland and lowland zones show very similar growth rates which were 35.83 and 33.91 respectively (Table 1). Thus, lowland and midland areas also had high population concentrations but as per recent census, a negative growth rate was reported in midland zone but still holds one third of the population of the district. The redrawing of the boundary of the corporation can be a major cause of

Table 2
Growth rate of Population in Different Physiographic Divisions of Thiruvananthapuram District, 1971 to 2011

Physiographic zones	*Growth rate of Population*				
	1971-81	*1981-91*	*1991-01*	*2001-11*	*1971-2011*
Highland	-3.9416	10.2978	5.79871	-4.4678	6.61708263
Midland	20.006	15.6062	18.4115	-5.1274	35.837547
Lowland	19.3689	12.3235	3.84244	8.68613	33.9171198
Total	18.0799	13.5024	9.76383	2.0737	33.4043733

Source: Census publications, 1971 to 2011.

this reduction along with the general reduced growth rate experienced in the district.

Variations in the Land Use in various Physiographic Divisions

Land use analysis of physiographic division shows that along with the lowland region, settlement with mixed trees dominated and constituted 175.7 sq.km. (Table 3) Area during 1966-67 with a slight reduction of 1.94 sq.km area (Table 4) making the area 173.76 sq.km (Table 3) during 2011. Paddy fields which were spread over an area of 92.33 sq.km in 1966-67 decreased to 22.55 sq.km in 2011. The built up area experienced a growth of 89.77 sq.km. in the forty years in this region. In the case of midlands, area built up areas showed a high increase with an addition of 214.2 sq.km area in the four decades. Scrub forest and scrub land also showed positive growth (Table 4). Highest reduction in area can be noted for the area under paddy fields with a reduction of 99.3 sq.km.

Along the highland, a notable increase can be witnessed for the scrub forest with an addition of 149.39 sq.km. area from 1966-67 to 2011. Built-up land and settlement with mixed trees also showed positive growth. All other land use categories showed negative growth rate in this zone during the period of study.

Table 3

Area Under Various Land Use Categories in the Physiographic Zones of Thiruvananthapuram District

Land use Categories	Lowland		Midland		Highland	
	1966-67	2011	1966-67	2011	1966-67	2011
Settlement with mixed trees	175.7	173.76	940.17	847.73	209.44	211.8
Aerodrome	1.47	2.79	0		0	0
Built-up land	15.97	105.74	10.67	224.87	4.36	30.18
Paddy field	92.33	22.55	127.81	28.51	7.84	0.35
Forest	0	0	33.59	14.64	406.82	273.71
Forest Plantation	0	0	13.55	6.68	42	18.03
Grassland	0	0	0	0.09	5.78	0.26
Sandy area	18.67	4.54	0	0	0	0
Scrub forest	0	0	0.07	14.64	4.14	153.53
Scrub land	0	0.8	1.09	2.94	4.02	6.8
Wasteland	0.16	0.008	1.55	0.39	16.55	8.02
Waterbody	23.56	17.6	25.2	13.23	5.03	3.53
Total	327.86	327.788	1153.7	1153.72	705.98	706.21

Source: Compiled from Survey of India Topographic sheets 1966-67 and Satellite Imageries

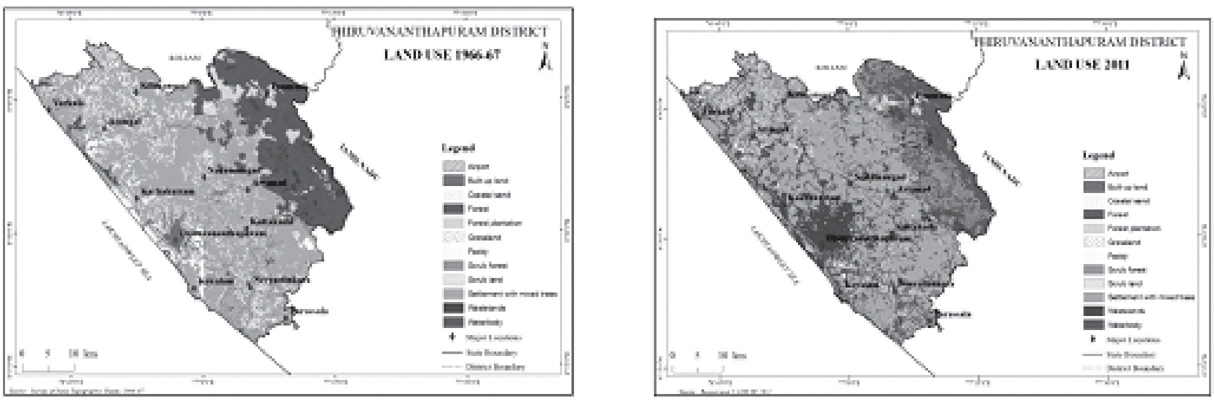

Fig. 3 : Land Use – 1966-67 and 2011

Land use conversions based on physiographic zones

In order to get a detailed idea about the land use conversion taking place in the district in the past forty years, land use transitions in the three physiographic zones were dealt with in detail. This was done by utilizing land use maps of 1966-67 and 2011. Based on the land use change matrix obtained from the

Table 4.4
Changes in the Land Use in Various Physiographic Divisions,1971 to 2011

Sl. No.	*Land Use Categories*	*Lowland*	*Midland*	*Highland*
1.	Settlement with mixed trees	-1.94	-92.44	2.36
2.	Aerodrome	1.32	0	0
3.	Built-up land	89.77	214.2	25.82
4.	Paddy field	-69.78	-99.3	-7.49
5.	Forest	0	-18.95	-133.11
6.	Forest Plantation	0	-6.87	-23.97
7.	Grassland	0	0.09	-5.52
8.	Sandy area	-14.13	0	0
9.	Scrub forest	0	14.57	149.39
10.	Scrub land	0.8	1.85	2.78
11.	Wasteland	-0.152	-1.16	-8.53
12.	Waterbody	-5.96	-11.97	-1.5

analysis of lowland areas, paddy fields can be identified as the most affected land use type. From the total area of 92.29 sq.km, occupied by paddy in this zone, about 49.67 sq.km. was changed for settlement with mixed crops purposes (Table 5). The field work conducted in the region revealed that these areas are now mainly used for coconut and plantain cultivation. 24.29 sq.km. of paddy cultivated area was converted for built up purposes. The reduced percentage can be attributed to government policies that prevent and restrict conversion of paddy fields for other purposes. Another important conversion can be witnessed between settlements with mixed trees and built up land. In the total area of 175.75 sq.km. Occupied by settlement with mixed trees, 55.8 sq.km area was changed for built up purposes. This change is inevitable as the increasing population demanded more space for building purposes and thus these areas were prioritized. Coastal areas have seen modifications in the period under investigation. 8.82 sq.km area, which was previously under sandy area is demarcated as built uplands and another 5.94 sq.km of the area is used for settlement with mixed

Table 5
Land Use Matrix of Lowland Region of Thiruvananthapuram District

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Forest plantation	Grassland	Sandy area	Scrub forest	Scrub land	Wasteland	Waterbodies
Settlement with mixed trees	107.31	0.59	55.8	6.58	-			2.03		0.2	0.08	3.16
Airport	0.007	1.4	0.06		-			0.001				
Built-up land	1.54		14.32	0.002	-			0.07				0.02
Paddy	49.67		24.29	15.63	-			0.04		0.22		2.45
Forest					-							
Forest plantation					-							
Grassland					-							
Sandy area	5.94	0.79	8.82		-			2.55		0.35		0.19
Scrub forest					-							
Scrub land					-							
Wasteland	0.02		0.14		-							
Waterbodies	9.26		2.01	0.33	-			0.08		0.019		11.83

trees. This is due to the encroachment along the coastal areas for both residential purposes and also for tourism activities. The area was used for cultivation of tree crops especially coconut. Variations in the area under water bodies are also important and it is seen that 9.26 sq.km of the area from this land use is now under a settlement with mixed trees. This is an important link which proves that rivers are vulnerable along the banks. Sand mining taking place in many areas along the midland and lowland regions

Table 6
Land Use Matrix of Midland Region of Thiruvananthapuram District 1971 to 2011

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Forest plantation	Grassland	Sandy area	Scrub forest	Scrub land	Wasteland	Waterbodies
Settlement with mixed trees	724.77		189.35	15.94	1.45	0.34	0.09		3.22	2.19	0.38	2.39
Airport												
Built-up land	1.59		8.73	0.04	0.13				0.11			0.04
Paddy	92.14		22.19	12.23	0.16	0.29			0.37			
Forest	10.12		1.61		10.2	1.61			7.79	0.33		1.94
Forest plantation	5.18		0.42	0.02	1.02	3.82			1.97	0.15		0.92
Grassland												
Sandy area												
Scrub forest					0.02	0.002			0.05			
Scrub land	0.95		0.05		0.04				0.02	0.007		
Wasteland	1.14		0.4		0.001				0.001			0.01
Waterbodies	11.79		2.07	0.25	1.58	0.56			1.11	0.007		7.77

are also important factors causing variations in the water bodies.

