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Focal Theme

*Integrated Decentralized Planning :
Geospatial Thinking, ICT and Good Governance*

XXXIII INCA International Congress

19 - 21 September, 2013 ♦ Jodhpur, Rajasthan INDIA

Hosted by

National Remote Sensing Centre (NRSC), ISRO

CAZRI Campus, Jodhpur – 342 003

&

Central Arid Zone Research Institute (CAZRI), ICAR

Jodhpur – 342 003

Organized by

Indian National Cartographic Association (INCA)

Hyderabad – 500 039



Journal of the Indian National Cartographic Association

Integrated Decentralized Planning : Geospatial Thinking, ICT and Good Governance

19 - 21 September, 2013 ? Jodhpur, Rajasthan INDIA

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मुख्यमंत्री
राजस्थान

सन्देश

मुझे यह जानकर प्रसन्नता है कि अन्तरिक्ष विभाग, जोधपुर एवं काजरी, जोधपुर के संयुक्त तत्वावधान में 19 से 21 सितम्बर, 2013 तक जोधपुर में "एकीकृत विकेन्द्रीकृत योजना: भूस्थानिक चिंतन, 'सूचना संचार एवं तकनीक और सुशासन' विषय पर 33वें भारतीय राष्ट्रीय मानचित्र-कला संस्था के अन्तर्राष्ट्रीय सम्मेलन का आयोजन किया जा रहा है।

अन्तरिक्ष के फोटो एवं नक्शों, भौगोलिक सूचना प्रणाली द्वारा विकेन्द्रीकृत योजनाओं एवं सुशासन से आर्थिक विकास एवं सामाजिक न्याय पर चिंतन अपने आप में महत्वपूर्ण है। इससे देश और दुनिया में इस दिशा में अर्जित ज्ञान, अनुभव, अनुसंधान एवं तकनीक पर विचार-विमर्श का अवसर मिलता है।

आशा है कि इस सम्मेलन में शामिल विषय विशेषज्ञों द्वारा इन क्षेत्रों के महत्व और सामाजिक सरोकारों में इनके उपयोग के विभिन्न पहलुओं पर विचार-विमर्श किया जायेगा।

इस सम्मेलन के उद्घाटन समारोह की अध्यक्षता के लिए मुझे याद किया। इसके लिये हृदय से आभारी हूं। मैं सम्मेलन में शामिल सभी महानुभावों का स्वागत करते हुए इस सम्मेलन की सफलता के लिये अपनी हार्दिक शुभकामनाएं प्रेषित करता हूं।

(अशोक गहलोत)

Organizing Committee sincerely thanks all the EC members, delegates, speakers, invitees, sponsors, exhibitors, guests and supporters for their participation, presentations, contributions, co-operation and assistance for successfully organizing XXXIII INCA International Congress.



Indian National Cartographic Association (INCA)

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Message

The Planning Commission, Govt. of India, emphasizes number of key issues essential for integrated decentralized planning for faster, inclusive and sustainable growth in 12th Five Year Plan. The recent measures taken by the Ministry of Panchayat Raj and other ministries to activate the process of planning from below in a participatory manner are indeed laudable. There is a need to optimize efforts through convergence of inter-sectoral approaches. The convergence brings in synergies between different government programs / schemes in terms of planning and implementation; and facilitates sustainable development through creation of durable assets, connectivity, productivity enhancement, environment management and capacity development. Geo spatial thinking and ICT play a big role in this exercise in taking right decisions, optimization of resources and good governance.

We are at a unique juncture where integrated, participative, spatial, decentralized planning is gathering momentum. Side by side, innovations in Information and Communication Technology (ICT) are facilitating to adopt and practice. The time is now ripe for grounding planning from the grassroots level upwards, so that plans relevant to the local area are prepared by communities. Geospatial thinking and ICT therefore are important levers for promoting sustainable development and improving the quality of life in the country.

The Indian National Cartographic Association (INCA) has been organizing annual congress at different locations of the country since 1979 on contemporary topics of national relevance. It provides an important platform for extensive and open exchange of ideas and experiences among all stakeholders of Cartography, Geoinformatics, ICT and allied disciplines. Over the years the importance of this event is growing, as it provides an opportunity for interactions and learning amongst practitioners, researchers, NGOs, industry and students.

I compliment the INCA National Executive Committee (2012-13) and the Local Organizing Committee (LOC) of XXXIII INCA for the excellent team work which has resulted in a very successful organization of International Congress as well as bringing out this publication, Indian Cartographer (Vol. 33, 2013).

Dr. VK Dadhwal

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Preface

Indian National Cartographic Association (INCA), a non-profit making professional body, was established on 7 August, 1979 at Hyderabad. The association is devoted primarily to promote cartographic research in the country, and also to enhance the understanding, creation, analysis, use of maps as well as geographic information in order to support effective decision making. The annual event, XXXIII INCA International Congress on 'Integrated Decentralized Planning: Geospatial Thinking, ICT and Good Governance' has been organized by National Remote Sensing Centre (NRSC), ISRO and Central Arid Zone Research Institute (CAZRI), ICAR at Jodhpur during 19-21 September, 2013. The congress has provided a platform for interaction among all stakeholders on the present issues pertaining to integrated decentralized planning.

The congress brought together 536 delegates, 259 are from central government departments, followed by 213, 42 and 22 delegates from academic institutions, state government departments and industries respectively. In response to the call for papers, 240 papers were submitted, 81 papers were presented as oral in 18 sessions and 36 papers were presented as posters in 3 sessions. The papers are evaluated on the basis of their significance, novelty, technical quality and coverage and form part of this proceedings. It also includes two valuable and insightful memorial lectures of this year; 1) Prof. SP Chatterjee Memorial lecture by Prof. Ram Gopal, Former Director, DRDO Hqs. New Delhi and 2) Todarmal Lecture by Dr. V Jayaraman, Satish Dhawan Professor, ISRO Hqs. Bangalore.

Putting together XXXIII INCA-2013 was a team effort. I am thankful to the editorial committee members particularly Dr. Balak Ram and Dr. AK Bera who worked very hard in reviewing papers and providing feedback to authors and finalizing. It is their untiring efforts which have brought out this volume (Indian Cartographer, Vol. 33, 2013) in time.

Finally, I thank INCA National Executive Committee (2012-13) for guidance, all the sponsors for their support and all LOC committees for the hard work for successful organization and bringing out this publication. I hope that this publication will serve as a valuable reference for all stakeholders of decentralized planning.

Dr. JR Sharma

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10. Inland Waterways Authority of India, Noida
11. Survey of India, Dehradun
12. Open Source Consortium



Host Institutions

National Remote Sensing Centre (NRSC) a key functionary of Indian Space Research Organization, is striving to realize the Indian Space Vision through Earth Observation. It is responsible for the ground segment of Remote Sensing Programme through satellite data acquisition, archival, processing, dissemination, remote sensing applications, training and capacity building. It also provides aerial services in the civilian sector for the country. The Organization has four Regional Centres located at Bangalore, Nagpur, Kolkata and Jodhpur to address region/area specific remote sensing application needs. The Earth Station located at Shadnagar, 65 km from Hyderabad city, which is being developed as a full-fledged centre to carry out the entire chain of remote sensing activities. NRSC is continuously exploring the practical use of Remote Sensing for societal applications through multilevel initiatives, development of value added data services and Remote Sensing Applications.

Regional Remote Sensing Centre-West (RRSC-West), Jodhpur is one of the regional centres of NRSC; established in 1988 under the aegis of National Natural Resources Management System to cater to the needs of different user agencies of North West India. The centre is acting as a hub of space technology applications in the region since last two and half decades through generation and maintenance of natural resources repository. Presently the centre is involved in executing a major national level project popularly known as 'India- WRIS'.

Central Arid Zone Research Institute (CAZRI) owes its origin to the Desert Afforestation Research Station, which was established in 1952 at Jodhpur and was upgraded to the Desert Afforestation and Soil Conservation Station in 1957. In order to put appropriate emphasis on arid zone research and development, the Government of India in 1958 sought the advice of an UNESCO expert, Mr C.S. Christian, upon whose suggestion the Institute came into existence on October 1, 1959. The Institute conducts multi-disciplinary research to seek solutions to the problems in hot arid zone of the country, covering about 32 million ha area and the cold arid zone, covering about 7 million ha. The institute is mandated to carry out following activities : To undertake basic and applied research for sustainable farming systems in the arid ecosystem; act as repository of information on the state of natural resources and desertification processes and its control; develop livestock-based farming systems and range management practices for the chronically drought-affected areas depending on livestock species; also aquaculture; utilize high and precision technologies in production systems; provide scientific leadership and to develop collaboration; act as a centre of learning for arid land management technologies etc. Besides the Institute Headquarters and a Central Research

Farm at Jodhpur, CAZRI has four Regional Research Stations at Bikaner, Jaisalmer and Pali in Rajasthan, and at Kukma near Bhuj in Gujarat, five Range Management and Soil Conservation areas, Dr. P.C. Raheja Library and The ENVIS centre on Desertification.

General Information - About Jodhpur

Jodhpur traditionally known as the “Sun City” was founded by Rao Jodha, a chief of Rathore clan, in 1459. It is the second largest city in Rajasthan and a very popular tourist destination. Jodhpur is best known for Mehrangarh (Majestic Fort), Umaid Bhawan Palace, Mandore Garden and Clock Tower. They have a typical Marwari accent. Jodhpur is famed for its traditional sweets and spicy savories. The lifestyle in Jodhpur, India is quite fascinating. Lending a romantic aura to Jodhpur, are its exquisite handicrafts, folk dances, folk music and the brightly attired people. The desert people are quite affable. Jodhpur has emerged as Center for Academic Excellence where apart from CAZRI and ISRO, a number of institutions like IIT, AIIMS, ONGC, DRDO, AFRI, National Law University, Ayurvedic University, Police & Forensic Science University, NIFT are located. Famous Osian sand dunes are just 65 km away from the city. Petroleum refinery at Barmer, announced by Govt. of India, will be just 270 km from the city. The weather during September month will be pleasant as the temperature ranges from 20-35 C. Jodhpur city is well connected with the national capital and other Indian cities through Air, Rail and Road transport. The congress venue is located within 6-8 km of the respective terminals. Jodhpur is about 600 km away from Delhi, 300 km from Jaipur, 450 km from Ahmedabad and 280 km from Udaipur.

Indian National Cartographic Association (INCA)

Indian National Cartographic Association (INCA) founded on 7 August, 1979 at Hyderabad, has evolved into one of the biggest organisation of its kind in the world. The beginning was with 79 members and as on today it is a grand body of 2685 life members and 82 reputed institutional members. It has branches functioning at Ahmedabad, Bangalore, Bhubaneswar, Chandigarh, Chennai, Dehradun, Delhi, Hyderabad, Indore, Jodhpur, Kolkata, Mumbai, Patna, Shillong and Thiruvananthapuram.

INCA is devoted to the cause of cartography as a graphic mode of communication. It has in its fold most eminent scholars, professionals and industrialists. The bulk of its members hail from Survey of India, ISRO, National Atlas and Thematic Mapping Organisation, National Hydrographic Office, universities and other scientific research institutes in India. The association has the following as its foremost aims and objectives:

- To promote cartographic research in the country.
- To foster co-operation among research institutions and quasi government organizations and professional organisations of allied disciplines for the advancement of Cartography.
- To collaborate with international organisation on similar lines to take such measures that will help to secure for cartography, its legitimate place in national life to strengthen among cartographers a sense of professional excellence.

In order to achieve the above objectives, INCA organizes several programmes including national / international conferences at various places in India. These conferences are attended by experts from not only India but also from other countries. The conference provides an ideal platform for interaction among professionals, academicians, scientists and industrialists engaged in cartographic and related activities.

Technical lectures, as a part of the Todar Mal Memorial Lecture Series and S.P. Chatterjee Memorial Lecture Series are delivered by eminent persons during the Annual Congress. The association with its branches also conducts an annual map quiz program for school children, "INCA-National Map Quiz" (formerly called Geo Map Quiz). The Association publishes its journal "Indian Cartographer" which is a compilation of technical papers presented at the annual conference. These papers have earned wide acclaim for their high academic and professional standards. A newsletter, highlighting the main activities, is also brought out annually.

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Background

The development performance of our country is improving day by day with varying speed across states, regions, along rural & urban areas having disparities in socio-economic conditions, opportunities and access to basic services. The country's growing economy is placing increasing demands on natural resources with potentially serious consequences for the environment. The development challenges call for priority action for enhanced programme implementation, proactive measures for the inclusion of disadvantaged groups into the development process, accountability, service delivery and finally good governance.

In its Approach Paper to the XIIth Five Year Plan, the Planning Commission highlighted a number of key issues essential for inclusive growth and also recognizes the need for a comprehensive social protection system to reduce poverty and vulnerability. Greater devolution and empowerment are needed and government programmes need a new approach; the greater localization, involvement and feedback from citizens, and mechanisms for learning and sharing of best practices in planning, implementation and development.

Integrated Decentralised planning (administrative decentralization or deconcentration, fiscal decentralization, and devolution or democratic decentralization; and integration of all sectors) has always been a desirable goal ever since the inception of developmental planning in India. However, never before we have moved more determinedly towards the goal as now.

The recent measures taken by the Planning Commission, the Ministry of Panchayat Raj and other ministries to activate the process of planning from below in a participatory manner are indeed laudable. Substantial public investments are being made for strengthening of economy and livelihood base of the poor, especially the marginalised groups like SC/STs and women. To effectively address the issue of poverty alleviation, there is a need to optimise efforts through convergence of inter-sectoral approaches. **The convergence** brings in synergies between different government programmes/schemes in terms of planning, process and implementation and facilitates sustainable development through creation of durable assets, connectivity, productivity enhancement, environment management and capacity development.