The perusal of the land use of midland region shows that paddy fields are most vulnerable to changes (Table 6). From the total 127.38 sq.km. area, 92.14 sq.km. were converted to settlement with mixed trees and 22.19 sq.km. for built up uses. Along the midland region, paddy fields are mainly changed for banana cultivation and also for tapioca, vegetable and pepper as inter-crops. Coconut plantation still remains an active choice of the residents of these regions. The water body is also seen facing challenges for its existence with about 11.79 sq.km. Converted for settlement purposes and 2.07 sq.km. for built up purposes. About 5.18 sq.km. of forest plantations and 10.12 sq.km. of forest areas have were also converted for settlement with mixed trees. Variations in other land uses are almost negligible.

In the highland zone, the same fate of paddy continued. Here due to nature of relief, very little area was used for paddy which was only 7 sq.km. In 1971. Within that size, 6.18 sq.km. is seen to have been converted for settlement with mixed trees and 0.75 sq.km. for built up purposes (Table 7). By 2011, almost 90 percent of the area previously used for paddy and seasonal crops have been changed for other uses. The crops cultivated mainly include rubber which has an important position in the highland areas of the district followed by tapioca and other tree crops like arecanut, jack, mango etc. From the total area of 209.3 sq.km. under settlement with mixed trees, 22.16 sq.km. has been converted for built up purposes alone. Conversion is also seen in forest regions with 128.63 sq.km. now under scrub forest, 19.91 sq.km. for settlement with mixed trees and 1.8 sq.km. for built up purposes while 241.15 sq.km. of the area remained unchanged.

Table 7
Land Use Matrix of Highland Region of Thiruvananthapuram District 1971 to 2011

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Forest plantation	Grassland	Sandy area	Scrub forest	Scrub land	Wasteland	Waterbodies
Settlement with mixed trees	175		22.61	0.28	2.78	1.05	0.26		3.65	2.49	0.94	0.24
Airport												
Built-up land	0.31		0.09		2.12	0.05			1.63	0.08	0.11	0.05
Paddy	6.18		0.75	0.07	0.28				0.29	0.26		0.03
Forest	19.91		4.4		241.15	6.23			128.63	1.58	3.52	1.43
Forest plantation	6.25		1.68		12.75	10.45			9.5	1.12		0.22
Grassland					1.83				3.94			
Sandy area												
Scrub forest					0.7	0.18			3.25			
Scrub land	2.32		0.08		0.01				0.4	1.2		
Wasteland	1.31		0.47		10.08				1.29	0.04	3.43	0.003
Waterbodies	0.48		0.06		1.95	0.06			1.05			1.44

CONCLUSION

The study revealed that the midland and lowland areas of the district remained favorable sites for population concentration in the district while the highland regions with majority of areas under forest cover are still untouched to some extent. The land use study identified paddy fields as most vulnerable to changes along with settlement with mixed trees, forest, forest plantations and water bodies. The conversion of paddy is highest along the midland areas of the district and the main reason for conversion is to create settlement with mixed trees and in some areas for built up purposes alone. Thus the information regarding demographic aspects and land use data is inevitable in the analysis of environmental processes and changes. Remote sensing and GIS techniques provide a strong base for these studies. The present study could reveal the fact that in Thiruvananthapuram district, the increasing population concentration is the major cause of land use change.

Acknowledgements

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REFERENCES

1. R.H.Arnold, "Land use and Land Cover Mapping. In: Arnold RH (ed) Interpretation of Air Photos and Remotely Sensed Imagery". Prentice Hall, Upper Saddle River, 1997.
2. D. Bardhan, and S.K. Tewari, "An Investigation into Land Use Dynamics in India and Land under Utilization." Indian Journal of Agricultural

Economics 65 (4): pp. 658-676., 2010

3. Fazal Shahab, Urban Expansion and Loss of Agriculture Land – A GIS Based Study of Saharanpur City, India, Environment and Urbanisation, Vol. 12 Issue No. 2, pp. 133-149., Oct 2000.

4. S. Gaire, "Land Use Dynamics in Karnataka – An Economics Analysis," M.Sc. (Agri Econ) Thesis, Submitted to University of Agricultural Science, Dharwad, Karnataka (India), 2011.

5. C. He, N.Okada, Q. Zhang, P. Shi, and J.Zhang, "Modeling Urban Expansion Scenarios by Coupling Cellular Automata Model and System Dynamic Model in Beijing," China. Applied Geographer, Vol. 26, pp. 323-345., 2001.

6. Hou Lisheng, Cai Yunlong, "An Essential Analysis and Review on Land Use/Cover Change Research," Progress in Geography, Vol. 23, No. 6, pp. 96-104., 2004.

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EVALUATION OF URBAN ENVIRONMENTAL SERVICES IN BURDWAN MUNICIPALITY

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ABSTRACT

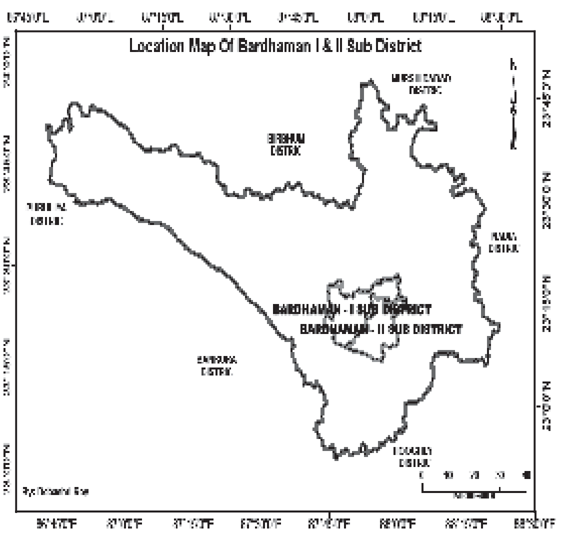
Urban development does not mean an increase in the number of urban centers and population in quantity. The quality of urban life is most significant in the present scenario. But, the living environment of our cities and towns is degrading fast owing to inefficient land use, increasing automobiles, heavy pollution, mismanaged waste disposal, water, sanitation, hygiene, etc. urban planning involves objective of target based process adopted for urban environmental development. Urban environmental services provided by municipality are very important to a beautiful urban living environment

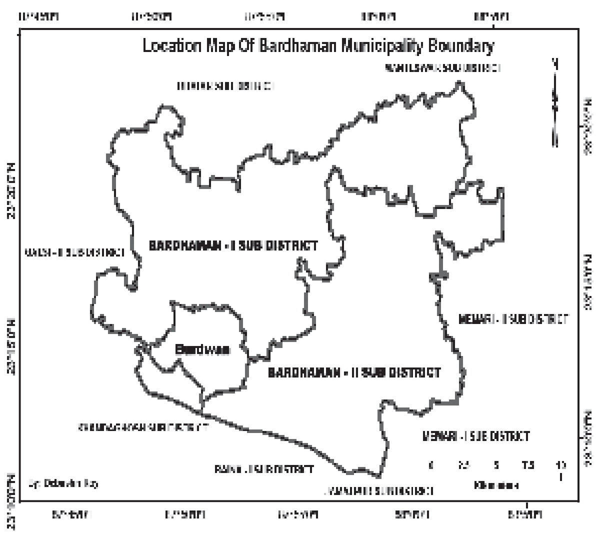
So, the paper attempts to assess in providing urban environmental services in Burdwan municipality. Evaluation of the services provided by the municipality (its quality, content, consistence and relevant) has been designed through a perception survey. The study identifies water supply, sewerage, garbage disposal, sanitation, market facilities, road development, street lighting, recreation and amusement as the criteria for assessing the quality and content of municipal areas.

INTRODUCTION

The subject of urban local self governance is an integral aspect of the field of urban geography. The progress of an urban area depends on its local body governing. UNDP defines governance as the exercise of political, economic and administration authority in the management of country's affair at all level. The quality of urban life, basic urban amenities, urban environmental management, slum development and total improvement planning depend upon it. It is important to define urban Governance at the outset. Urban governance comprises the complex mechanisms, processes and institution through which citizens and group articulate their interests, mediate their differences and exercise their legal right and obligation. Good governance is participatory, transparent and accountable. It is also effective and equitable and it promotes the rule of law. Good governance assures the political, society and economic priorities based on broad consensus in society and the voices of poorest and the most vulnerable are heard in decision making over the allocation of development resources.

The 74th Amendment to the Constitution of India provides the broad and compulsory framework for urban local self governance as democratic institutions. The functioning of municipalities in West Bengal like in many other states involve a participatory process the micro-level study of the quality of the service and infrastructure will help understand the true nature of the process.





Source: In use government boundary

Fig 1: Location Map of Burdhaman I & II District.

Fig 2: Location Map of Burdhaman Municipality Boundary

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This study, therefore, attempts to assess the role of the municipality in providing good governance to the selected study area. The broad range of planning for the urban area falls upon the urban local self governance or the municipality. This study discusses the planning directive programs and policy as pacts of the municipality attempts to provide urban service and finally analysis the citizen's assessment of the quality and content of service provided by the municipality.

THE STUDY AREA

Burdwan Municipality is selected for the case study as it is a development authority and being a district headquarters its importance is increasing day by day as an urban center. Burdwan municipality is located between 23°12′0″ N to23°16′30″N latitudes and 87°48′45"E to 87°53′15"E longitudes.