People at village level have understanding about the ground level issues and thus their need plays crucial role in planning process. Therefore, Indian Government attaches highest priority to the agenda of broad based inclusive growth, which is vital to achieve the overall progress of the country. This can be brought about only if **governance** is inclusive by ensuring active

and effective participation of all sections of society at every level of government – Union, State and Local.

The Context

The 73rd and 74th Constitution Amendments 1993, for rural and urban areas are the realization of consistent and conscious effort towards decentralized planning since the process of planned development began in the country; and have provided the much needed constitutional legitimacy to local governance institutions, defined their functional domains and provided financial devolution to these institutions. Our Constitution mandates preparation of plans for economic development and social justice by Panchayati Raj Institutions (Article 243G) and Urban Local Bodies (Article 243W). The 74th amendment also mandated the establishment of District Planning Committee (DPC) as the formal body for preparation of the District Development Plan by consolidating the plans prepared by the villages and towns in a district.

Consolidation and integration of rural and urban plans is one of the key tasks of the DPC and is also of great significance in the light of growing problems related to urban expansion into rural areas. The sequence followed in consolidation of rural and urban plans is:

- Gram Panchayats (GPs) prepare Participatory Plans and send to Intermediate Panchayat (IP) - Block level
- IP compiles information sent by the GPs in the block development plan and along with its own information, prepares a Block Plan and sends to Zilla Parishad (ZP) - District level
- ZP compiles information from Block Panchayats and along with its own information, sends to the DPC
- Urban Local Bodies (ULBs) transmit plans to DPC
- DPC compiles information from ZP and ULBs to form Draft Development plan (DDP) and forward these plans to the state for final approval.

DPCs play an anchoring role between Panchayats and ULBs. These help provide the common platform for integrating rural and urban plans; identify planning projects of common interest and spread across both rural and urban areas, which can be jointly planned and funded. The planning process carried out in the district is largely sectoral and the DPCs play an instrumental role in integrating sectoral plans for a unified district plan.

The planning exercises by the community using **maps / spatial information** are of great help in identifying opportunities as the locally generated plans strengthen local-level decision-making and provide great opportunity for **participatory, spatial, integrated decentralized planning**. By virtue of proximity to the people the local institutions serve, they are likely to have access to correct information about local conditions and better understanding of local needs and aspirations. Further, besides maps; other data and information to support the planning process throughout its various stages, ranging from problem identification, analysis, priority setting, solutions, implementation, monitoring and evaluation, are easy to gather by the local institutes. Many elements that are central to development occur in a specific geographic space and involve gathering information that is linked to particular location. The use of maps, image maps and GIS technology provide planners ability for **spatial thinking** and meeting the challenge of sustainable development through optimization of resources.

Today, **Geo-ICT** is available at local levels, promises to empower members of the community as partners in development planning and management of the natural resources for economic development and social justice. Further, these sophisticated systems provide opportunities to be applied in participatory, integrated and spatial aspects of the decentralized planning processes.

Earth observation plays a key role in community driven management and acquires special importance in the context of decentralized planning. Observations of the Earth system constitute critical input for advance understanding towards local planning by providing information, measurements and quantifications of natural or artificial phenomena. The synoptic view provided by satellite imagery offers technologically the most appropriate method for quick and reliable mapping and monitoring of various natural resources both in space and time domain. Further, Remote Sensing and GIS technologies are capable of creating various resource information layers in the shortest possible time along with regular updates. The illustration through maps and cartographic representations in GIS is an innovative approach for planning process and strategy for economic development, disaster management and human welfare as the same datasets could be used for all tiers of integrated decentralised planning by data aggregation at different scales.

With above background and context, Indian National Cartographic Association presents XXXIII INCA International Congress on “*Integrated Decentralized Planning: Geo-spatial*

Thinking, ICT and Good Governance” with the aim to provide a platform to share, discuss, present the role of Geospatial thinking, ICT and Good Governance in Integrated Decentralised planning for economic development and social justice in the country. This annual meet provides opportunities to learn innovative approaches and exchange of ideas amongst the professionals.

Focal Theme and Sub Themes

The main theme identified for XXXIII INCA International Congress is **“Integrated Decentralized Planning: Geospatial Thinking, ICT and Good Governance”**. The sub themes cover the topics related to the concepts; applications in different agro climatic regions and sectors of economy, programmes; advances in tools and technologies in cartography; education, training & capacity building for PRIs, citizens and the outreach.

1. Integrated Decentralized Planning and Governance

- Cartographic information needs for Spatial, Participatory, Integrated Decentralized Planning and spatial aspects of Governance
- Role of Spatial thinking, Digital approach and Geo-ICT in Decentralized Planning and Governance
- Local level economic and social development
- Maps, Image map, GIS and Society - uses and user issues
- Development management using geospatial technology

2. Panchayat Raj Institutions (PRIs), Agro-Climatic Regions and Activity Planning

Agricultural resources, Forestry resources, Grazing resources, Water resources, Common property resources, Watershed management, Cadastral mapping and NRM Implementation, monitoring & management.

3. Social Infrastructure & Amenity Planning

Asset mapping, Social infrastructure and amenity planning

4. Urban Planning, PURA and Decentralized Planning

Role of decentralized planning in urban planning, Reconfiguring relations between cities and their hinterlands, Bridging rural-urban divide and providing urban amenities.

5. Census data, Meteorological data; Cartography and Thematic Mapping

- Web Based interfaces for browsing, geo-visualisation and online thematic mapping of census and meteorological data
- The Role of ICT in realizing the goal of social justice in the country

6. Cartographic and Geospatial inputs for Flagship and Welfare Programs

MGNREGA 2.0, IAY, IWMP, PMGSY, JNNURM, AIBP, RKVY, NRDWP etc.

7. Environmental Planning & Management

- Mine Area Planning & Management
- Industrial Environment Planning & Management
- Thermal and Hydro Power plants
- Coastal area mapping & management
- Desertification and Land Degradation

8. Disaster Management

- Drought, Floods, Fire, Earthquake, Landslides etc.
- Vulnerability mapping and Disaster Risk Reduction
- Climate Change, Adoption and Development

9. Advances in Tools and Technologies in Cartography

- Developments in Earth Observation, Cartography & Geospatial Technologies
- Mapping from Satellite Imagery - Economics and Intellectual Property Rights
- Open Source Tools, Technologies and Web Services for enabling environment in Participatory, Spatial and Integrated Decentralized Planning
- Maps, Internet and the Geo-Visualization
- Volunteered Geographic information, GPS applications, Crowdsourcing and Cartography
- Service oriented mapping
- Generalization, Multi-scale and 3D Representation
- Open Source spatial & non-spatial data

10. Education, Training & Capacity Building for PRIs, Citizens and Outreach

Scale of operation, training needs at different levels, training for trainers and technology support.

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➤ Cultural Programme	• Shri Sagar Salunkhe, Shri Goutam Bhati Ms. Pratima Tak, Ms. Shilpa Taneja, Ms. Manasa Devi

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Proceedings of the Event

1. Introduction

XXXIII INCA International Congress on the theme “**Integrated Decentralized Planning: Geospatial Thinking, ICT and Good Governance**”, was held at Jodhpur, Rajasthan, during September 19-21, 2013. The congress was organized by Indian National Cartographic Association (INCA) and was jointly hosted by National Remote Sensing Centre (NRSC) of ISRO, Jodhpur and Central Arid Zone Research Institute (CAZRI) of ICAR, Jodhpur.

The Congress aimed to provide a platform to share, discuss, and present on the role of Geospatial thinking, ICT and Good Governance in Integrated Decentralized Planning for Economic Development and Social Justice in the country.

The main theme was sub divided into 10 sub themes as:

- a. Integrated Decentralized Planning and Governance
- b. Panchayati Raj Institutions (PRIs), Agro-Climatic Regions and Activity Planning
- c. Social Infrastructure & Amenity Planning
- d. Urban Planning, PURA and Decentralized Planning
- e. Census data, Meteorological data; Cartography and Thematic Mapping
- f. Cartographic and Geospatial inputs for Flagship and Welfare Programs
- g. Environmental Planning & Management
- h. Disaster Management
- i. Advances in Tools and Technologies in Cartography
- j. Education, Training & Capacity Building for PRIs, Citizens and Outreach, scale of operation

In response to the first announcement of this International congress, a total of 240 abstracts were received. The technical committee evaluated and grouped these papers into oral and poster presentations depending upon the technical suitability. Out of 240 abstracts, 144 were selected for oral presentations in 18 technical sessions and 96 posters were selected for 3 poster sessions during three days congress.

The congress had two plenary sessions of invited talks by the eminent speakers and the regular annual feature; The Todarmal and the SP Chatterjee memorial lectures.

2. Delegates and Representation

The congress brought together 536 delegates; represented by, 259 from central government, 42 from state governments, 213 from academic institutions and 22 from industries. In all 23 states and UTs were represented by the delegates; having 69% male and 31% female representation, highest being from Rajasthan, followed by Andhra Pradesh, West Bengal, NCT of Delhi, Uttarakhand, Madhya Pradesh, Maharashtra, Gujarat, Tamil Nadu, Uttar Pradesh, Haryana, Karnataka, Bihar, Chhattisgarh, Kerala, Meghalaya, Punjab, Assam, Jharkhand, Himachal Pradesh, Odisha, and Andaman & Nicobar.

3. Day 1: September 19, 2013

3.1. The Inaugural Programme

The inaugural programme of XXXIII INCA International Congress was convened at Jai Narain Vyas Smrati Bhawan, Town Hall, Jodhpur on 19th September, 2013. The day brought together more than 600 professionals from multidisciplinary background including eminent citizens of Jodhpur.

The programme started with invocation and lighting of lamp by the guests: Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, New Delhi; Dr. V. K. Dadhwal, President INCA & Director, National Remote Sensing Centre, Hyderabad; Dr. Swarna Subba Rao, Surveyor General of India, Dehradun and Shri Rajesh Mathur, Vice President, AGI & Vice Chairman, NIIT-GIS Ltd., New Delhi. The recital of saraswativandana by Ms Rashmi, Research Scientist, RRSC West, Jodhpur delighted the hall.

The Chairman, Local Organizing Committee, Dr. J. R Sharma, Chief General Manager, NRSC, New Delhi; welcomed all the dignitaries, delegates and guests and appraised about the objectives of the Congress and gave an overview of the congress schedule of three days. He also mentioned about the origin of Panchayati Raj & its historical relevance especially in reference to the state of Rajasthan, from coining of word “Panchayati Raj” by Pandit Nehru on October 2, 1959; on the foundation of Panchayati Raj at Nagaur. He explained the components of Decentralized planning including the scale of operation in the country, 73rd & 74th amendments, Development Schemes of government of India, Planning Process under Panchayati Raj. He also emphasized the role of maps, ICT & earth observation data including orthorectified images and their importance in Decentralized Planning.

The Guest of Honor Dr. Swarna Subba Rao, Surveyor General of India, Dehradun shared his personal experience in Decentralized Planning during 1980 when he started his career at Panchayati Raj Department, Andhra Pradesh. He mentioned that the role of maps & geospatial data is paramount in planning. The importance and use of geospatial data in integrated decentralized planning is immense. He told that SOI is on the verge of starting a major initiative on mapping the country at 10k scale which could be of great use for decentralized planning in the country. He thanked INCA for selecting topic of great importance to the nation and the role of cartographers, geographers and all dealing with the spatial data could play.

The Guest of Honor Shri Rajesh Mathur, Vice President, AGI & Vice Chairman, NIIT-GIS Ltd., New Delhi complimented INCA for selecting Integrated Decentralized Planning as the topic. He mentioned that Rajasthan was a pioneer in Decentralized Planning; the state launched a project VikasDarpan for the generation of data, which was distributed to collectors with GIS tools for planning. He told about the National e-governance project initiated by the Government of India with three key objectives: enhancing transparency in the government, strengthening governance systems & improved citizen services.

He said that GIS can play an enabling role which can help government in realizing their objectives i.e. Geo-enabling the government. He mentioned reengineering the existing business process as the most challenging task ahead with the emergence of high resolution satellite imagery, tools and platform for planning process.

Dr. V. K Dadhwal, President INCA & Director, National Remote Sensing Centre, Hyderabad in his Presidential Address emphasized the role of Geo-ICT which allows geospatial thinking and right decisions. He explained the importance of cartography, its role & capability as a technology that can easily get engaged with the society & Community.

The satellite data is increasing in spatial resolution with time and has great role in decentralized planning. Talking about Bhuvan, the web portal of NRSC, he said Bhuvan is serving the society in many ways; providing high resolution images, historic data, thematic information, information related to disasters in the country etc. Bhuvan has 14 TB data including 2.5m high resolution consistent seamless data of the entire country.

Further, he mentioned about the Project SIS-DP (Space Based Information Support for Decentralized Planning) by NRSC and the efforts of generating orthoimages for the entire country as a base input for planning and thematic mapping on 10k scale.

The chief guest and the keynote speaker Dr. Shailesh Nayak, Secretary, MoES released the proceedings of XXXII INCA 2012, Dehradun along with two maps of Pushkar and Udaipur on 10k prepared by NATMO, Kolkata.

Further INCA Map quiz 2013 winners were awarded: St. Xavier's High School, Patna, Bihar got the First position (*Shri Aditya Raj, Shri Anish Tripathy, and Shri Omar Eqbal*), Second Position was of D.A.V. Public School, Bhuvneshwar, Orissa (*Shri Soumya R. Mohanty, Shri Suvam Mishra, and Shri Adarsh Ku. Mahapatra*) and the Third Position was of Rachana School, Gandhinagar, Gujarat (*Shri Aniket Sarvate, Shri Shirayu Mundra and Shri Tarun*).

Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, New Delhi in his keynote address explained about efficient management of Natural Resources that leads to sustainable development at global, social and human level, development of rural and urban area depends on resources & how you plan without degradation of environment.