Table 1
Demographic Growth Pattern

Year	*1981*	*1991*	*2001*	*2011*
Population	1,68.00	2.45.00	2,85,602	3,47,016
Decadal Growth	18%	46%	17%	21%
Population Density (per/sq. km)	6315	9316	10869	15054

Source: Demography Book.

OBJECTIVES

The major objective is to evaluate the satisfaction level of the Citizens on the various municipal environmental services. This becomes the basic for few subsidiary objectives such as the following:

(1) To analyze the nature and ranges of services provided by the Municipality.

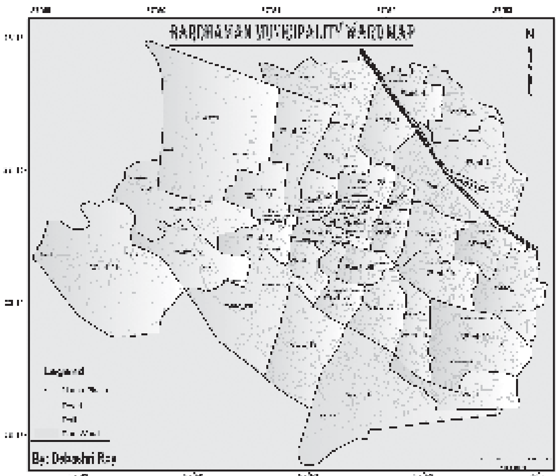
(2) To evaluate the people's perception about the selected municipal services.

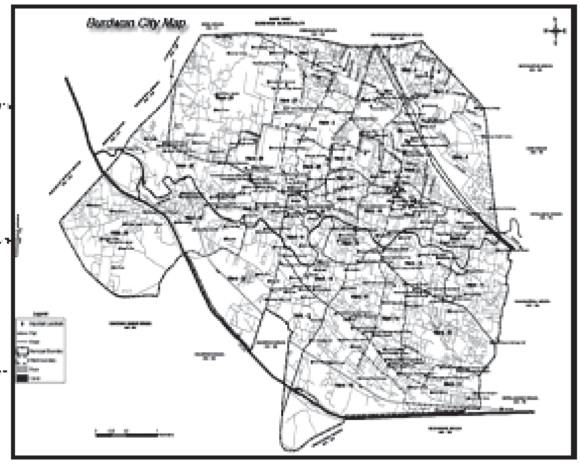
(3) Ward wise comparative analysis of the satisfaction level of urban environmental services.

Historical Background and Overview of Burdwan Municipality

Burdwan is quite an old and important Town of the state and has strong reference in history in regard to trade and commerce. Burdwan also called Burdhaman is a major communication center located on the banks of Damodar River, the town of Burdwan is the district headquarters. It was named after the 24th Jain monk, Tirthankar Mahavir Burdwan during the Mughal rule, its name used to be Sharif bad.

In the 17th -18th century, Krishna Ram Roy, belonging to a merchant family from Punjab, established the zamindari of Burdwan on a 'Farman' issued by the Mughal emperor Aurangzeb. The Ray's went on to rule Burdwan till 1955.





Source: New Updated Boundary Verses Municipality Own Boundary

Fig 3: Updated Burdwan Municipality Map

Fig 4: Burdwan Municipality Own Map

Historically the town is associated with a minority of Sher Afghan. Poet Gobinda Das is a celebrated name of this town. The background of this town a rich and fertile legacy in history. The University of Burdwan is housed in the place of the Rajas of Burdwan. The town started to flourish with the introduction of railways.

The municipality of Burdwan was established in the year 1865. At that time municipality area was 12.8 sq. km with a population of 39.818. As per 2011 census, the population and the area of Burdwan municipality are 347,016 and 26.30 sq. Km respectively. At present, the municipality has 35 wards. Burdwan is the principal town and civil station of the district. It is situated on the banks of river Banka on the northern side of river Damodar.

METHODOLOGY

The total study used descriptive and analytical methods. The stages in the methodology are followed:

- Secondary data has been collected from the report and plans published by the municipality, Draft Development Plan and census of India Reports.
- Primary data was collected by administration of a structured questionnaire. A random sampling method was used to select the respondents across 35 wards of the Burdwan Municipality. Their numbers were determined by calculating 0.5% of the total word household.
- Data analysis and representation includes the analysis of the different types of the data about the municipality amenities services and physical infrastructure to show the spatial variations. This analyzed data is represented by using different cartographic and quantitative techniques.

LEVEL AND ACCESS OF MUNICIPAL SERVICES

Water Supply

The development of an adequate water supply system is one of the most vital necessities of every community. Water is required for sustaining life, safeguarding health, promoting sanitation, providing fire protection and supplying the needs of industry, commerce and agriculture.

Adequacy

Although water usage varies greatly from city to city, the average daily consumption usually runs from 100 to 200 gallon per persons. Normally, the consumption of water for domestic use and for drinking purposes does not exceed 60 gallons per day per person. The adequacy of a city water supply is concerned with quality as well as quality.

In Burdwan, water supply is maintained by the ULB itself. The main source of water in the area is now from ground water. Good quality is maintained for the supply of water in the town. At present Burdwan municipality receives 28-75 MLD. of water. There are 37 submersible pumps with a capacity of 20,000 GPH each.

There are 6 reservoirs in the municipal area, with capacity varying from 75,000 gallons to 150.000 the oldest of them was constructed in 1885.There are about 272 km of water distribution network throughout the municipality. The diameter of the pipes varies. The pipes are mostly mode of cast iron; there is asbestos cement, galvanized iron and plastic pipes too. There are 21,388 household connections, 7,300 stand post and 2,600 hand tube wells.

Table 2
Projected Water Supply Demand 2025

Sl. No.	*Year*	*Population Demand*	*Water Water*	*Present Supply (in MLD)*	*Deficiency*
1.	2001	2,85,871	285.87.100	28.75	+1,62.900
2.	2013	3,60,050	48606,750	28,75	-198.56,750
3.	2025	4,34,232	5821320	28.75	-298,71,320

Source: Municipality Corporation Data.

Sewerage and Sanitation

One of the most important consequences of urban growth is the need for providing adequate sewers. The system used for disposing of liquid wastes is called the sewerage system. The materials carried in the sewerage system are one of most dangerous waste products of any community.

The problem of sewage disposal has increased with the size of the modern city. The average flow ranges from 100 to 200 gallon per person per day.

The type and capacity of the system must depend upon a number of considerations, including present population and anticipated growth, type of industries, the amount of rainfall and the seasonal variation, topography, and nature of the drainage areas.

The sewerage system is two types (a) Separate System (b) Combine System.

The sewerage system of this municipality is a combined system because here the entire volume of surface waters and domestic water is carried in the same set of mains.

Burdwan is basically a non-severed city, but recently underground sewerage system has been installed in water no 21, length of that sewerage line is only 0.02 km and it covers 0.001 sq km area. There is mainly

Table 3
Overview of Sanitary Facility

Indicators	*No*
Population covered by septic tank	2,15,000
Number f septic tank	40,750
Population covered by ILCS	52,025
No of individual par flash latrines	16,240
No of community latrines	532

Source: Questionnaire for 'Urban West Bengal' for Burdwan Municipality.

open surface drain and some covered drain. Besides, there are other outfalls too. Individual houses in the municipal areas are connected with septic tank. Some are also covered under ILCS. Only word no 11, 12, 16 and 29 available the facility of covered drain. In other areas, there is open surface or other (kuchha) kind of drains.

Table 4
Road Length and Footpath in Municipality in sq.km.

Surfaced road		*Un Surfaced Road*	*Total Road*	*Foot Path*
B.M	*PWD*			
166.06	35	88.562	289.622	1.2

Source: NUDB

Road and Local Transport

There are mainly 5 types of roads in municipality area, these are concrete 15%, black top 35%, brick paved 15%, kaccha 25% and cement cone 10%.

Characteristics of Road

Arterial, Number of lanes double, Undivided, Foot Bridge, Railways Over Bridge, Flyover Present near Purta Bhawan.

Name of the few Important Roads

G.T Road, SH-7, B.C. Road, Sarat Palli Road, Mithapukur Road, Khosbagan Road, University Road, B.B. Ghosh Road, Deewan Dighi Road, Kalna Road, Chhotonilpur Road, B.S. Para Road.

Type of Transport in the Municipal Area

Government Transport- Train, State Bus

Private Transport- Private Bus, Mini Bus, Chattered Bus, Van-rickshaw, Cycle & Rickshaw

SOLID WASTE MANAGEMENT

In addition to sewage, every community is faced with the necessity of disposing of large quantities of solid waste including garbage, rubbish, ashes, street cleanings and all sorts of refuse resulting from trade, industry and building operations. In rural communities, self disposal of waste is normally the rule, but in areas of high population density, the responsibility for waste collection and disposal becomes that of the local self government.

Main sources of solid waste in Burdwan Municipality

(a) *Household:* These are collected from the house and transported by tricycles directly to disposal ground.

(b) *Market and other public places:* These waste are collected from markets and other public places (including drain waste) and transported to disposal ground by tractors and trailer.

Type of Solid Waste

(i) Municipality Solid Waste: Organic, inorganic and leached wastes are including in this category.