After the industrial revolution, the human and social system have influenced our environment and became the drivers of influencing the earth system processes especially: the carbon cycle & ocean acidification, sea level changes, the loss of biodiversity, modern agriculture induced pollution, etc. which have reached to the levels which can damage the earth system. Hence it is pertinent to deliberate the manner in which we manage our natural resources and the role of Decentralized Planning in this endeavor.

He also stressed on the point of maps being the loudest way of expression. He mentioned about India-WRIS for planning and said that we need to consider ecological aspects while exploring natural prospects for economic growth and Panchayats have a major role to play in ecological security.

The Vote of Thanks was given by Dr. A.K. Bera, Organizing Secretary, Local Organizing Committee. He extended his gratitude and thanks to all the dignitaries & supporters, INCA, all the sponsors, media persons, colleagues and members of LOC and sub committees for support.

3.2. Todarmal Memorial Lecture

This year's Todarmal Memorial Lecture was delivered by Dr. V Jayaraman, SatishDhawan Professor & Senior Advisor, ISRO Headquarters Bangalore. In his talk, he enlightened the gathering on “Cartography: A Fertile Landscape for Innovative Convergence” where he explained about how the technology changes have changed the way the maps are made.

He also emphasizes that “Everything digital” made the analysis of huge volume of spatial data possible & resulting accessibility, availability & affordability made geography closer to everyone interested. He also told that innovation were always part of geography. He suggested that simplicity is the ultimate sophistication, keep the interface simple & domesticate the technology.

3.3. Plenary Session 1

The day also featured plenary session 1. The session was Chair, Co- Chair and Reported by: Dr. P. G Diwakar, Mr. R. K Nigam, and Ms. Chilka Sharma respectively

The session demonstrated and outlined the views of 8 expert speakers on the main themes namely Dr. A. P Singh, Census of India, RGI, New Delhi; ShriYogeshPaithankar, CWC, New Delhi; ShriAnupArvind, MoPR/NIC, New Delhi; ShriVinod M Bothale, Bhuvan NRSC, Hyderabad; Dr. V. V Rao, NRSC, Hyderabad; Shri Vishal Anand, Geospatial technologies, ESRI India, Gurgaon; Dr. S. S Rao, NRSC, Hyderabad; and Dr. N. K Jain, Defense Laboratory, Jodhpur.

3.4. Prof. SP Chatterjee Memorial Lecture

Prof. SP Chatterjee Memorial Lecture this year was delivered by Prof. Ram Gopal, Former Director, DRDO Headquarters, MoD, GOI, New Delhi. In his talk on “S P Chatterjee: A Triumvir of Karmayoga, Geography and Cartography” he said that the history of cartography is a complex story of changes in artistic representation, technical progress, and social construction, all of which bear the mark of economic and political power.

He also defined about the Vyaktitva and Krititva of Prof. SP Chatterjee. He told about National Spatial Data Information (NSDI) vision, knowledge & applications in DRDO for Exploring New Frontiers/Cutting Edge Defense Technologies.

3.5. Cultural Evening and Dinner

The day was concluded with Rajasthani cultural programme and traditional Rajasthani song *aavojipadharomahaaredeshji*. There were intense performances by the delegates and professional groups. MsPratima & Mr. SagarSalunkhe worked significantly to put the programme on place. The evening showcased very energetic and colorful traditional Rajasthani dances as well as dances on Bollywood numbers along with singing performances.

The bright eventful evening was followed by dinner.

4. Day 2: September 20, 2013

4.1. Exhibition

The day started with the inauguration of exhibition by Vice Admiral SK Jha, Chief Hydrographer to the Govt. of India. The following 13 exhibitors showcased their products.

1. State Remote Sensing Applications Centre, Jodhpur
2. Central Arid Zone Research Institute (CAZRI), Jodhpur
3. Open Source Consortium
4. NIIT GIS Ltd., Gurgaon
5. National Atlas and Thematic Mapping Organization (NATMO), Kolkata
6. Survey of India, Dehradun
7. NDC, National Remote Sensing Centre, Hyderabad
8. CWC/NRSC, India-WRIS
9. Indian Institute of Remote Sensing, Dehradun
10. Census of India, New Delhi
11. Inland Waterways Authority of India
12. MP Council of Science & Technology, Bhopal
13. Amigo Optima Software Solutions Pvt. Ltd., Hyderabad

4.2. Technical and Poster Sessions

On second day 12 Technical Sessions and 2 poster sessions were conducted at three halls in CAZRI Campus namely: CAZRI Theatre, CAZRI Conference Hall & RRSC Conference Hall.

The dignitaries, who chaired, co-chaired and reported the technical sessions are:

1. Prof. J.L. Jain, Mr. Amod Srivastava and Ms. Divya Mishra in Technical Session 1
2. Dr. Anuradha Banerjee, Dr. Mehtab Singh and Ms. Jyotsana Chuchra in Technical Session 2
3. Dr. A. P. Singh, Prof. Premlata Singhi and Ms. Ila Agnihotri in Technical Session 3
4. Prof. Sarvesh Palria, Dr. R.B. Singh and Ms. B. Manasa Devi in Technical Session 4
5. Prof. V.C. Jha, Dr. Prasad Gogate and Ms. Pragya Chaturvedi in Technical Session 5
6. Commodore Vinay Badhwar, Dr. Dipti Mukherji and Ms. Sneha in Technical Session 6
7. Vinod M. Bothale, Mr. S.C. Chaturvedi and Mr. Goutam Bhati in Technical Session 7
8. Dr. Baisakhi Sarkar, Dr. R A Prasad and Mr. Niteen Bankar in Technical Session 8
9. Dr. M. K. Ojha, Dr. S.K. Dadhich and Ms. Himani in Technical Session 9
10. Sr. S. Murli Krishnan, and Ms. Divya Mishra in Technical Session 10
11. Dr. T.S. Sharma, Dr. Sudha Ravindranath and Ms. Jyotsana Chuchra in Technical Session 11
12. Dr. V. M. Chowdary, Mr. B. Narender and Ms. Ila Agnihotri in Technical Session 12

Each poster session was evaluated by Chairman and Co-Chairman as:

1. Mr. V. V. Rao and Mr. Rajiv Kumar for Poster Session 1
2. Dr. S. S. Rao and Prof. M.P. Punia for Poster Session 2

4.3. Cultural Evening and Dinner at Anand Bhavan

A Cultural evening was hosted at Anand Bhavan having Loud Participation from audiences. The guests were welcomed in traditional way, Ganesh vandana and Rajasthani welcome song

KesariaBalam. The entire programme and the cultural evening were hosted by Ms. B. Mansa Devi and Ms. Himani.

The evening showcased various Rajasthani dance forms, dance and singing performances from delegates mainly by the students from MDS University Ajmer, Banasthali University, Jaipur and Professional artists. The day was concluded with gala dinner.

The evening was brightened by felicitating the enthusiastic performers by dignitaries. MDS University, Kuchaman College and Banasthali University were appreciated for their energetic performances. Ms. Rashmi Rekha Dutta, Ms. Shalu Soni, Prashali & group and Ms. Urmila were given the medals for their cultural presentations. Ms. Nisha was felicitated with the star of the show award for her energetic performances both the days. Parihar amplifier group, Sh. Dayanand Peshwa, Sh. MK Gaur and Sh. Kailash Gupta were felicitated for their wholehearted effort and arrangements.

5. Day 3: September 21, 2013

The third day had 6 technical sessions, 1 poster session followed by Plenary Session 2.

5.1. Technical and Poster Sessions

The dignitaries, who chaired, co-chaired and reported the technical sessions are:

1. Captain Sajeev K. Nair, Ms. A. Vijaya Banu and Ms. B. Manasa Devi in Technical Session 13
2. Captain G.S. Inda, Dr. T. Narendra Babu and Ms. Pragya Chaturvedi in Technical Session 14
3. Dr. P.C. Moharana, Ms. Khushboo Mirza and Ms. Sneha in Technical Session 15
4. Dr. M. Stalin, Dr. Binod Kumar Singh and Mr. Goutam Bhati in Technical Session 16
5. Dr. D. Dutta, Dr. Kaushalya Ramachandran and Mr. Niteen Bankar in Technical Session 17
6. Mr. Uday Raj, Dr. Rakesh Kachhwaha and Ms. Himani in Technical Session 18

The poster session was evaluated by Chairman and Co-Chairman as:

1. Dr. Mahesh K. Gaur and Mr. Amitabh Kumar for Poster Session 3.

5.2. Plenary Session 2

The plenary discussions reflected the energized environment. The Chair, Co-Chair and Rapporteur for the session were Prof. J.L. Jain, Dr. Balak Ram and D. Rama Devi respectively. There were 3 presentations for the plenary session 2:

Dr. Stutee Gupta from IIRS, Dehradun delivered on Education and training for Decentralized Planning; Mr. Atul Malhotra, ESRI delivered on Examples of Geospatial technology in decentralized planning; and Deputy Commissioner Shri KK Shrivastava on IWMP in Madhya Pradesh.

5.3. Closing Function

Dr. J.R. Sharma, Chairman, Local Organizing Committee welcomed all the dignitaries Dr. Swarna Subba Rao, Surveyor General of India, Dehradun; Dr. M.M. Roy, Director, CAZRI, Jodhpur; Dr. V. K. Dadhwal, President INCA & Director, NRSC, Hyderabad and the participants.

Chairman, LOC, presented the brief report on the congress and declared the names of best paper, poster and exhibition awardees followed by address of incoming president Dr. Swarna Subba Rao, Surveyor General of India and Chief Guest Dr. M.M. Roy, Director, CAZRI, Jodhpur.

Prize distribution ceremony for Best Oral, Poster and Exhibitor was conducted followed by presentation of Memento to the Panel of Judges. Vote of thanks was given by Dr. A.T. Jeyaseelan, GM, RRSC-W, Jodhpur. Concluding remarks were delivered by Dr. VK Dadhwal, President INCA.

Chief Guest Dr. M. M Roy, Director, CAZRI, Jodhpur & Dr. VK Dadhwal, President INCA & Co-President Dr. Swarna Subba Rao, Surveyor General of India were felicitated after concluding remarks.

Eventually, the Annual General Body Meeting was convened to conclude the three day congress

6. Awards

Based on performance and presentation, the following winners were declared for Oral presentation, Poster presentation & Exhibition stall.

Position	Winners	Topic of Presentation
Oral Presentation Winners		
1 st	P. Gunasekara, A. Ganesh	Green Energy potentials from poultry litters for reducing greenhouse gas emission in Atmosphere-using GIS.
2 nd	Dipti Mukherji, B.B. Sonule	Disaster information system for mitigation and management-greater Mumbai case study.
3 rd	Kaushalya Ramachandran, C.A. Rama Rao, B.M.K. Raju, M. Gayatri, V. Praveen Kumar, J. Satish	Mapping Agricultural vulnerability for India employing Time-series satellite data products.
Special Prize-Student	Ismail Mondal, Jatisankar Bandyopadhyay and Malay Kumar Jana	Mangrove Zonation and Succession Pattern of Fazergange and Bakkhali Area, at Sundarban, WB India, using Remote Sensing & GIS Techniques.
Poster Presentation Winners		
1 st	Gargi Gupta, Jyoti Singh, Vandana Tomar, Pawan Kumar	Spatial explicit large area net soil organic carbon estimation in tropical wildlife reserve using geospatial strategy.
2 nd	Jyothy Narayanan, Suparn Pathak, A.T Jeyaseelan	Assessing drought for arid regions using satellite derived vegetation index (MSAVI2)& TRMM data.
3 rd	Rashmi Rekha Dutta, Vineeta Sharma, Suparn Pathak	Change detection analysis of the mine environment using remote sensing and GIS application- a case study of Vastan lignite mine, Surat, Gujarat, India.
Exhibition Stall Winners		
1 st	Census of India, New Delhi	
2 nd	Central Arid Zone Research Institute (CAZRI), Jodhpur	
3 rd	Amigo Optima Software Solutions Pvt. Ltd., Hyderabad	

7. Technical Sessions & Poster Presentations

Details of presentations in each Technical Session and Poster session is listed below:

Technical Sessions			
Technical Session No.	Sub-Theme	Selected	Presented
Technical Session – 1	Integrated Decentralized Planning and Governance	7	4
Technical Session – 2	Social Infrastructure & Amenity Planning	5	2
Technical Session – 3	Census data, Meteorological data; Cartography and Thematic Mapping	7	4
Technical Session – 4	Panchayati Raj Institutions (PRI), Agro-Climatic Regions and Activity Planning	5	0
Technical Session – 5	Social Infrastructure & Amenity Planning	6	4
Technical Session – 6	Census data, Meteorological data; Cartography and Thematic Mapping	8	5
Technical Session – 7	Panchayati Raj Institutions (PRI), Agro-Climatic Regions and Activity Planning	6	5
Technical Session – 8	Social Infrastructure & Amenity Planning	6	3
Technical Session – 9	Census data, Meteorological data; Cartography and Thematic Mapping	8	3
Technical Session – 10	Panchayati Raj Institutions (PRI), Agro-Climatic Regions and Activity Planning	8	3
Technical Session – 11	Cartographic and Geo-spatial inputs for Flagship and Welfare Programs	11	6
Technical Session – 12	Environmental Planning and Management	12	9
Technical Session – 13	Urban Planning, PURA and Decentralized Planning	6	4
Technical Session – 14	Disaster Management	6	4
Technical Session – 15	Advances in Tools and Technologies in Cartography	15	14
Technical Session – 16	Urban Planning, PURA and Decentralized Planning	8	4
Technical Session – 17	Disaster Management	9	5
Technical Session – 18	Education, Training & Capacity Building for PRIs, Citizens and Outreach, Scale of Operation	11	3
Total		144	82
Poster Sessions			
Poster Session No.	Sub-Theme	Selected	Presented
Poster Session – 1	Panchayati Raj Institutions (PRI), Agro-Climatic Regions and Activity Planning, Social Infrastructure & Amenity Planning and Environmental Planning and Management	34	17
Poster Session – 2	Urban Planning, PURA and Decentralized Planning and Census data, Meteorological data; Cartography and Thematic Mapping	35	10
Poster Session – 3	Disaster Management, Advances in Tools and Technologies in Cartography and Education, Training & Capacity Building for PRIs, Citizens and Outreach, Scale of Operation	27	9
Total		96	36

8. Sponsors for INCA 2013

The Organizing Committee of the XXXIII INCA International Congress would like to acknowledge the considerable support of Sponsors & Exhibitors who contributed in convening this event successfully.

1. North-Eastern Space Application Centre, Shillong
2. ANTRIX Corporation Ltd., Bangalore
3. Indian Institute of Remote Sensing (IIRS), Dehradun
4. State Remote Sensing Applications Centre, Jodhpur
5. Maharashtra Remote Sensing Applications Centre, Nagpur
6. Karnataka State Remote Sensing Applications Centre, Bangalore
7. Chhattisgarh Council of Science & Technology, Raipur
8. Andhra Pradesh State Remote Sensing Centre, Hyderabad
9. Madhya Pradesh Council of Science & Technology, Bhopal
10. Bank of Baroda
11. National Bank for Agriculture and Rural Development, Mumbai
12. Ministry of Earth Sciences, New Delhi
13. Indian Space Research Organization, Department of Space, Bangalore
14. National Spatial Data Infrastructure (NSDI), New Delhi
15. Mizoram Remote Sensing Applications Centre, Aizwal
16. Uttar Pradesh Remote Sensing Applications Centre, Lucknow
17. Jharkhand Space Applications Centre, Ranchi
18. Assam Remote Sensing Applications Centre, Guwahati

9. Recommendations of XXXIII INCA International Congress-2013

1. INTEGRATED DECENTRALIZED PLANNING

Noting

The long standing realization of importance of decentralization planning and its pivotal role in good governance.

Recognizing

The need for integrating technology, all stake holders such as people and domain experts with panchayat and local level planning for Integrated environmentally sound sustainable development.

Recommends

To promote the development of easy to use tools with accessible data from various government agencies for Integrated Decentralized Planning.

2. PANCHAYAT RESOURCE INFORMATION

Noting

The need for technology based solution to local specific problems and development plans.

Recognizing

The local variability in terms of space and time.

Recommends

Efforts must be made to utilize multi temporal high-resolution satellite data products and services and their integration with ground based information along with socio-economic data for effective preparation of village plans.

3. CONVERGENCE OF TECHNOLOGIES

Noting

The advances in geo spatial and space technologies including digital cartography, remote sensing and WebGIS, softcopy photogrammetry, internet and satellite based communication, location & navigation, and mobile technology.

Recognizing

The complementary and supplementary nature of all the above technologies.

Recommends

Synergistic use of all converging technologies for planning, governance, citizen applications as well as meeting goals of sustainable development and disaster resilience.

4. REMOTE SENSING DATA VISUALIZATION, WEB GIS AND MOBILE MAPPING

Noting

That many Indian agencies are making available high scale maps, web based products to all government, private & NGOs with large user base.

Recognizing

That cartography & web GIS are moving towards customized, on demand digital /web cartographic products & services.

Recommends

That special effort should be taken for sharing, accessing and use of such products and services at all levels of governance including panchayat local.

5. DISSEMINATION OF SPATIAL AND NON-SPATIAL INFORMATION

Noting

The advances in Web based technology, interoperability and data exchange possibilities, high speed internet connection.

Recognizing

The benefit in scientific research and development planning.

Recommends

Efforts must be taken to develop Portals and networking of systems like geoportalBhuvan to provide frequently updated metadata and different products and services for dissemination in online and off line modes.

6. OUTREACH, EDUCATION AND BUILDING TECHNOLOGY BASE FOR FUTURE

Noting

Rapid advances continue to be made in all the contemporary technologies which lead to access of digital map by all.

Recognizing

Future challenges such as infrastructure, environmental protection and disaster resilient climate change proofing will increasingly rely on such technologies.

Recommendations

That INCA, all members especially the academia work towards spread, outreach, educate for training for these integrated disciplines to meet future challenges.

7. APPRECIATION

Noting

The importance of the 33rd international congress for professionals in cartography, remote sensing & GIS and ICT from government, NGOs, industry and academia.

Recognizing

The excellent planning and successful organization of the Annual Convention and Congress.

Appreciated

RRSC-W/NRSC, Jodhpur and CAZRI, Jodhpur for their excellent team work of organization which has resulted in a very successful and eventful congress.

Space Based Information Support for Decentralized Planning (SIS-DP) Empowering Communities for Reshaping Economy, Society and Environment

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*National Remote Sensing Centre, Indian Space Research Organization,
Hyderabad & Jodhpur**

1. Introduction

Space based Information Support for Decentralized Planning (SIS-DP) project was formulated by NRSC and is being implemented in partnership with State Remote Sensing Application Centres in the country. The SIS-DP Project outputs; Satellite image maps and thematic maps on 1:10k scale generated for the first time in the country, have great potential in meeting the current requirements and opportunities for spatial, participatory, integrated decentralised planning in the country.

2. Decentralized Planning in India

The 73rd and 74th Constitution Amendments 1993, for rural and urban areas are the realization of consistent and conscious effort towards decentralized planning since the process of planned development began in the country; and have provided the much needed constitutional legitimacy to local governance institutions, defined their functional domains and provided financial devolution to these institutions.

Important Features of 73rd and 74th Amendments are -

Article 243-G: Preparation of plans for economic development and social justice and their execution concerning 29 subjects listed in the 11th Schedule of the Constitution

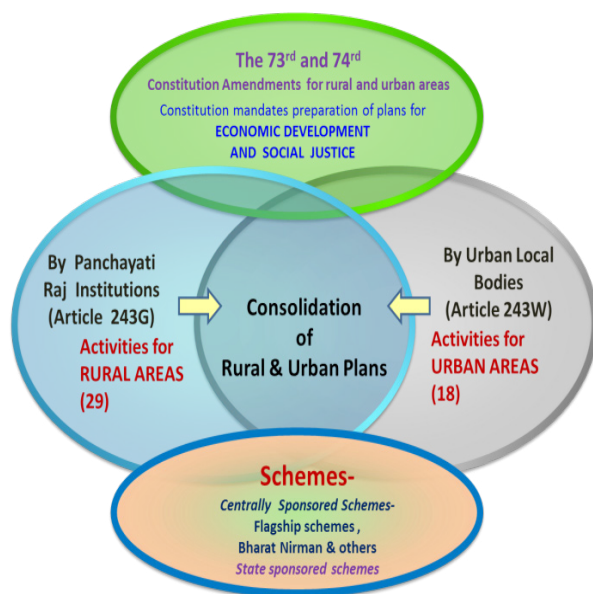
Article 243-ZD: Constitution of a District Planning Committee at the district level and a Metropolitan Planning Committee in metropolitan areas of every State, for the preparation and consolidation of development plans

Article 243-W: Specification by law, through the State Legislatures, of the powers (including financial) and functional responsibilities to be entrusted to municipalities and wards committees

Our Constitution mandates preparation of plans for economic development and social justice by Panchayat Raj Institutions (Article 243G) and Urban Local Bodies (Article 243W). The 74 amendment also mandated the establishment of District Planning Committee (DPC) as the formal body (Article 243-ZD) for preparation of the District Development Plan by consolidating the plans prepared by the villages and towns in a district.

Consolidation and integration of rural and urban plans is one of the key tasks of the DPC and is also of great significance in the light of growing problems related to urban expansion into rural areas. The sequence followed in consolidation of rural and urban plans is:

- Gram Panchayats (GPs) prepare Participatory Plans and send to Intermediate Panchayat (IP) - Block level
- IP compiles information sent by the GPs in the block development plan and along with its own information, prepares a Block Plan and sends to Zilla Parishad (ZP) - District level
- ZP compiles information from Block Panchayats and along with its own information, sends to the DPC
- Urban Local Bodies (ULBs) transmit plans to DPC
- DPC compiles information from ZP and ULBs to form Draft Development plan (DDP) and forward these plans to the state for final approval.



Decentralized Planning for rural and urban areas & consolidation

DPCs play an anchoring role between Panchayats and ULBs. These provide the common platform for integrating rural and urban plans; identify planning projects of common interest, spread across both rural and urban areas, which can be jointly planned and funded. The planning process carried out in the district is largely sectoral and the DPCs play an instrumental role in integrating sectoral plans for a unified district plan.

PRI's and ULB's are constitutionally entrusted to develop plans for economic development and social justice in concurrence with 29 subjects listed in XI schedule and 18 subjects listed in XII schedule.

2.2 Subjects/Activities (18) for urban areas as per schedule XII

Sl. No.	Subjects/ Activities
1	Urban planning, including town planning
2	Regulation of land-use and construction of buildings
3	Planning for economic and social development
4	Roads and bridges
5	Water supply for domestic, industrial and commercial purposes
6	Public health, sanitation, conservancy and solid waste management
7	Fire services
8	Urban forestry, protection of the environment and promotion of ecological aspects
9	Safeguarding the interests of weaker sections of society, including the handicapped & mentally retarded
10	Slum improvement and upgradation
11	Urban poverty alleviation
12	Provision of urban amenities and facilities, such as parks, gardens, playgrounds
13	Promotion of cultural, educational and aesthetic aspects
14	Burials and burial grounds cremations, cremation grounds and electric crematoriums
15	Cattle pounds prevention of cruelty to animals
16	Vital statistics, including registration of births and deaths
17	Public amenities, including street lighting, parking lots, bus stops and public conveniences
18	Regulation of slaughterhouses and tanneries

2.1 Subjects/Activities (29) for rural areas as per schedule XI

S.No.	Subjects/ Activities
1	Land and Water Development Activities (2) - Land Improvement, Implementation of Land Reforms, Land Consolidation and Soil Conservation, Minor irrigation, Water Management and Watershed
2	Productive Activities (8) - Agriculture (including Horticulture) and Extension, Animal Husbandry, Dairying and Poultry, Fisheries, Social Forestry and Farm Forestry, Minor Forest Product, Small Scale Industries Including Food Processing Industries, Khadi, Village and Cottage Industries, Fuel and Fodder
3	Civic Amenities and Infrastructure Development Activities (11) - Rural Housing (Including Indira Awas Yojana), Drinking Water, Roads, Culverts, Bridges, Ferries, Waterways and other Means of Communication, Rural Electrification Including Distribution of Electricity, Non-conventional Energy, Education including Primary and Secondary Schools, Technical Training and Vocational Education, Adult and Non-formal Education, Libraries, Health and Sanitation including Hospitals, Primary Health Centres and Dispensaries, Maintenance of Community Assets
4	Social Welfare Activities (6) - Poverty Alleviation Programmes, Cultural Activities, Family Welfare, Women and Child Development, Social Welfare, including Welfare of the Handicapped and Mentally Retarded, Welfare of the Weaker Sections and in Particular of the Scheduled Castes & the Scheduled Tribes
5	Governance Activities (2) - Markets and Fairs, Public Distribution System

3. Empowering the citizens

To empower the citizens for decentralized planning and governance the needs are:

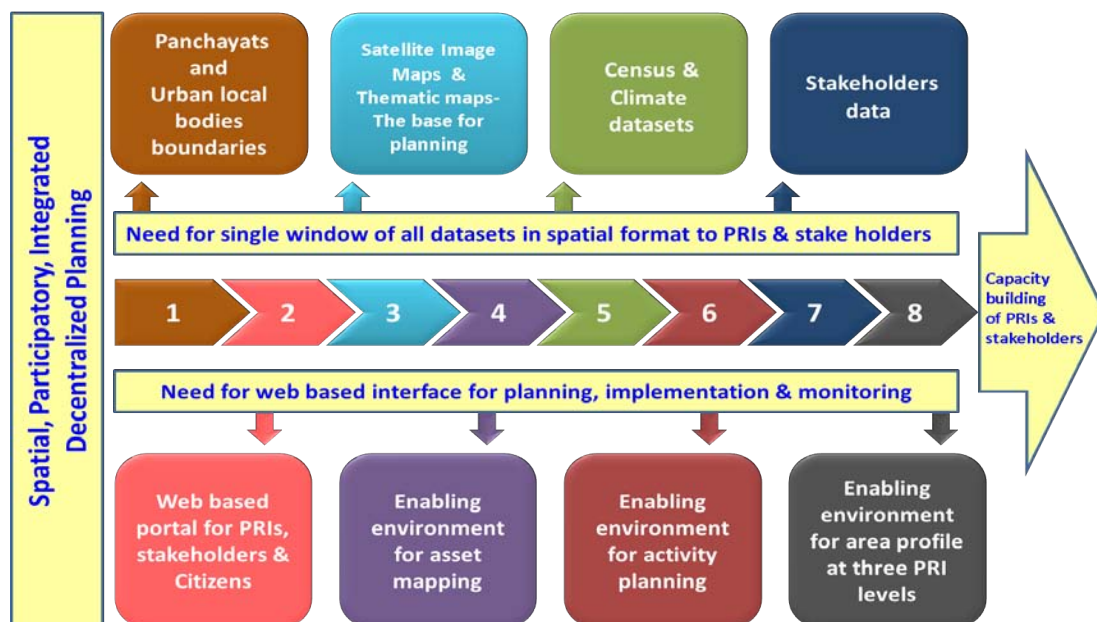
1. Single window source of all datasets in spatial formats to PRIs and Stakeholders.
 - Demarcation of Panchayats and Urban Local Bodies boundaries.
 - Aggregation of spatial and non-spatial data on Panchayat basis (instead of currently available on village basis)
 - Assessment of Data at three Levels of PRIs as per the functions and functionaries for Participatory Planning – 10K, 50K & Database generation and organization accordingly.
 - All data to be made available panchayat wise to PRIs, having a total number of 2,39,544 panchayats and the functionaries of nearly 28.29 lakhs. Looking at the large number of panchayat; the data to be made available through web enabled system as:
 - Panchayats and Urban local bodies boundaries
 - Satellite Image Maps & Thematic maps - the base for planning
 - Census & Climate datasets
 - Stakeholders data

2. Web based interface for mapping of the available assets, planning of activities, implementation and monitoring

- There should be an interface for planning the activities and also choice of activities in a menu driven system for selection of activities by the PRIs in different schemes of central and state government at three levels of PRIs. For this, integration of Sectors and Schemes by Department Wise/Scheme Wise/ Sector Wise and their spatial coverage is required.
- The facility for mapping of the available assets to be provided to PRIs for database collection and use in planning.
- An enabling environment for consolidation of rural plans at 3 levels of PRI's and integration with urban plans and their spatial organisation through web enabled system.
- Need of an area profile to get a snapshot of all resources available, socio-economic conditions and climate data.