(ii) Biomedical Waste: These are generated from hospital and nursing home.

(iii) Construction and Demolition Waste: These are the result of housing project and construction of new multistoried housing complex in the place of old building. These are used for filling up low-lying areas. These are no problematic now.

(iv) Vehicle used for garbage collection

Primary Vehicles

Pedal Tricycle-135, Handcart-175, Lorries-11, Tippers-4, Dumpers-4, Tailors-1, Trolley-5, Cass Pool-2, Covered Van-2.

Disposal System and Treatment

The total quantity of solid generated in this municipality area is 103 metric tons. Day waste management system in Burdwan is not adequately self sufficient. There is a lack of sanitary dumping ground.

Urban Amusement

Status of urban recreation and amusement is satisfactory. Perception study reveals that the citizens are satisfied. There are parks auditorium, cinema hall planetarium stadium and different type of restaurant also.

Level of Satisfaction with the Urban Environmental Services Provided by the Urban Local Self Government

To know the level of satisfaction about the municipality services of the citizen, a perception study has been done by questionnaire survey. The selected environmental services are water supply, sewerage, garbage disposal, road development, street lighting, sanitation, recreation and amusement.

Water Supply

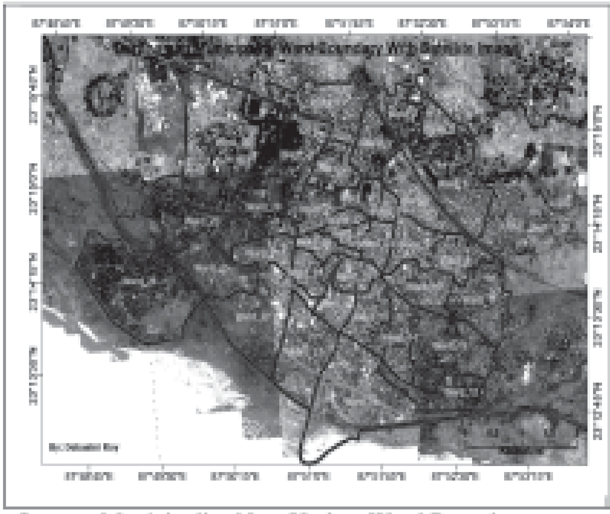
Maximum numbers of the respondent (89%) belong to the level of satisfaction in this service.

Sewerage

Maximum number of people (63%) were in medium satisfaction level. 18% of the respondents say that they are satisfied with the service. Only 3% of them are without any sewerage facility.

Garbage Disposal

37% of them belong to the medium satisfaction level.



Source: Municipality New Update Ward Boundary

Fig 5: Bardhhaman Municipality Ward Map with satellite image

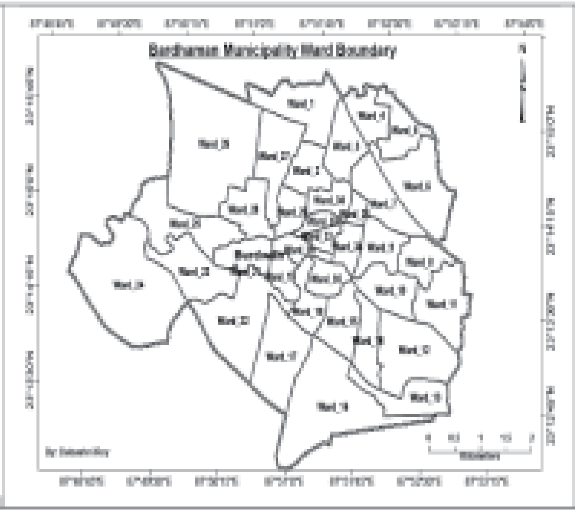


Fig 6 : Bardhhaman Municipality Ward Map

34% think that the particular service is in poor condition. 19% gives an opinion that they are satisfied with the service.

Road Development

24% are satisfied with the existing street condition, whereas 39% are in the medium satisfied level.

Street Lighting

Maximum number of respondents (33%) are satisfied the facility. 37% of them informed that the condition is very poor.

Sanitation

Maximum (41%) of respondents informed that they are satisfied with the level available. 19% give the highest mark to denote their level of satisfaction.

Recreation and Amusement

Maximum of them is in very good satisfaction level.

CONCLUSION

(a) The level of urban environmental services is more satisfactory in those wards which are adjoining to the urban centre, particularly adjacent to the market areas.

(b) C.B.D zone is in satisfaction level.

(c) According to citizen perception among these services they are most satisfied with sanitation, street lighting, Recreation and amusement and moderately satisfied with road, sewerage, garbage disposal, water supply.

Table-5
Issues As Suggested By Ward Committee

Sl. No.	*Issues As Suggested By Ward Committee*	*Wards Agreed*
1.	Unused Pond Filled By Waste	18,35,21
2.	Waste Clearing From Drain	Almost All Wards
3.	Water Logging	19, 20,21,23
4.	Irregular Clearing Of Drains	All Wards
5.	Unnecessary Wastage Of Water	All Wards
6.	Filling Up Ponds	15,18,21,25
7.	Required Public Toilet	1,7
8.	No Social Activities	32
9.	Cow Shade Make Hung Pollution	35
10.	Garbage Stored Beside Pond And Make Pollution	Almost All Wards
11.	Less Water Level And Pollution Pond	15,18,21,25
12.	Random Cutting of Trees	Not So Prominent

Source: Questionnaire survey by the author

A common present day practice by the local self government is to involve the end user citizen participate in the municipal administration and this practice helps to achieve the characteristics of good governance. Their suggestions are the most acceptable mode and content for the development initiative.

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REFERENCES

1. Burdwan Municipality 2008-09 to 2013-14, Draft Development Plan.
2. Census of India, 2001, District Census Hand book, Burdwan.
3. Khullar, D.E, 2008 India –A Text Book of Social and Cultural Geography, Kalyani Publishers.
4. Ahuja, R, 2009 Social Problem in India, Rawat Publications.
5. Sen, Jyotirmoy, 2007, A Text Book of Social and Cultural Geography, Kalyani Publishers.

TOWARDS INCLUSIVE CITIES: TACKLING GENDER BASED VIOLENCE

Paramita MAJUMDAR[1]

ABSTRACT

The fast pace of urbanization in India has thrown challenges as well as opportunities. For women, urbanization is associated with greater access to employment opportunities, lower fertility levels and increased independence. However, urbanization does not necessarily result in a more equitable distribution of wealth and wellbeing through its economic growth and development, it also exacerbates the challenge of creating security in a city. Women and girls experience a higher degree of insecurity and vulnerability to violence, both in public and private spheres, which limits their socioeconomic opportunities and access to city services, in comparison to their male counterparts. The challenge is to ensure that towns and cities provide healthy and safe living environments, productive economies and social benefits to diverse groups of people. When designing the city and its services including water, sanitation, transport and markets, it is crucial that gender discrimination is addressed to promote equal opportunities and achieve greater social and economic benefits. This paper examines the nature and relationship between urbanization and gender-based violence, especially violence against women and highlights as to how such violence cuts across geographic scale as it is rooted in patriarchal relations. It just requires certain triggers or risks to intensify or worsen the situation. However, as cities themselves do not generate gender-based violence, there are opportunities for reducing it as well. Success depends on good governance and the engagement of men and women as equal partners and agents for change as well as the implementation of legislations to deal with such occurrences.

Keywords: *Urbanization, Governance, Violence, Gender, Safety, Gender Equality*

INTRODUCTION

Gender Based Violence (GBV) is a global health, human rights and development issue that transcends geography, class, culture, age, race and religion to affect every community and country in every corner of the world. The UN Declaration on the Elimination of Violence provides a definition of gender-based abuse, calling it "*any act of gender-based violence that results in, or is likely to result in, physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life*". This definition hints that gender-based violence is a broader category than violence against women, and that gender-based violence—at least theoretically—could also include violence that affects men, as long as it is conditioned upon or affected by men's gender roles. In practice, however, gender-based violence (GBV) has come to be almost synonymous with violence against women. The definition is amplified in Article 2 of the Declaration, which identifies three areas in which violence commonly takes place: physical, sexual and psychological violence that occurs in the family, including battering; sexual abuse of female children in the household; dowry-related violence; marital rape; female genital mutilation and other traditional practices harmful to women; non-spousal violence; and violence related to exploitation; physical, sexual and psychological violence that occurs within the general community, including rape; sexual abuse; sexual harassment and intimidation at work, in educational institutions and elsewhere; trafficking in women; and forced prostitution; physical, sexual and psychological violence perpetrated or condoned by the State, wherever it occurs.

At the domestic front, right to a life as present in Article 21 of Indian Constitution is a fundamental right which gives right to a dignified life i.e. free of violence; further the Constitution also grants equality to women and empowers the State to adopt measures to stop discrimination against women, so as to neutralize the cumulative socio-economic, educational and political discriminations against them, however, women continue to be victim of disparate treatment, violence and crime. Violence or the threat of violence not only violates this right but restrict women's freedom and germinates imbalance of power between women and men. In the present paper an attempt has been made to analyse the nature and relationship between urbanization and gender-based violence, especially violence against women that cuts across geographic scale as it is rooted in patriarchal relations and the opportunities that are available towards ensuring inclusive governance, importantly the engagement of men and women as equal partners and agents for change. This article focuses on the physical, sexual and psychological violence that occurs within the general community and not specifically the one that occurs in the family or is committed by the State.