3. Capacity building of PRIs and Stakeholders

- There is a thrust on capacity building of PRIs and stakeholders for spatial, participatory, integrated, decentralised planning, implementation and monitoring using spatial information including of NGO'S and Facilitators.



Empowering the citizens: Data & Enabling Environment

4. Earth Observation and Spatial Planning

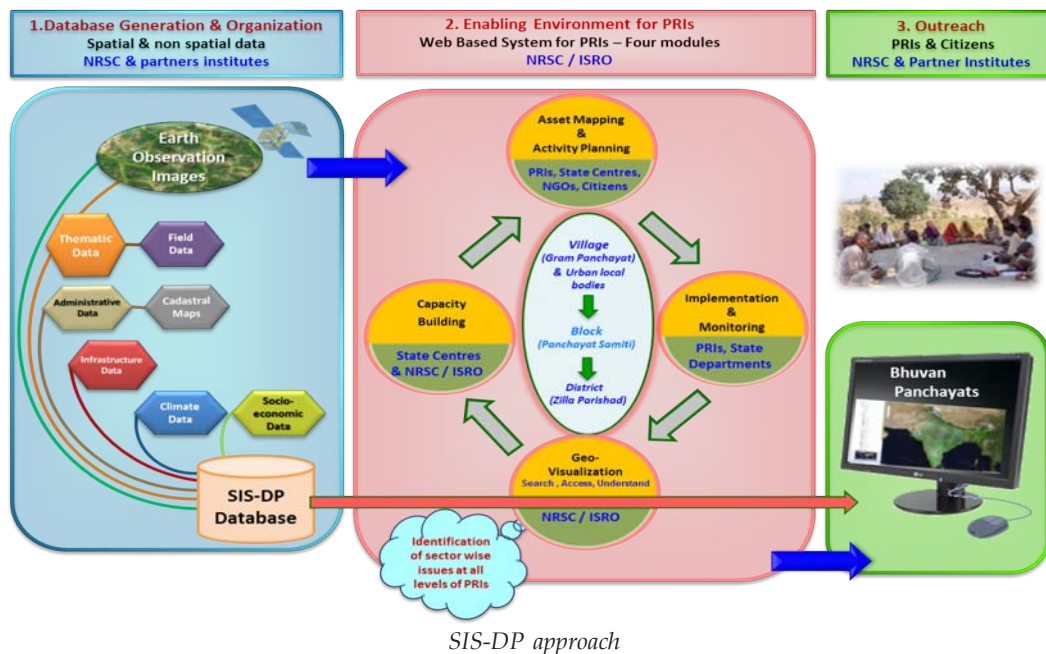
- The synoptic view provided by satellite imagery offers technologically the most appropriate method for quick and reliable mapping and monitoring of various natural resources both in space and time domain. Further, Remote Sensing and GIS technologies are capable of creating various resource information layers in the shortest possible time along with regular updates.
- The illustration through GIS is an innovative approach for planning process and strategy for economic development, disaster management and human welfare as the same datasets could be used for all tiers of integrated decentralised planning by data aggregation at different scales.
- Earth observation plays a key role in community driven management and acquires special importance in the context of decentralized planning. Observations of the Earth system constitute critical input for advance understanding towards local planning by providing information, measurements and quantifications of natural or artificial phenomena.

5. SIS-DP Goal

The goal of the SIS-DP project is to empower the Panchayati Raj Institutions (PRIs) and the Stakeholders with Space Based Information Support for Decentralized Planning and Governance in the country.

6. SIS-DP Objectives

1. To generate and provide 'Satellite Image Maps' for the entire country as base for decentralized planning. (High resolution, true color, Ortho-rectified, merged satellite data products)
2. To prepare thematic & base layers on 1:10000 scale using 'Satellite Image Maps', slope classes maps and Cadastral maps vectorisation & geo-referencing
3. To create databank: comprising of 'Satellite Image Maps', thematic and base maps, slope class maps; and organize census data, climate data, cadastral maps, stakeholder's data and available legacy thematic & base data on GIS platform.
4. To develop comprehensive web portal as per PRIs & stakeholders needs for decentralized planning, governance, outreach to the citizens and data dissemination.
5. To build Capacity of PRIs & stakeholders for the use of Space Based Information in Decentralized planning and governance.



7. SIS-DP Project Tasks

Sl. No.	Project Components & Objectives	Tasks
1.	Project Planning tasks	- Initial Proposal, SIS-DP: SARVONNATI formulated in February, 2009 - Project approval in 17th PC-NNRMS on March 09, 2009 - Chairman's Review of the project proposal on April 07, 2009 Approval of project proposal, Prioritized components of SIS-DP Project on September 14, 2009 - Project Management structure was identified on August 11, 2010 - MoUs with Partner Institutions and Formation of Project Implementation Committees (PICs)
2.	Objective 1 and tasks To generate and provide 'Satellite Image Maps' for the entire country as base for decentralized planning. <i>(High resolution, true color, Ortho-rectified, merged satellite data products)</i>	- Procurement of CartoSAT-1, LISS-IV and Carto DEM - Ortho-product generation - Cartosat-1 data - Ortho-product generation - LISS-IV data - Merging of CartoSAT-1/LISS-IV (FCC) - Merging of CartoSAT-1/LISS-IV (NCC) - Uploading NCC to Bhuvan portal - Generation of seamless DEM - Editing with Break lines - Compilation of DEM at 1° spatial extent - Procurement of ResourceSAT- 2 LISS-IV data (2012) - Ortho-product generation - ResourceSAT- 2 LISS-IV data
3.	Objective 2 and tasks To prepare thematic & base layers on 1:10000 scale using 'Satellite Image Maps', slope classes maps and Cadastral maps vectorization & geo-referencing	- Thematic Mapping - Land Cover - Settlements (Habitation extent) - Drainage and water bodies - Infrastructure (Road, Rail, Canals etc.) - Slope classes maps from DEM - Cadastral maps vectorization and geo-referencing (for 5 priority states)
4.	Objective 3 and tasks To create databank: comprising of 'Satellite Image Maps', thematic and base maps, slope class maps; and organize census data, climate data, cadastral maps, stakeholder's data and available legacy thematic & base data on GIS platform.	- Establishment of Project facility - Labs/Servers etc. - All raw and intermediate products organization - Organisation of Satellite Image Maps - Organisation of 1:10000 scale Thematic & base maps and slope classes maps - Organisation of Legacy data of 1:50000 scale - Organisation and Integration of Census data - Organisation and Integration of Climate data - Stakeholder's data organisation and integration - Cadastral maps overlay on Satellite Image maps and organization. (For 5 priority states) - Demarcation, Organisation and Integration of Panchayats & Urban Local Bodies Boundaries.

Sl. No.	Project Components & Objectives	Tasks
5.	Objective 4 and tasks To develop comprehensive web portal as per PRIs & stakeholders needs for decentralized planning, governance, outreach to the citizens and data dissemination.	30. Documentation for the comprehensive web portal as per PRIs & stakeholders needs, in view of the commencement of 12th Plan and meeting the requirements as conceptualized for: A. Visualization by all citizens B. Enabling environment for PRIs 1. Asset mapping (Inventory of assets, their classification, database standards – Codes and Symbols) 2. Activity planning under Centrally sponsored & state schemes (PRI's activities - 29 subjects for rural area and 18 subjects for ULB's, classification of subjects by sectors, interfacing various schemes into sectors and scheme wise activity planning) 3. Implementation & Monitoring (Scheme wise, Department wise and Sector wise at three tiers of decentralized planning and governance) 4. Area profile generation 5. Marking locations of interest (Crowd Sourcing) C. Outreach to citizens and data dissemination • The eight documents • Document 1: Review of Spatial, Participatory and Integrated decentralized planning • Document 2: SIS-DP: Facilitating Spatial, Participatory and Integrated Decentralized Planning in India • Document 3: Assets directory and Mapping Guidelines: • Classification, Attributes and Standards • Document 4: Activity Planning & Monitoring Guidelines • Document 5: Area Profile Report • Document 6: Bhuvan - Panchayat: Requirements Document • Document 7: Bhuvan - Panchayat: Software Design Document • Document 8: Bhuvan - Panchayat: Test & Evaluation Document 31. Design and development of comprehensive multi-lingual web portal – Software Development. • Version-1: Selection, Visualization, outreach and data dissemination. • Version-2: Providing enabling environment for Panchayat wise asset mapping and for activity planning under different schemes and their components. • Version-3: Providing enabling environment for Implementation & Monitoring : Scheme wise, Department wise and Sector wise at three levels of PRI's
6.	Objective 5 and tasks To build Capacity of PRIs & stakeholders for the use of Space Based Information in Decentralized planning and governance.	32. Develop means for State wise popularization and creating awareness for SIS-DP products, web portal and their utilization. • Project Brochure in local languages • A document and documentary film on ISRO's Contribution to Panchayat Raj • Media Support, internet and social networks • Conferences and exhibitions • Tie-up with lead NGOs and institutions 33. Capacity building for Spatial, Participatory and Integrated Decentralized Planning for PRIs and stakeholders; how to use space based information – the satellite image map and Bhuvan Panchayats Web portal modules/ services for Decentralized planning. • Development of Course Contents • Self- Learning module on the portal • In House and state centers Capacity Building

Sl. No.	Project Components & Objectives	Tasks
		• Tie-up with MoPR, NIRD/SIRDs to effectively reach Panchayats. • Organising state and district level trainings / workshops sessions
		34. PIs to facilitate Panchayat Raj Institutions and line departments to prepare plans, monitor and implement various schemes.
7.	Project Management Tasks	35. Documentation of all technical tasks: digital photogrammetry, ortho product generation, thematic mapping, slope class generation, Cadastral Maps Overlay, Metadata generation and quality checks. • Document 1: Space Based Information Support for Decentralised Planning (SIS-DP) – Sarvonnati; May 2009; NRSC, Hyderabad • Document 2: Prioritized Component of Proposal on Space Based Information Support for Decentralized Planning (SIS-DP); July 2009; NRSC, Hyderabad • Document 3: Manual on “Preparation of geo-spatial layers using High Resolution (Cartosat-1 PAN and LISS-IV MX) ortho-rectified satellite imagery”, NRSC, Hyderabad, September 2011 • Document 4: Ortho-product generation using CartoSAT-1 stereo images under SIS-DP Project, Operations Manual, NRSC, December 2010 • Document 5: Generation of ortho-image under SIS-DP Project, NRSC, January, 2012 • Document 6: Photogrammetric Block Adjustment Quality Control Records under SIS-DP – Volume 1; NRSC, Hyderabad, January 2012 • Document 7: Overlay of cadastral maps on High Resolution Satellite Images, NRSC, Hyderabad, August, 2012 • Document 8: Generation of slope from Digital Elevation Model (DEM) under SIS-DP Project, NRSC, Hyderabad, February 2012 36. Capacity Building of ISRO Centres, States Centres and Partner Institutions for digital photogrammetry, ortho product generation, thematic mapping, slope class generation, Cadastral Maps Overlay, Metadata generation and quality checks. 37. Quality check of all products generated. 38. Procurement of Hardware and Software. 39. Manpower Recruitment. 40. Project Monitoring, reporting and compliance of suggestions. (PMB, EOA-MC & ISRO Council) 41. Monthly progress monitoring of tasks. 42. Budget monitoring and management. 43. Development of web based Project monitoring module. 44. Mechanism for online Feedback from PRIs. 45. Project Report Generation.

8. SIS-DP Database

High-resolution satellite data from Cartosat-1 PAN and Resourcesat-I LISS-IV Mx are used

for creating a merged product which is further used to generate various resource layers at 1:10k scale as follows:

Data Categories	District/Block (1:50k)	Village/Panchayat (1:10k)
1. High Resolution Satellite Image		
Satellite Data	Orthorectified Merged Product	Orthorectified Merged Product
DEM	DEM Layer	DEM Layer
2. Base Data		
Administrative	State, District, Block	District, Block
	Village (Revenue & Census)	Village (Revenue & Census)
	Panchayat	Panchayat
Village wise Cadastral Maps		Cadastral Maps
Hydrological Unit	Basin	
	Subbasin	
	Watershed	Watershed
Village Infrastructure	Rail	Rail
	Road	Road
	Canals	Canals
	Settlements	Settlements
	Waterways	Waterways
3. Thematic Data		
Natural Resources Data	LULC	LULC
	Slope	Slope
	Surface Water Bodies	Surface Water Bodies
	River/Drainage Network	River/Drainage Network
	Soil	Soil Sample
	Groundwater Quality	Groundwater Quality
	Groundwater Depth (Pre/Post Fluctuations)	Groundwater Depth (Pre/Post Fluctuations)
4. Climate Data		
	Rainfall	Rainfall
	Temperature	Temperature
	AWS Stations	AWS Stations
5. Socio-economic Data		
	Population, Demography, Economy	Population, Demography, Economy

9. Bhuvan Panchayats Portal and Outreach

SIS-DP project has three major components as follows:

1. SIS-DP Database Generation and Organization: Spatial & non spatial data including Earth Observation Images, Thematic Data, Field Data, Administrative Data, Cadastral Maps, Infrastructure Data, Climate Data, Socio-economic Data and stakeholders data.
2. Enabling Environment for PRIs: Web Based System for PRIs – Eight sub modules as:
 - Geo-Visualization
 - Area Selection
 - Area Profile Report
 - Asset Mapping

- Activity Planning (Scheme Wise)
 - Implementation and Monitoring of the activities (Sector, Scheme, Department Wise)
 - Share Views
 - Download Data
3. Outreach to PRIs & Citizens
 - Web based data dissemination for PRIs, stakeholders & the Citizens
 - Enabling environment for asset mapping
 - Enabling environment for activity planning
 - Enabling environment for area profile at three levels of PRIs

Version 1.0 of the web enabled portal was launched on September 15, 2013 in public domain.