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URBAN GROWTH IN INDIA

India as a developing country is urbanizing at a rapid pace. India's urban population which increased from 217 million in 1991 to 377 million in 2011 is expected to reach 600 million, or 40 percent of the population by 2031, according to the New Climate Economy Report by The Global Commission on the Economy and Climate[1]. The increase in total and urban population and the proportion of urban to the total population in India is presented in the table and figure below. As can be seen, people living in urban areas of the country have increased by over nine crores between 2001 and 2011.

Table 1
Urban Population in India

Year	*Total*	*Urban*	*% Urban*
1981	68,33,29,097	159,462,547	23.33
1991	84,64,21,039	217,611,012	25.70
2001	1,02,87,37,436	286,119,689	27.82
2011	1,21,01,93,422	377,105,760	31.16

Source: Census of India.

The boost to urbanization process and a substantial increase in urban population is due to the setting up of new industries which also resulted in starting up of ancillaries and service units thereby triggering opportunities for better employment and overall economic strength of the city. It is a known fact that the per capita income in urban areas is relatively higher than in rural areas which attract the rural dwellers to migrate to cities. The growth in population and the economic activities is manifested in the increasing contribution of the urban sector. It is estimated that the urban sector presently contributes 63% of India's GDP[2] highlighting its importance in achieving nation's economic goals.

Growth in Urban Employment

As per Census 2011, the total number of workers (who have worked at least for one day during the reference year) is 481.88 million. Of this, 331.94 million workers are males and 149.95 million are females (Table 2).

Table 2
Working Population in India

	Working Population			*Workforce Participation Rate*		
	Total	*Urban*	*Rural*	*Total*	*Urban*	*Rural*
Total	481888868	133145776	348743092	39.8	35.3	41.8
Male	331939875	105102862	226837013	53.3	53.8	53.0
Female	149948993	28042914	121906079	25.5	15.4	30.0

Source: Census of India 2011.

The work participation rate for the country was 39.8 percent, marginally higher than the corresponding work participation of 39.1 percent in Census 2001.

While the workforce participation rate has remained stagnant, the unemployment rate has shown that a large number of women in urban India are unemployed. As per the latest available data, the unemployment rate based on Usual Principal Status (UPS) approach is 12.4 per cent for females in urban areas against 6.4 in rural areas, as is depicted in Table 3.

Table: 3
Labour Force Participation and Unemployment Rate (in per cent)

Sector	*Labour Force Participation Rate*			*Unemployment rate*		
	Male	*Female*	*Person*	*Male*	*Female*	*Person*
Rural	74.7	29.1	54.7	4.2	6.4	4.7
Urban	73.8	18.5	47.2	3.9	12.4	5.5
Rural + Urban	74.4	25.8	52.5	4.1	7.7	4.9

Source: Report on Fourth Annual Employment - Unemployment Survey (2013-14) Volume I

As India is following the goal of inclusive growth with a view to ensure that the benefits of growth percolate to the last man. These results could be very useful inputs not only in framing our employment policy, but also for the policies on gender-equality.

It becomes more important as a high proportion of socially and economically underprivileged sections of society are concentrated in the informal[3] economic activities. It is estimated that more than 90 per cent of workforce and about 50 per cent of the national product are accounted by the informal sectors. As it can be seen from Table 4 that, only four groups of workers in urban informal sectors in India account for the major chunk of women with 40% women in home based work.

Under the changed circumstances where informal sector is increasingly interlinked with the formal and plays pervasive role in the economy and in the livelihoods of the people, it is imperative to improve the safety and security needs/concerns of the women.

Not only the women engaged in the informal sector, but the poor women living in cities, the homeless women living on the streets also suffer the most severe kinds of abuse and violence. While housing stress is no excuse for violence, it does aggravate family tensions and lack of affordable housing makes it more difficult for women to get away from abusers. The problem has increased in urban areas as there has been a 20% increase in houseless people living in the cities according to 2011 Census. Table 5 depicts

Table 4
Four Groups of Urban Informal Workers in India, 2011-12

Informal Workers	*% of Urban Employment*			*% of Urban Informal Employment*		
	Total	*Male*	*Female*	*Total*	*Male*	*Female*
Domestic Workers	5	12	13	6	13	17
Home-Based Workers	14	10	32	17	12	40
Street Vendors	4	4	3	5	5	3
Waste Pickers	1	5	2	1	1	3
All Four	23	17	49	29	21	62

Source: http://www.in.undp.org/content/dam/india/docs/humandevelopment/Measuring% 20Informal %20Work.pdf

the number of houseless households and houseless population.

Table 5
Houseless Population 2001 and 2011

		2001	*2011*	*Growth Rate (%)*
All Households	Total	193,579,954	249,454,252	28.86
	Rural	137,773,323	168,565,486	22.35
	Urban	55,806,631	80,888,766	44.94
Houseless Households	Total	447,552	449,761	0.49
	Rural	259,742	192,865	-25.75
	Urban	187,810	256,896	36.79
Houseless Population	Total	1943476	1772889	-8.8
	Rural	1164877	834541	-28.4
	Urban	778599	938348	**20.5**

Source: Primary Census Abstract for Total population and Houseless Population, 2011

Not only the increase in number, but the problem of houseless population is also acute and has been on the rise in the top five cities as is shown below. (Table 6)

Table 6

S. No.	*Cities*	*Total Urban Population*	*Houseless Urban Population*
1.	Greater Mumbai	18,414,288	95,755
2.	Delhi	16,314,838	46,724
3.	Kolkata	14,112,536	69,798
4.	Chennai	8,696,010	16,682
5.	Bangalore	8,499,399	16,531
	Total	66,037,071	245,490

Source: Census of India 2011.

As the inflow of FDI in the construction sector is steadily increasing with constant demand from the infrastructure sector, the residential and commercial development in cities, the demand for both skilled and unskilled labour is bound to increase.

However, with the increasing crime rate[4] the holistic empowerment of women, particularly in urban areas remains a distant dream. While the growth rate of urban population has been 31.8% between 2001 and 2011, the growth of crime in 53 mega cities, each having population over 10 lakh has been unprecedented. A total of 53,464 cases of crimes against women were reported from these 53 cities during the year 2013 as compared to 36,622 cases in the year 2012. The rate of crime in cities at 69.7 was comparatively higher as compared to the national rate of 52.2.

GENDER BASED VIOLENCE IN URBAN AREAS

According to the latest NCRB data, the top ten cities unsafe for women are Delhi, Mumbai, Bengaluru, Kolkata, Jaipur, Hyderabad, Indore, Kochi, Chennai, Patna and Ahmedabad, where 60% of the total crimes are reported from.

Table 7
Crime in Top Ten Cities, 2014

S. No.	*Cities*	*Incidence of Total Cognizable Crime*	*Percentage Contribution to All-India*	*Total Population (in lakhs)*
1.	Delhi (City)	139707	22.7	163.1
2.	Mumbai	40361	6.5	184.1
3.	Bengaluru	31892	5.2	85.0
4.	Kolkata	26161	4.2	141.1
5.	Jaipur	26070	4.2	30.7
6.	Hyderabad	18940	3.1	77.5
7.	Indore	19197	3.1	21.7
8.	Kochi	17088	2.8	21.2
9.	Chennai	16861	2.7	87.0
10.	Patna	15396	2.5	20.5
	Ahmedabad	15286	2.5	63.5
	Total Cities	616639	100.0	1607.2

Source: Table 2.1- Incidence & Rate of Total Cognizable Crimes (IPC) During 2014, NCRB- 2014.

The manifestation of violence against women in these cities can be seen from the table in next page. Incidents of assault on women with intent to outrage her modesty and cases of sexual harassment have been increasing in the country. As can be seen from the above table, the number of sexual harassment cases is maximum in Delhi followed by Mumbai and others. In all these cities, cutting across class and profession, women face continuous and different forms of sexual harassment in crowded as well as secluded places, including public transport, cars, markets, roads, public toilets and parks. In schools

Table 8
Violence against Women in Top Ten Cities in India

S. No.	Cities	Incidence of Total Cognizable Crime	Total Rape (Custodial + Other than Custodial)		Attempt to commit rape (Incidence)	Kidnap & Abduction of Women to compel her for marriage	Dowry Deaths (Incidence)	Sexual Harassment (Incidence)
			Incidence*	Rate*				
1	Delhi (City)	139707	1813	11.1	59	1	127	1066
2	Mumbai	40361	607	3.3	2	15	22	650
3	Bengaluru	31892	104	1.2	4	11	57	53
4	Kolkata	26161	36	0.3	1	109	12	133
5	Jaipur	26070	263	8.6	6	97	33	52
6	Hyderabad	18940	126	1.6	2	6	22	115
7	Indore	19197	185	8.5	3	46	23	80
8	Kochi	17088	64	3.0	2	1	0	175
9	Chennai	16861	65	0.7	1	16	10	0
10	Patna	15396	54	2.6	21	359	41	0
	Ahmedabad	15286	100	1.6	0	201	11	69
	Total Cities	**616639**	**5761**	**3.6**	**240**	**2939**	**749**	**4655**

* Indicates Total Rape other than custodial

Source: Table 2.2- Incidence (I), Victims(V) & Rate (R) of Cognizable Crimes (IPC) under Different Crime Heads During 2014, NCRB- 2014

and colleges students are most vulnerable to harassment, particularly rampant in public transport, particularly buses. While some cases are reported, most of them are not registered due to the social stigma.

Impact of Gender Based Violence

It is important to note that the economic cost of violence against women is extensive and many individuals and institutions bear this cost. Rape and sexual harassment of women adversely affect India's tertiary sector, in particular IT and BPO, banking and financial, interior designing, sales and marketing, medicine, nursing, retail and tourism as women form a large proportion of the workforce. Further, economically empowered women are a new and steady source of consumption demand as they are benefitting the manufacturers and retailers bags, beauty care and cosmetics, food and beverage, expensive clothing and lingerie and other lifestyle products. Lack of participation of women in the workforce on the issue of their safety and security concerns will erode the cost competitiveness of Indian businesses and lead to a slowdown.

On the other hand, sexual harassment and rape events also negatively affect the Indian tourism industry, which contributes to around 6% of the GDP. If taking cognizance of sexual assaults on the female tourists, overseas governments issue instructions to women tourists to refrain from visiting India due to growing risks of insensitivity and insecurity, it will be a loss to the Indian economy.

However, the first and most significant cost is to the victim of the crime, as it impacts on the individual and the society as a whole whether it is direct or indirect, economic or psychological. The impact of violence affects health, education, social service, employment, etc. The individual bears the expenses on health and the burden of loss of income, the productivity of the individual too is hampered which would negatively impact the economy.

Therefore, collectively the entire economy is affected by the monetary losses resulting from gender based violence. But to quantify the economic impact is not possible, as there is no instrument/tool to measure it.

Success depends on good governance and the engagement of men and women as equal partners and agents for change as well as implementation of legislations to deal with such occurrences.

TACKLING GENDER BASED VIOLENCE – RESPONSE OF THE GOVERNMENT

The Government of India is deeply concerned with the current situations and has taken necessary steps to curb it. The government of India has enacted legislations that seek to address gender based violence to provide a safe environment for women to work and live and fulfill their dreams. Some of the recently enabled legislations are:-

1. The Criminal Law (Amendment), Act 2013 which makes the punishment more stringent for offenses like rape. New offenses like acid attack, sexual harassment, voyeurism and stalking, disrobing a woman, have been incorporated in the Indian Penal Code.
2. The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 provides for a safe and secured

environment at the workplace.

3. Apart from this, The Protection of Women from Domestic Violence Act, 2005 provides for protection of the rights of women who are victims of violence of any kind within the family; The Prohibition of Child Marriage Act, 2006declares prohibition of solemnisation of child marriages; The Protection of Children from Sexual Offences Act, 2012 protect children from offences of sexual assault; The Pre-Conception and Pre-Natal Diagnostic Techniques Act (PC&PNDT), 1994 puts prohibition of sex selection, before or after conception has been enacted by the Government.

The key programmatic interventions to respond to the victims of violence include the One Stop Centre Scheme for facilitating/providing medical aid, police assistance, legal counseling/court case management, psycho-social counseling and temporary shelter to women affected by violence; the Scheme for Universalisation of Women Helpline envisaging 24 hour emergency and non-emergency response to all women affected by violence both in public and private sphere; Swadhar and Short Stay Home Schemes for relief and rehabilitation of women in difficult circumstances including the victims of rape; the Victim Compensation Scheme for providing compensation to women affected by violence and compensation to women victims of sexual exploitation belonging to SC/ST under the Schedule Caste and Schedule Tribe (Prevention of Atrocities) ACT, 1986.

The Ministry of Home Affairs has been issuing advisories to State Governments from time to time to take action w.r.t. gender sensitization of police personals, adopting appropriate measures for swift and salutary punishment to public servants found guilty of custodial violence against women, minimizing delays in investigations of murder, rape and torture of women and improving its quality, setting up a 'Crime Against Women Cell' in districts where they do not exist, providing adequate counseling centers and shelters for women who have been victimized, setting up of specific women courts, and improving effectiveness of schemes developed for the welfare and rehabilitation of women who are victimized with greater emphasis on income generation to make the women more independent and self-reliant[5]. An advisory has also been issued on 22nd April 2013 whereby the States / UTs were requested to raise the women representation in Police to 33% and another advisory on 10th May, 2013 regarding registration of FIR irrespective of territorial jurisdiction and Zero FIR. Taking a huge step towards gender-sensitive policing, Government has cleared 33% quota for women in Delhi Police and six other Union Territories.

While the government is taking all the necessary steps required to curb the crime against women in cities and elsewhere in the country, it is pertinent that the problem so entrenched and complicated requires much larger multi stakeholder responses at all levels and across levels of governance.

Collaborative response of Government and Non-Government: Safe Cities Program

It is towards this collaborative endeavor that the Safe Cities Program of the Delhi Government along with its partner Jagori, a Delhi based NGO is much appreciated. Beginning as a multi-city stud[6] in 2009-10, the programme has entered its third phase under a renewed Memorandum of Understanding with the Government of Delhi to make Delhi a safe city, a city free of violence for women and girls. The Jagori study underlined the flawed architecture of the city spaces and the gender insensitive attitude of the institutions that govern.

The research brought to the fore a number of factors that play a role in creating safer spaces for women and girls. These include better planning and design of public spaces such as roads, bus stops, parks and public toilets. Some recommendations included lighting, design of pavements, presence of vendors and designated spaces and better design of male and female public toilets. The glaring lack of public toilets for women is a strong indictment of the state of services. A second important factor is the way that public spaces are used. The presence of a multitude of users made a space more amenable to inclusion and safety. Thus parks that had a range of users including older people, young, children, etc. were safer.

The Jagori study identified seven areas for planning interventions which include : (i) Urban planning and design of public spaces (ii) Provision and maintenance of public infrastructure and services (iii) Public transport (iv)Policing (v) Legislation, justice and support to victims (vi) Education (vii) Civic awareness and participation.[7] After successful implementation of first two phases (Phase I from September 2009 – April 2011) and (Phase II from November 2011 – September 2013), Delhi Safe City Program has resulted in some key accomplishments in Delhi, besides capacity building of various stakeholders and reaching out to school children. This include:

(1) Pioneering the use of ICT to conduct safety audits in low income neighborhoods of Bilaspur Camp in Molarband, Tajpur Pahadi in Badarpur, Indira Gandhi Camp and Valmiki Camp in Malviya Nagar.

(2) As part of enhanced state accountability and gender sensitization of government functionaries, a Core Committee has been instituted under the leadership of Chief Secretary on the issue of Women's safety and the Government of Delhi has launched Awaaz Uthao scheme to upscale the Safe City program methodology of conducting safety audits and creating women's safety collectives in 25 low income areas of the city.

(3) As a result of the safety audit findings and recommendations submitted by Jagori, UTTIPEC (Unified Traffic and Transportation Infrastructure Planning & Engineering Centre, which is the key Infrastructure planning body, is in the process of preparing a document on "Women Safety guidelines for the city" and a layout plan for a micro level project for vulnerable zones in the city. The program has extensively worked with the Delhi Transport Corporation and trained close to 40,000 drivers and conductors.[8]

The program is now being experimented in other cities like Bhopal and Mumbai to strengthen the evidence base on the issue and create a network of cities committed to promoting inclusive cities free of violence against women and girls.

Though Delhi has shown the way as to how Government–NGO partnership along with community intervention can help to reduce violence against women by developing a city-wide strategy that combines prevention, intervention, treatment, and re-entry strategies. It is crucial that each city particularly those reflected in the NCRB records initiate measures with resources available to them to curb violence against women.

Smart Cities Mission: The Solution?

The recently launched Smart Cities initiative would be the best way to start planning for safer cities. To foster rapid urban growth Government realizes that well planned cities are of utmost importance and smart cities can drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes.

Initially, the Mission aims to cover 100 cities across the countries (which have been shortlisted on the basis of a Smart Cities Proposal prepared by every city, and its duration will be initially for five years (FY2015-16 to FY2019-20). This initiative aims to focus on area-based development in the form of redevelopment or developing new areas (Greenfield) to accommodate the growing urban population and ensure comprehensive planning to improve the quality of life, create employment and enhance incomes for all, especially the poor and the disadvantaged.

The objective as outlined in the Smart Cities Mission document is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act as a light house to other aspiring cities.

The core infrastructure elements in a Smart City would include:

i. adequate water supply,

ii. assured electricity supply,

iii. sanitation, including solid waste management,

iv. efficient urban mobility and public transport,

v. affordable housing, especially for the poor,

vi. robust IT connectivity and digitalization,

vii. good governance, especially e-Governance and citizen participation,

viii. sustainable environment,

ix. safety and security of citizens, particularly women, children and the elderly, and

x. health and education.

Additionally, Foreign Direct Investment regulations have been relaxed to invite foreign capital and help into the Smart City Mission.