Tool for Local Level Development Planning: Combining Use of Participatory Appraisal and GIS

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Keywords: *Decentralized Planning, Geo-ICT, Asset mapping, Cartography & Geospatial Technologies, Crowdsourcing*

Abstract: Mahatma Gandhi advocated Panchayati Raj a decentralized form of Government. Information technology has emerged as a powerful phenomenon influencing every walk of life in the present society. The present work reviews briefly the capabilities of Remote Sensing and GIS for planning. The central theme of this paper is how to use the capabilities of Remote Sensing and GIS to establish the data, which will be used for Decentralized planning. An attempt has been made to develop a model for the study area, creating database for spatial and non-spatial data and development of user interactive query shell. Data used in the study are SOI Toposheet, Satellite data, different thematic layers, Census data (2011), other secondary data like drinking water quality, education, health, agriculture, bank and post - office etc. and limited field survey. The database pertains to the year 2011. Spatial database pertaining to natural resource has been interpreted using IRS P6 LISS IV and CARTOSAT imagery. By efficient use of these data a GIS based information network has been developed which will flow between Gram Panchayat, panchayat Samiti, Zilla Parishad, District administration and various lined department. The study area has been chosen as one of the Block of Raipur district of newly formed state Chhattisgarh.

1. Introduction

India has been an agrarian country ever since her Independence and the primary objective is of alleviation of rural poverty and development of rural areas. Rural development implies bringing the economic betterment of people as well as greater social transformation. In order to provide the rural people with better prospects for economic development, the focus has to be on increased participation of people in the rural development programmes, decentralization of planning to villages, better enforcement of land reforms and greater access to credit and employment opportunities. The focus of course, is in the 74th Amendment of Constitution that provides for Panchayat-level planning and development for a set of specific items covering various things like land, water, agro-economy, etc. This growing urge for decentralizing the process and practice of planning led to us to have a fresh look at methods of data management.

Decentralized planning in India is dispersal of decision making and administrative process. Planning and development activities

carried out through decentralized manner, is referred as decentralized planning. It implies the hope of opening the blockages of an inert bureaucracy, giving more direct access for the people to the government and the government to the people, which essentially stimulate the entire nation to participate in the national development plans (Mahwood, 1993). The interface between cartography and scientific visualization and between technology for mapping and ways in which mapping can facilitate geographic thinking has been labeled Geographic visualization or Geo-Visualization (MacEachren & Monmonier, 1992). Every Panchayat area needs a Panchayat -GIS a comprehensive map-based Geographical Information System that powers panchayat planning and management. The GIS must meet the needs of the panchayat with focus on Asset mapping and GIS based Asset database. There should be unique capability to meet the needs of surveying in rural areas, land records survey, using satellite images, creating GIS data and customized GIS solutions that can help rural development and Panchayati-Raj institutions.

1.1 Objectives

1. Create a geo-spatial database for Gram Panchayat compiled from locally available data sources.
2. To develop an interactive GIS Gram Panchayat.
3. To integrate all aspects of rural economy and life.
4. Development of query shells for decision support system
5. Statistics and report generations at various levels of selected themes.

2. Datasets

- Survey of India Toposheets
- Panchayat resource maps
- Panchayat asset registers
- Taluk map with villages and Gram Panchayat boundaries
- Cadastral map
- Census data, 2011
- Photographs of houses and its members, schools, etc.
- Satellite data - IRS P6 LISS IV and CARTOSAT

2.1 Methodology

Spatial Database Organisation

The spatial database has been created on ArcGIS. In order to obtain the information sets, different types of primary input data sets have been identified most of which are on 1:50000 scale, are using remotely sensed data and the ancillary data. The primary elements of spatial database are as follows:

1. **Administrative Map:** Administrative (district, block, panchayat villages) were delineated using district, block and census village maps
2. **Geomorphological Map:** It depicts the landforms. It is an input layer to derive ground water potential map. It was prepared using remote sensing data on 1:50000 scale.
3. **Soil Map:** It shows different soil types on 1:50000 scale. It was prepared in consultation with the district soil survey report apart from the satellite data.

4. **Slope Map:** It shows the slope categories at 1:50000 scale. This derives from DEM.
5. **Drainage Map:** Showing the detail of drainage and waterbodies, this map is prepared from SOI Toposheets.
6. **Landuse / Landcover Map:** This theme was prepared from IRS P6 LISS IV and CARTOSAT merged product imagery by visual interpretation at 1: 10000 scale.
7. **Watershed Map:** This map is a derived map from drainage theme prepared from SOI Toposheet upto watershed level.

Non-spatial Database

The non-spatial data is organized on Microsoft Access. It consist of demography, health, drinking water, education, roads, household, banking, etc. are collected from Zanpad Panchayat office of the study area.

2.2 Study Area

The study area, Abhanpur block lies in the southern part of Raipur district of Chhattisgarh. It extends between 81°35' to 82°00' east longitude and 20°55' to 21°00' north latitude (Fig. 1). Total geographical area of Abhanpur block covers 605.16 Sq. km. Abhanpur block has one Janpad Panchayat, ninety-six Gram Panchayat with one hundred six villages. According to census 2011, total population is 241121, population density is 398 person/sq. km, literacy rate is 72% and majority depends on agriculture for their livelihood.

3. Result and Discussions

3.1 Generation of Spatial Village Map

District and block boundaries were drawn from Survey of India Topographical maps. These were brought in an ArcGIS after following the standard procedure that is digitizing, georeferencing etc. Block map collected from the local government offices in the district, contain village boundaries. This Block map which do not show geographical co-ordinates system were traced, marked the GCPs with respect to the SOI base map, digitized and brought to the real world coordinates system after projecting the maps. Each village in this map was assigned unique IDs (user defined) in a regular sequence. Thus, block map with village boundaries within built table have arial extent, village IDs, gram panchayat name &

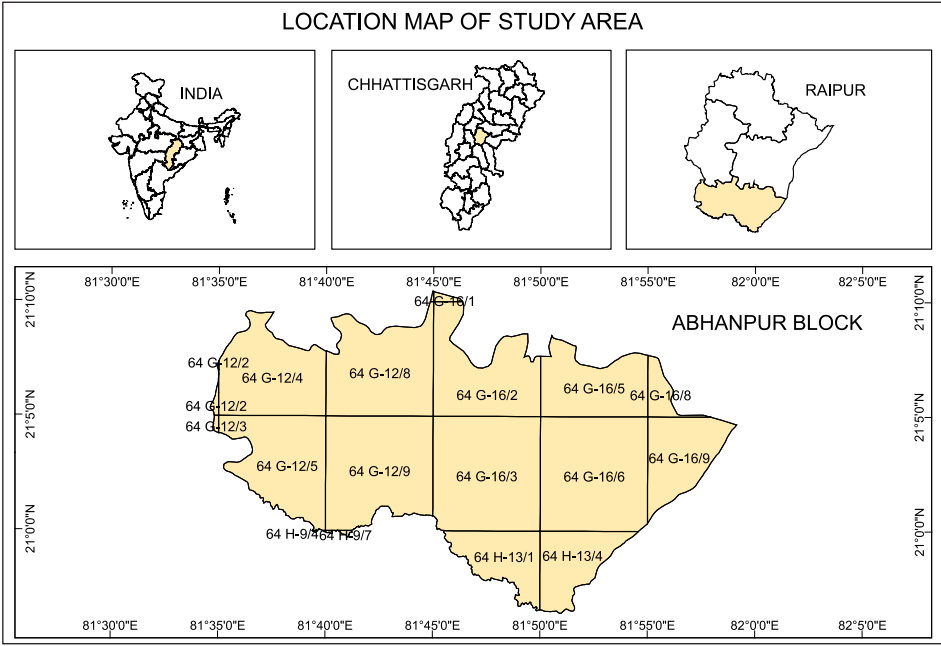


Fig. 1. Location Map of study area.

code, etc. has generated for Abhanpur Block (Fig. 2).

3.2 Transformation of Non-Spatial Census Database into GIS

2011 census data collected from Census office. Census information can be displayed using MS Excel Sheets. This file contains vast information on socio-economic characteristics of each village, including census code on

region, district, block and village. Village IDs same as given in the spatial village map were fed in the excel sheet for all the villages in the block. Thus spatial and non-spatial data contain similar columns in their respective tables with uniform village IDs. These IDs will help in joining the spatial and non-spatial data in the system. Thus an information system has been generated for the district showing the village map with its boundary and relevant

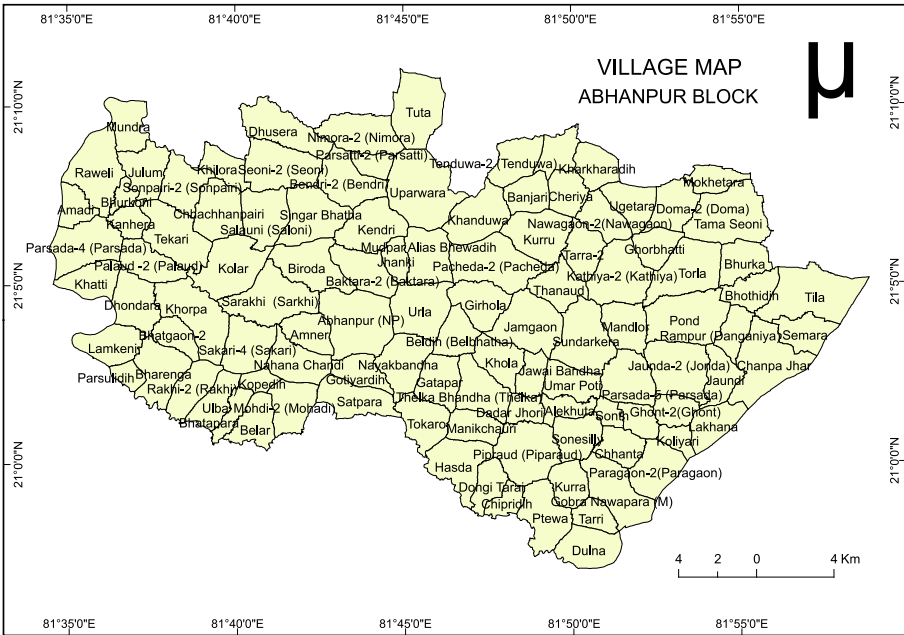


Fig. 2. Village Map of study area.

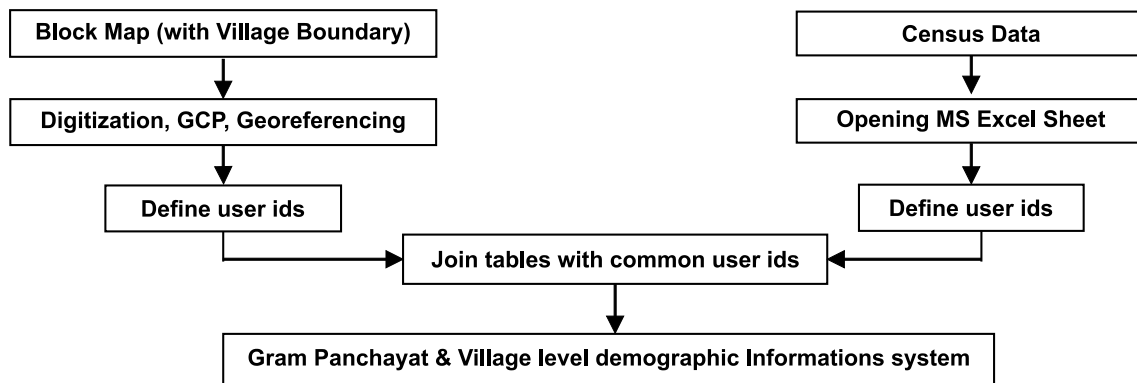


Fig. 3. Flow Chart of Methodology.

census information containing socio-economic dimensions. Generalized process of flow for developing gram panchayat and village information system is shown in fig.3.

Thematic mapping on available Census data for block and village level is possible with user defined class intervals or statistical intervals. Likewise user can generate various views by themselves depending upon their needs, to make plans and take appropriate rural development decisions. The scenarios on developing underprivileged SC/ST population village clusters would be useful in indentifying hot spots for implementing the Gram Panchayat based poverty alleviation rural development

schemes. Distribution of general and SC/ST population is shown in fig. 4.