However, the need for gender sensitive urban planning is not explicitly mentioned in the Guidelines and critical processes like vulnerability mapping, Institutionalisation of Safety Audit, Capacity Building of Local Institutions/Municipalities, Training in gender mainstreaming (for elected officials and staff, men and women), developing Women's Organisation at the neighborhood level for information service in wards and neighborhoods' or processes to handle citizen requests and complaints from women and men separately, participatory planning etc. are missing in the document

The Guidelines does not consider the fact that women not only perceive and experience cities in a different way than men but also use public spaces in different ways. It is therefore critical that the local government recognizes the systemic impacts of discrimination. This in fact is a critical starting point in the assurance of equalities, inclusion, and sustainability for a smart city. It is important to focus on the fact that smart cities are not an IT solution, rather the alignment of good governance, investments, institutions and time.

The Government is determined to end violence of all kinds against women and girls and there is recruitment of women police across many states, but the question is – will the smart cities be smart enough, particularly in terms of women's safety? For many, this ambition remains elusive in the Indian context, given that the basic amenities and infrastructure in many existing cities such as water supply, sanitation, sewerage, electricity and traffic management are generally not in place. However, as the Government of India has already committed to the Sustainable Development Goals, with gender equality as one of the important goals, it can be assumed that a smart city will be one where the women have a life free from violence, can participate and are economically empowered.

In conclusion, it can be mentioned that unless we move towards actual implementation of our legislation, policies and programmes from the present environment building phase, legislations will be enacted and programmes will be implemented at its own pace. Smart Mission initiatives will change our cities into technologically integrated meticulously planned entities, with crimes against women reaching an alarming stage and challenging all the developments of the country. It is time that we ask the following questions to have a violence free safe and smart city:

(i) How advanced is our city in terms of gender equality, particularly in terms of Political Structures, Mechanisms and Resources?

(ii) What is the Gender policy of the Smart City?

(iii) Does the Smart City have an Annual Gender Equality Action Plan for specific goals, indicators and budget?

(iv) Whether the national laws on women's rights and gender equality are implemented by the Municipal Corporation?

(v) Is gender disaggregated data on all issues collected by the city administration? Is the gender-disaggregated data on all urban issues accessible?

Notes:

1. India on the brink of urban revolution: UN-backed report, http://articles.economictimes.indiatimes.com/2014-09-17/news/54025181_1_urban-population-climate-summit-urban-revolution

   The year-long study was conducted by leading research institutes from Brazil, China, Ethiopia, India, South Korea, the United Kingdom and the United States and advised by a panel of world-leading economists.

2. Smart Cities Mission Statement & Guidelines, Ministry of Urban Development, Government of India, June 2015

3. There are three related official statistical terms and definitions which are often used imprecisely and interchangeably by analysts and observers: • informal sector refers to the production and employment that takes place in unincorporated small or unregistered enterprises (1993 ICLS) • informal employment refers to employment without social protection (i.e. without employer contributions) – both inside and outside the informal sector (2003 ICLS) • informal economy refers to all units, activities, and workers so defined and the output from them (ILO 2002). **In sum, the informal economy is the diversified set of economic activities, enterprises and workers that are not regulated or protected by the state; and the output from them.** (http://www.in.undp.org/content/dam/india/docs/human-development/Measuring%20Informal%20Work.pdf)

4. A total of 3,37,922 cases of crime against women (both under various sections of IPC and SLL) were reported in the country during the year 2014 as compared to 3,09,546 in the year 2013, thus showing an increase of 9.2% during the year 2014. These crimes have continuously increased during 2010 - 2014 with 2,13,585 cases reported in 2010, which increased to 2,28,649 cases in 2011, which further increased to 2,44,270 cases 2012 and 3,09,546 cases in 2013. In 2014, a total of 3,37,922 such cases were reported.

5. MHA Advisory to States, File No. 15011/21/2004-SC/ST Cell, dated 5th May, 2004

6. In 2009, the Montreal-based nonprofit organization Women in Cities International launched the Gender Inclusive Cities Programme (GICP), an innovative program designed to engage women and girls in creating safer cities. The program is implemented by partner organizations in four cities: Jagori in New Delhi, India; the International Centre and Network for Information on Crime – Tanzania, in Dar es Salaam, Tanzania; CISCSA (Centro de Intercambio y Servicios Cono Sur Argentina) — the Women and Habitat Network in Rosario, Argentina; and the Information Centre of the Independent Women's Forum in Petrozavodsk, Russia. The program targets circumstances that make women and girls vulnerable to urban violence and engages local communities in making public spaces safer

   (http://iipdigital.usembassy.gov/st/english/publication/2012/02/20120228112141ael0.7284597.html#ixzz3kVCK8mYA

7. Safe Cities Free of Violence against Women and Girls Initiative, Report of the Baseline Survey Delhi 2010, https://d3gxp3iknbs7bs.cloudfront.net/attachments/5ab6a670-bb73-463a-8eb8-a757edb4de94.pdf

8. http://wfsnews.org/images/brief%20-%20safe%20city%20program%20delhi%20-%20un%20women-1.pdf

REFERENCES:

1. The costs and impacts of gender-based violence in developing countries: Methodological considerations and new evidence Andrew R. Morrison Maria Beatriz Orlando1 November 2004 (http://siteresources.worldbank.org/INTGENDER/Resources/costsandimpactsofgbv.pdf)
2. Chapter-II Growth of Urbanization Part-I Trend and Pattern of Urban Growth and Poverty in India (http://shodhganga.inflibnet. ac.in/bitstream/10603/14591/8/chapter%20-%202.pdf)
3. India on the brink of urban revolution: UN-backed report, http://articles.economictimes.indiatimes.com/2014-09-17/news/54025181_1_urban-population-climate-summit-urban-revolution
4. Smart Cities Mission Statement & Guidelines, Ministry of Urban Development, Government of India, June 2015
5. MHA Advisory to States, File No. 15011/21/2004-SC/ST Cell, dated 5th May, 2004
6. http://wfsnews.org/images/brief%20-%20safe%20city%20program%20delhi%20-%20un%20women-1.pdf
7. http://iipdigital.usembassy.gov/st/english/publication/2012/02/20120228112141ael0.7284597.html#ixzz3kVCK8mYA
8. Safe Cities Free of Violence against Women and Girls Initiative, Report of the Baseline Survey Delhi 2010, https://d3gxp3iknbs7bs.cloudfront.net/attachments/5ab6a670-bb73-463a-8eb8-a757edb4de94.pdf
9. http://www.in.undp.org/content/dam/india/docs/human-development/Measuring%20Informal%20Work.pdf
10. Annual Report 2013-14, Ministry of Women and Child Development, Government of India
11. Homeless Women and Violence, Shivani Chaudhry, Amita Joseph, Indu Prakash Singh http://www.hic-sarp.org/documents/Homeless_Women_and_Violence_Shivani_Amita_Indu.pdf

SPATIAL ASPECTS OF GOVERNANCE IN INDIA HIGHLIGHTING SMART CITY CONCEPT

Vrinda PRAKASH[1]

ABSTRACT

This paper looks at spatial aspects of governance in India highlighting smart city concept. A smart city is an urban region that is highly advanced in terms of overall infrastructure, sustainable real estate, communication and market viability. The announcement of 100 smart cities falls in line with this vision. To boost India's smart city project the United States is now helping India for 3 such cities which are Ajmer, Allahabad and Vishakhapatnam. Ajmer which is an ancient Hindu pilgrimage or a place of Hazrat Khwaja Moinuddin Chisty's shrine was set to build as satellite town with the objectives of water and waste management, transportation, safety and surveillance, tourism etc. Prime Minister Narendra Modi's government planned to allocate RS 48,000 Crore with 100 Crore to each city per year over the next 5 years. The government is planning to provide a clean and sustainable environment with services like adequate and clean water supply, sanitation and solid waste management, efficient urban mobility and public transportation affordable housing for poor, power supply and robust IT connectivity to its population.

According to the target set by the government of India for 2014-2015, 50,000 villages were to be connected through a national optic fiber network by the end of January. However, only 12% of the target has been met. There are still many sectors in which India needs to catch up before planning for smart cities like corruption, education, healthcare, electricity, education. The government first has to deal with all the aspects of governance including religious sentiments of the people residing in India and then can think of starting something because a nation can only progress after taking all its citizens along irrespective of class difference and catering to everyone's need equally.

Keywords: *Smart city, Sanitation, Solid Waste management, Clean water supply*

TOWARDS URBANISATION

The unprecedented level of urbanization and consequent growth in size and number of cities in India present both challenges and opportunities. Population residing in urban areas has increased from 11.4% according to 1901 census to 31.16% according to 2011 census. Indian government recognizes the importance of urbanization. Prime Minister Narendra Modi campaigned on a pledge to modernize the country and build 100 Smart Cities that would be focused on attracting investment. The phenomenal growth in urban population challenges traditional approaches to city management and urban lifestyles. To overcome these challenges, government at the city and other levels are initiating Smart City Programmes. These initiatives are directed at how the respective cities can transform themselves in different policy areas such as the use of alternative or renewable energy, use and management of natural resources, waste reduction and management, carbon emission, green areas, to desired sustainable socio-economic outcomes.