3.3 Generating Spatial Database at Cadastral Level

Cadastral data is usually stored in hardcopy registers and updated manually where available. Where a digital database is being prepared, map production often continues to be done manually in parallel. Often map showing land ownership is in the form of sketches, which are not to scale. Therefore, exact demarcation much of the land is impossible and time consuming. Most of the information about land is in the experienced hands of key

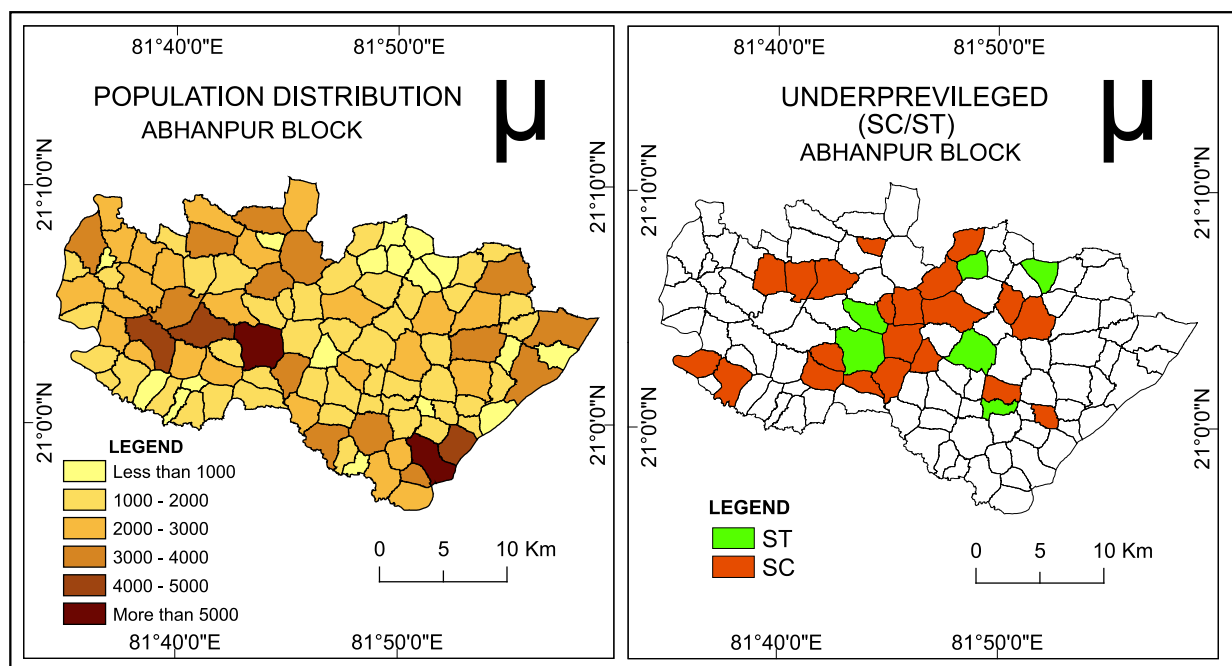


Figure 4: Population

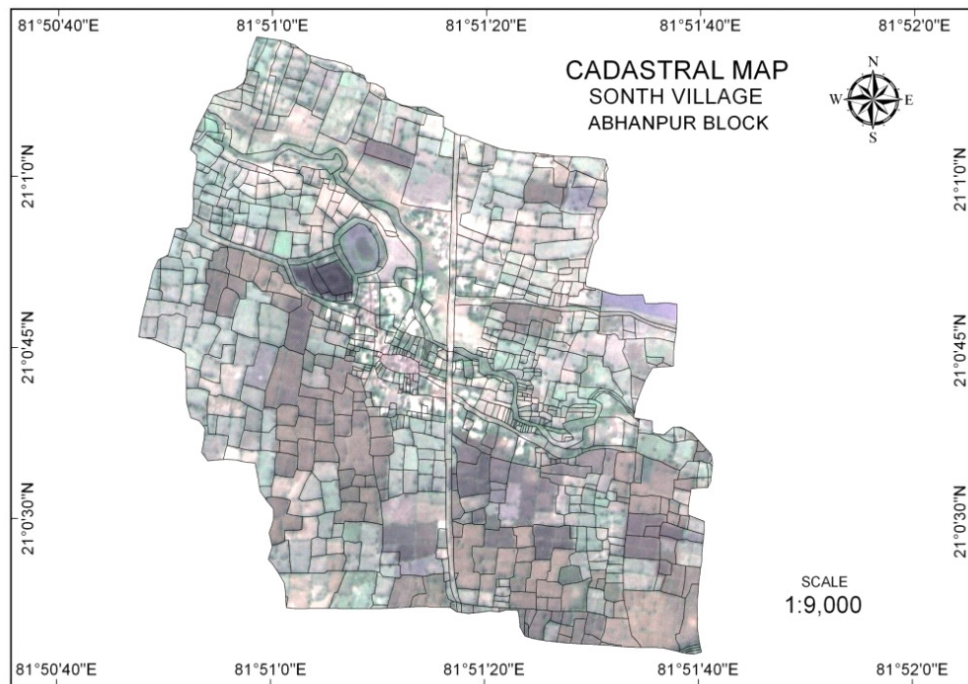


Fig. 5. Cadastral map of Abhanpur.

personnel in separate departments. Due to the absence of any other information system, they are treated as the primary information sources. As a result of this, information can be easily lost. When information linked with the Land Registration and GIS based cadastral maps of land, it will become a valuable asset for the state, district, block and village. Through one

can navigate through each plot of the land, can make specific queries. The aim should not only be to digitize the existing cadastral maps, but also plan the resources at grassroot level. Using such system revenue department can properly estimate the revenue to be generated and a farmer can easily settle his land related problems.

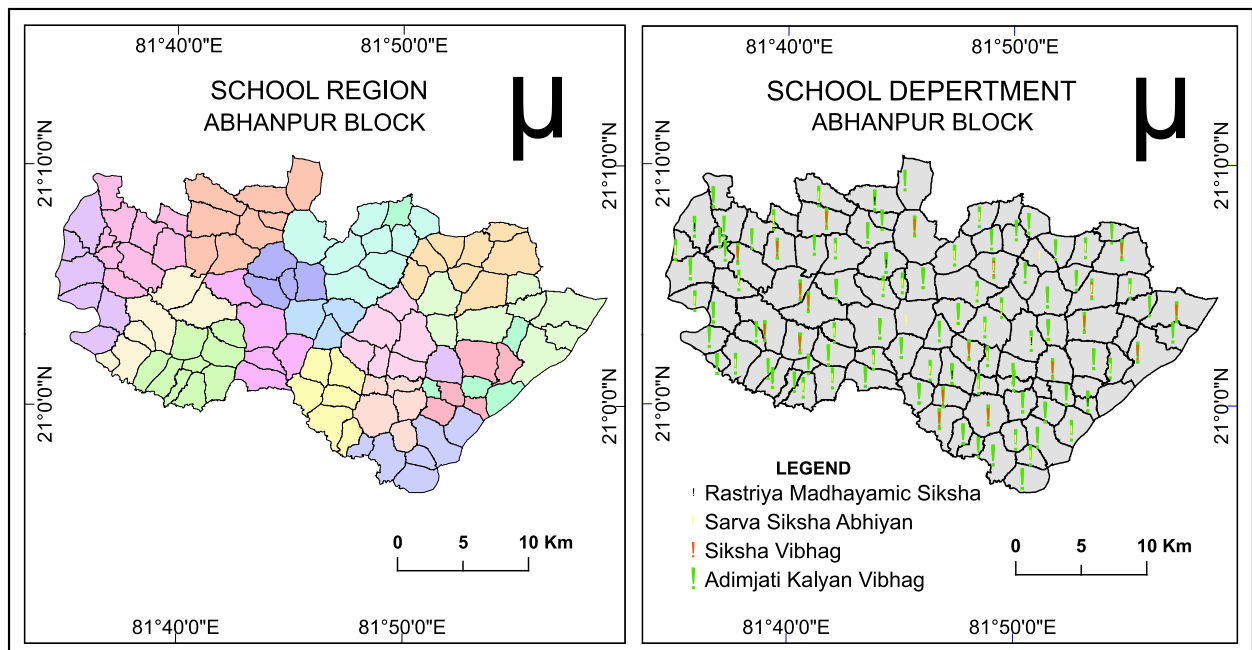


Fig. 6. Education Facilities.

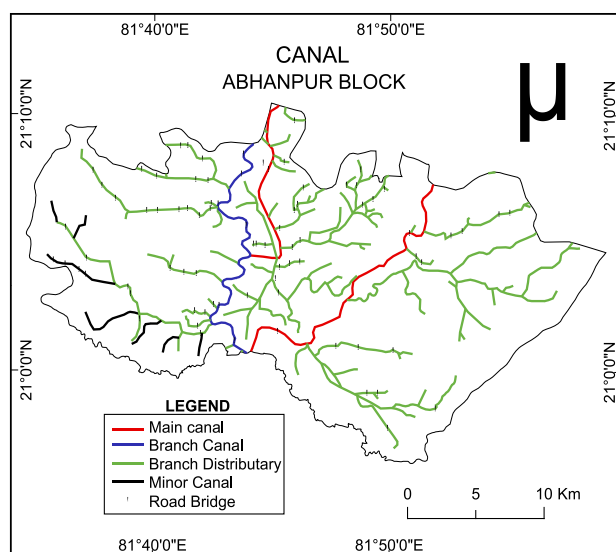


Fig. 7. Canals in Abhanpur.

Cadastral_Abhanpur.dbf: The file named under the category of cadastral. This database is comprised all the basic details data such as khasra no, plot no, name, area, etc. (Fig. 5).

3.4 Asset Mapping

3.4.1 Education Facilities

School is one of the important assets for Gram panchayat. It plays an important role in the rural development. It is very essential to have a proper record this asset, so that it can help for further planning. GIS is a tool which help us to keep a database with full of information. The above map depicts the school information at a broad level from block to village level. There are about seventeen school region having two eighty-six schools conducting by different departments. Such school facilities are shown in fig. 6. GIS can help in identifying the gap areas.

3.4.2 Water Availability

Ponds, streams, canals constitute the surface water sources. There are about 675 ponds in Abhanpur block, distributed in all the villages. These surface waterbodies were mapped from high resolution data, this data has helped in delineating even very small ponds. With the help of seasonal data gives us information about permanent or seasonal in nature. Ownership of these ponds has been collected whether it is private, panchayat or temple owned. Canal network is shown in fig. 7 and water bodies in fig.8.

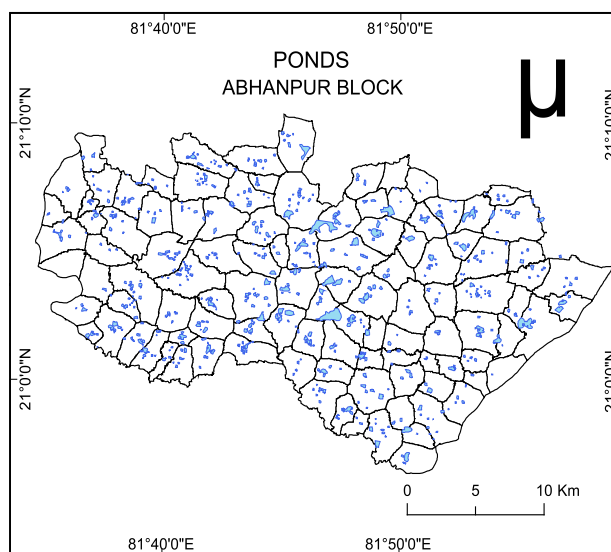


Fig. 8. Water Body in Abhanpur.

POND_Abhanpur.dbf: This database comprise of all the basic details such as UIDs, Village, GramPanchayat, Status(permanent/seasonal), purpose, Lined/not, Ownership, Size, x & y, Pond photos.

CANAL_Abhanpur.dbf: This database comprises of details like Canal UIDs, types, material, village, GramPanchayat, Road bridges etc.

3.4.3 Health Facilities

Health facility is an important aspect of rural development. The National Rural Health Mission (NRHM) proposed the decentralization of health planning so that the state health plan represents the needs and priorities of respective GramPanchayat, blocks and districts in the state. Data for analysis were gathered from secondary sources (registers). Here, GIS as a tool help us in visualize the scenario of health facilities availability at village leve (Fig. 9)l. It is also an asset of GramPanchayat and can be stored in database with different types of attribute which will further help in designing the state action plan from grass root level.

3.4.4 Bank and Post Office Facilities

The new rural finance paradigm is premised on the fact that rural people are bankable. Through the bank and post-office facilities in villages support a wide range of economic activities and household of various income levels. With the help of GIS an analysis has been done to observe the scenario or

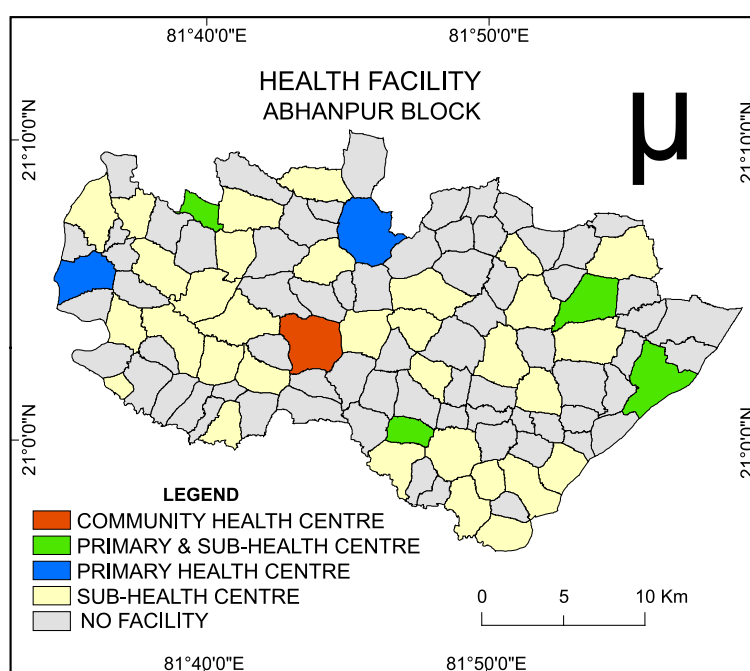


Fig. 9. Health Facility.

availability of bank and post office facility in Abhanpur block at village level (Fig.10). It helps us in visualize those villages which are lacking these facilities. Based upon this government can plane to spread the service areas of bank and post-office to all those villages.