Smart City: A Non-Unique Definition

A city equipped with basic infrastructure to give a decent quality of life, a clean and sustainable environment through the application of some smart solutions like assured water and electricity supply, sanitation, and solid waste management, efficient urban mobility, E-governance and citizen participation, safety and security of citizens. Smart city concept focuses on how to shape future Internet based services and application from a smart city perspective. A Smart City according to (Giffinger, 2007) is "A City performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive independent and aware citizens." A smart city (also smarter city) uses digital technologies or information and communication technologies (ICT) to enhance quality and performance of urban services, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens.

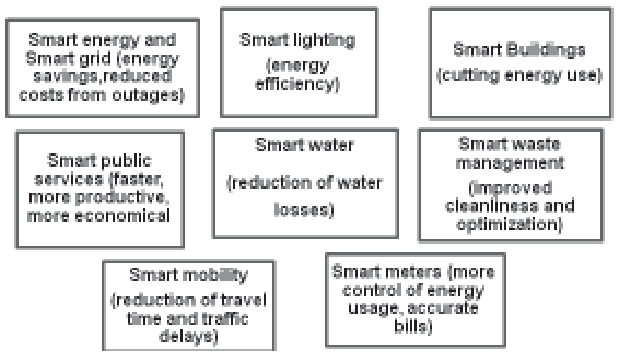

Fig. 1: Showing characteristics of a Smart City

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Announcement of Smart Cities

The government of India has announced an ambitious 100 smart cities programme. State capitals and many tourists, heritage cities are expected to

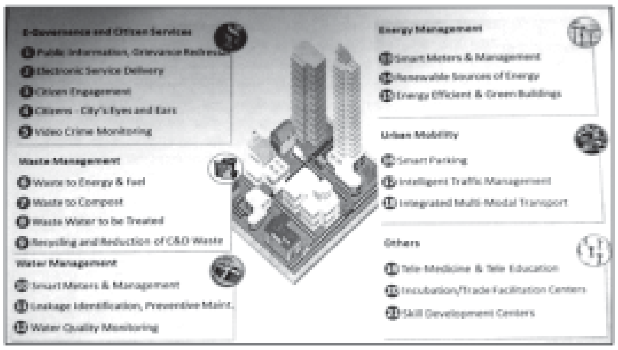


Fig. 2: Showing Smart Solutions for a Smart City

witness a rapid upgrade of urban infrastructure and online services to citizens, enabled by Information Technology. The government of India had allocated INR 7060 crore for the Smart Cities Mission in its interim budget of 2014-15. The budget of 2015-16 has a provision of INR 6000 crore for the Mission and the development of 500 habitations under the National Urban Rejuvenation Mission (NURM). A government panel has approved the allocation of INR 2.73 lakh crore over the next 10 years for the development of 100 smart cities and 500 cities under NURM. This smart city mission will solve problems like:

- Irregular water supply
- Solid waste
- Traffic jam
- City congestion
- Dirty water flow in open drains
- Cramped neighborhood
- Encroachment

Source: Ajmer City Area, 25th Sep., 2015(Field Visit)

Announcement of Smart Cities

The conceptual underpinning for the research was established by performing a mapping exercise on the conceptualizations and definitions of the core concepts of a Smart Cities. Each Smart City aspirant was selected through a 'City Challenge Competition.' The distribution of Smart Cities will be reviewed after two years of the implementation of the Mission. Based on an assessment of the performance of States/ULBs in the Challenge, some re-allocation of the remaining potential Smart Cities among States may be required to be done by MoUD.

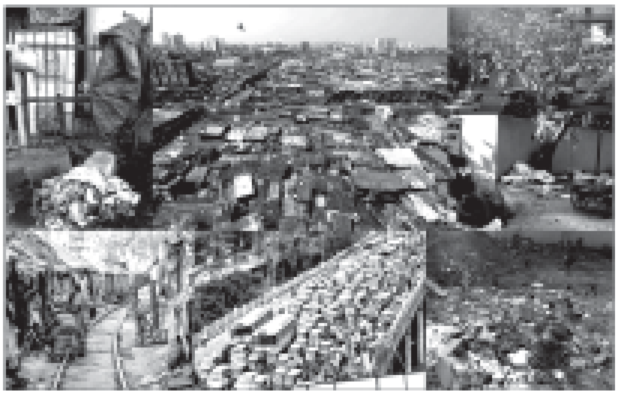
Fig. 3: Showing steps to choose smart city

Challenges

- Today, India is urbanizing at an unprecedented rate. Estimates suggest that by 2030, nearly 600 million Indians will be living in cities. Keeping in mind the population explosion, the scarcity of resources will be the biggest concern. Everything will have to be developed with sustainability at its core. Additional impetus needs to be given on planning for mobility, transportation requirements and future proof infrastructure.
- This requires new thinking about how to meet the request for public and other services and to achieve the improvement. However, experiences from earlier and on-going Smart City initiatives have revealed several technical, management, and governance challenges arising from the inherent nature of a Smart City as a complex "Socio-technical System of Systems." While these early lessons are informing modest objectives for planned Smart City programs, no concrete framework based on careful analysis of existing initiatives is available to guide policy makers and other Smart City stakeholders.
- A smart city will be irrelevant to most of its inhabitants unless they can learn how to use new technology, like rural people says Adam Dennett, lecturer in the smart city at UCL. Very few people can pull live data from an API or set up a new sensor network to monitor air pollution – but until more can, smart cities risk being "little

more than a marketing tool for big business," he says.

- The Smart Cities agenda contains risks as it remains unclear how the poor will be incorporated into the vision of modern growth – would the creation of vibrant growth engines translate into the elimination of poverty or does it risk further marginalizing the poor?
- The most challenging task would be to enlighten citizens. The physical infrastructure can be created, but we would need to work with the people and make them aware of the importance of sanitation and cleanliness. Only a city that can also address the issue of women's safety successfully can truly be called smart.
- There is urgent need to reform the current municipal system in all the cities going to become smart. Under the current system, corruption is rampant, and the welfare schemes are abused by corrupt politicians and officials. Even the planning and implementation of rules and regulations are very poor which needs to be corrected.
- There are a number of latent issues to consider when reviewing a smart city strategy. The most important are to determine the existing city's weak areas that need utmost consideration, e.g. 100-per-cent distribution of water supply and sanitation. The integration of formerly isolated legacy systems to achieve citywide efficiencies can be a significant challenge.
- It would be challenging to develop smart cities as our existing metro cities are not in good shape.
- We have quite a few cities abroad that are known for their impeccable planning. While a strong IT infrastructure is important, Indian smart cities need to go beyond that. As far as India is concerned, we should look at cities like Jamshedpur, a city with a large migrant population. It is a classic example of a perfect blend of large industries with social clubs, playgrounds and religious centers. This makes it sustainable in the sense that it has a strong livelihood component too. Like Jamshedpur, many Indian cities that have been and will be properly planned can be smart cities of the future.



Source: Clockwise: Delhi (field visit), Mumbai, Hyderabad, Mumbai (internet)

- The Jawaharlal Nehru National Urban Renewal Mission (JnNURM), launched in 2005 to modernize Indian cities and provide basic services for the poor.

CONCLUSION

Technology is important, but infrastructure lies at the core of the city and needs to be particularly focused. The development of these cities must be an ongoing process, much like its maintenance and should not be a one-time investment because "before cities can become smart, they must first be empowered." The city should therefore set as an "enabling platform for the activities that citizens are able to develop, linking those inherited from the past to those that can be realized in the future, so it is not focused on just applications but on the possibility that citizens realize them because smart citizens will lead towards smart city".

REFERENCES

Dr. V. Nath., Urbanization Urban Development & Metropolitan Cities in India, Neha Publisher and Distributor

Ajmer Development Authority Department http://reality.economictimes.indiatimes.com/realty-check/The-top-10-implementation-challenges-for-smart-cities-in-India/776

http://www.blueoceanmi.com/blueblog/smart-cities-in-india-implementation-challenges/Sfsf

https://en.wikipedia.org/wiki/Smart_city

http://www.academia.edu/3672753/Cities_and_Smartness_A_Critical_Analysis_of_Opportunities_and_Risks

http://ecis2014.eu/E-poster/files/0575-file1.pdf

http://www.omicsgrouporg/journals/smart-city-concept-applications-and-services-2167-0919-117.pdf

http://www.cstep.in/uploads/default/files/publications/stuff/eea96a2b03f66aa73f0cdc744712d793.pdf

http://www.dnaindia.com/money/report-india-us-strategic-meet-to-discuss-smart-cities-digital-india-2127133

http://m.thehindu.com/features/homes-and-gardens/green-living/what -are-smart-cities/aricle6321332.ece http://www.adaajmer.org/docs/AJMER%20MASTER%20DEVELOPMENT%PLAN%202030%20(REPORT)

http://en.m.wikipedia.org/wiki/Ajmer

http://www.smartcitiesprojects.com/

http://www.ndtv.com/topic/smart-cities

http://economictimes.indiatimes.com/topic/smart-cities

http://timesofindia.indiatimes.com/topic/smart-city

http://smartcitiescouncil.com/category-news

http://www.theguardian.com/cities/smart-cities

http://zeenews.india.com/tags/smart-cities.html