3.4.5 Village Road Inventory

Village roads are the tertiary road system, which provides access for the villages to the various centres of activities. A base map for road network in the the Block has been prepared in GIS environment using high

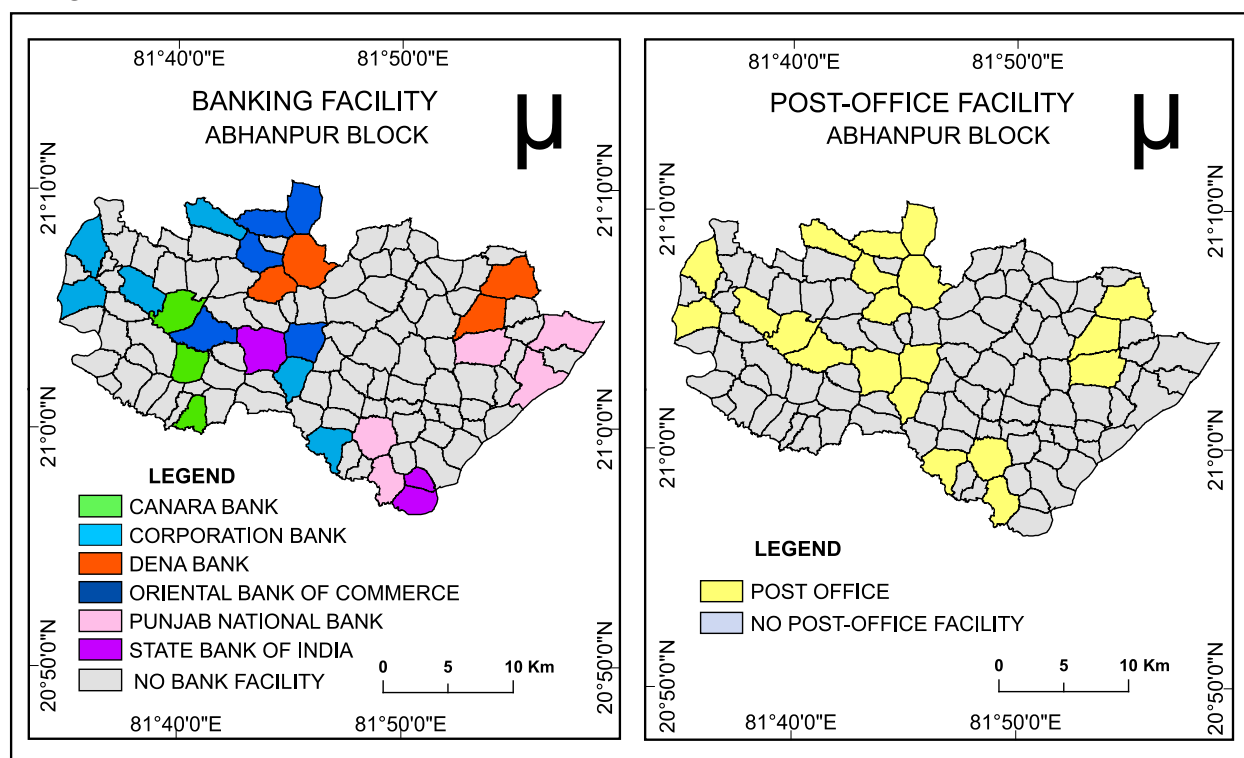


Fig. 10. Bank & Post Office Facilities.

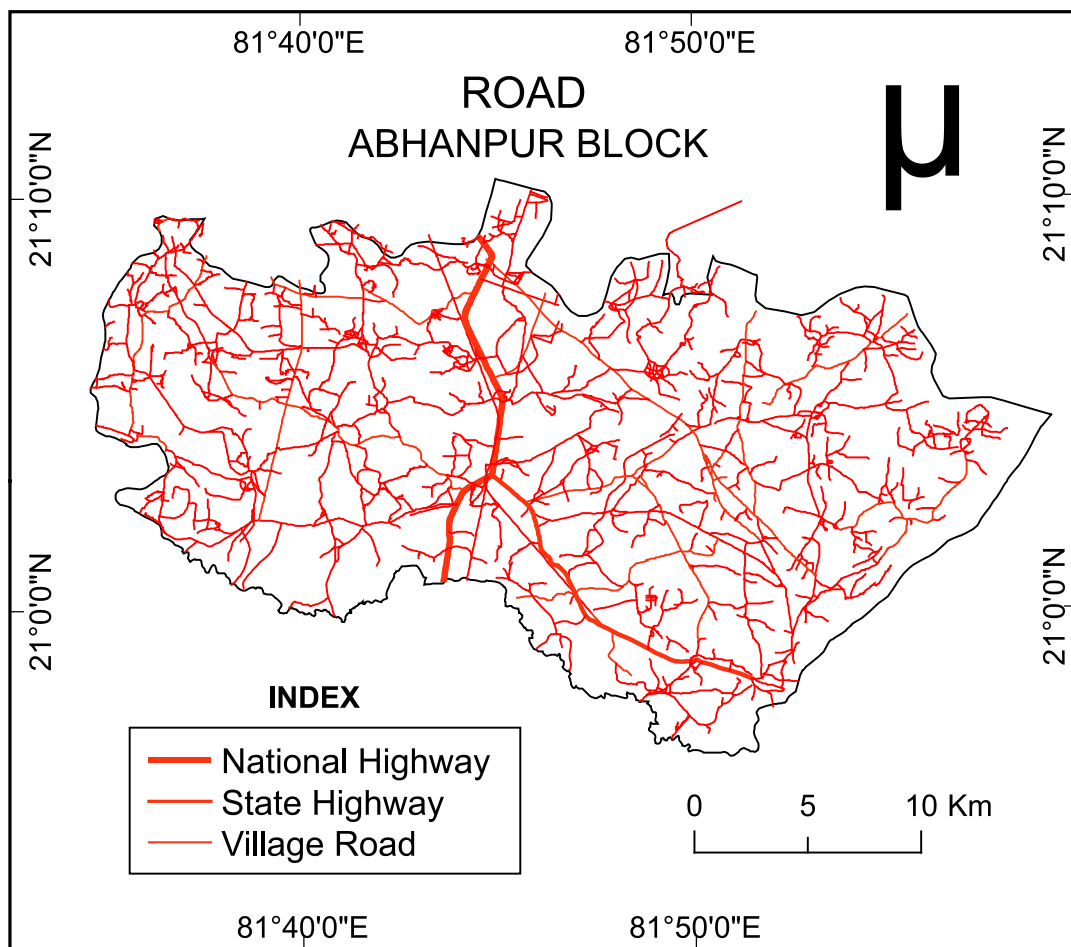


Fig. 11. Village Road Inventory.

resolution Cartosat data (Fig.11), which is capable of depicting all the features of the Block at village level in details. The important attribute data for planning and management of village road system include habitation level information, length of the road link, surface type, surface condition, etc.

4. Conclusion

A study has been undertaken at gram panchayat level to generate resources and asset information to assist the decision makers for decentralized planning with main emphasis on rural development. The major and significant conclusions emerging out of this study to generate a information system with a motto turning data into information integrating the spatial village maps with a non-spatial information from gram panchayat directory. This information system also established its usefulness to the decision-makers in the district to generate views for decision making at local

level. This community GIS tool will serve as a first step towards the development of Decision Support System for decentralized planning at Block and Gram Panchayat level. From this study it has been also observed that high-resolution data like CARTOSAT and LISS IV show tremendous potential to prepare the base map at large scale of the village. Many more parameters need to be taken into consideration while creating a Gram Panchayat information system but due to constraint of time it was not possible. The information system at village level would be helpful to plan out development policies for the village, Gram Panchayat and Block.

5. Acknowledgment

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Development department of Chhattisgarh for providing essential data regarding Gram Panchayat.

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Creation of Digital Village Cadastral and Thematic Information for Integrated Decentralized Planning in Kerala

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Keywords: Decentralized Planning, Geo-ICT, Village cadastral information, Kerala, India.

Abstract: Up-to-date and reliable spatial information and the participation of local people are the fundamental components for planning and implementation of various developmental programme at grass root level in the decentralized planning concept. Spatial information- images and maps, forms the foundation and basis for planning, implementation of developmental activities and management of natural resources. High resolution satellite imagery from Cartosat-1 (PAN) and Resourcesat-1 LISS-IV fused imagery having 2.5 m spatial resolution used basic common input for all resource themes has become proven source for generating resource information in a virtual seamless manner at cadastral level. At the instance of Planning Commission, Government of India, ISRO/DOS has taken the task of creating, updating, development of GeoICT tools and its dissemination for planning at grassroots level through a programme on "Space based Information support for Decentralized Planning (SIS-DP)". In Kerala the programme is being taken up by Kerala State Remote Sensing and Environment Centre. This paper discusses the task of creating various thematic layers and digital village cadastral information from the existing village cadastral maps geo-referenced with high-resolution satellite data on 1:10,000 scale.

Introduction

Government of India has brought in 73rd and 74th amendments to strengthen the decentralized planning and to enhance the participation of local people in the planning process. The 73rd Constitutional Amendment Act strengthened the role of the *Panchayati Raj* Institutions (PRI), the rural local bodies as institutions of self-governance responsible to plan and manage rural development. The new *PRIs* have the potential to usher change and development in accordance with people's needs and priorities. Thus, institutions of local self-governance can become the bases for the elaboration and strengthening of civil society in the country. The amendment provides for the devolution of powers and responsibilities to *PRIs* for preparation of plans and their implementation for economic development and social justice.

The advent of the new technologies like remote sensing, Geographical Information System (GIS), GPS, etc., have led to an overall change in the planning process. Information about the natural resources such as soil, hydro-geomorphology, slope, ground water

and land use/land cover is generated using remote sensing techniques. Based on this information, socioeconomic conditions and the government developmental policies/priorities, the management plans for natural resources development are generated.

Action plans for sustainable natural resource development essentially deals with area-specific and locale-specific measures. The first concern expressed by planners is that the plans are generated for a large area, i.e. at the district level ignoring the locale-specific problems. The second concern is the level of planning. If a large area is considered for planning, i.e. at district level, planning will be at 1:50,000 scale or 1:25,000 scale which cannot address the micro-level problems. Hence, the resultant plan-outputs do not effectively address the local issues. These limitations are overcome by decentralized planning projects at cadastral level.

Digital cadastral level information is essentially required for Integrated Decentralized Planning for providing for speedy, accurate and transparent decision making. Seamless digital data base generation at cadastral level

is a huge task. In order to provide spatial information in transparent, timely and cost effectively, development of scientific planning process can be effectively met by remote sensing and GIS tools. High resolution satellite data from Cartosat-1(PAN) and Resourcesat-1 LISS-IV fused imagery having 2.5 m spatial resolution used basic common input for all resource themes has become proven source for generating resource information in a virtual seamless manner at cadastral level.

At the instance of Planning Commission, Government of India, ISRO/DOS has taken the task of creating, updating, development of GeoICT tools and its dissemination for planning at grassroots level through a programme on "Space based Information Support for Decentralized Planning (SIS-DP)" using high resolution data. In Kerala the programme is being taken up by Kerala State Remote Sensing and Environment Centre. This paper discusses the task of creating digital village cadastral and various thematic layers from the existing village cadastral maps geo-

referenced with high-resolution satellite data on 1:10,000 scale.

Objectives

The present paper discuss the task of development of digital village cadastral database and various thematic layers along with their attribute information keeping cadastral data as base for Kerala state with the following objectives.

- Vectorization and geo-referencing of cadastral maps using high resolution satellite data in GIS and standardization of each product for unique identification of each cadastral.
- To test the accuracy level of geo-referencing of the cadastral maps with orthorectified satellite data.
- Value addition- socio-economic data has been integrated with the geo-referenced cadastral maps generated using remote sensing & GIS techniques on 1:10,000 scale for using as a micro-level management tool in decentralized planning.

Project area

The study area - Kerala state (*Figure.1*)

Districts	-	14
Taluks	-	63
Villages	-	1593
Cadastral	-	6135 (Aprox.)
Panchayats	-	978
Area	-	38,863 Sq.Km.

Status and Limitations in the Cadastral System in Kerala

In the generation of the digital cadastral maps from the hardcopy maps it is essential to analyse the status of existing cadastral maps to understand the importance of integration of cadastral maps. The following difficulties and limitations were encountered and thereby suitable procedures and methodology were adopted to minimize the limitations and generate accurate digital cadastral database. The limitations are as follows:

- The task of generating digital cadastral database is a mammoth for state of kerala with around 6200 cadastral sheets in 1593 villages.
- For available cadstral sheets no common standard scales being followed. It varies from



Figure 1. Location- Kerala state, India.

1:4,000 to to 1:8,000 in different parts of the state.

- The village maps are generally very old resulting in degradation of quality. The accuracy standards also differ and are not adequate for present day requirements. Resurveyed maps are not available in most of the rural areas.
- The scanned cadastral sheets are not north oriented. This will increase the burden while mosaicing the sheets.
- Standardisation, in terms of unique identification of each parcel, is not established. All the features in the cadastral map should be standardized, codified and symbolized for unique identification.
- *definition of the parcel*- latitude and longitude information is very essential for linking cadastral to the other thematic maps defined in real world coordinates. It is absent in the cadastral maps
- *projection*- projection used in India is Cassini projection in which the scale is true along the central Meridian and in a direction at right angles to it. However the scale along the other meridians is exaggerated away from the central meridian. Projection used here is -GCS,Datum- WGS84,Transformation method- first order polynomial (Affine).
- *elevation*- the cadastral do not have height information that is very important for development planning.
- In addition to these deficiencies, the traditional cadastral systems fail to meet requirements connected with supervision, management, decision-making, forecasting and development planning. The most significant problems in the traditional cadastral systems are low precision of geometric data quality and speed of data access; divergence between the map and the register; and lack of supervisory tools.

Data inputs and methodology

- Hardcopies of cadastral maps from survey and land records department, Government of Kerala

- Seamless Cartosat ortho rectified PAN data and Merged satellite data of PAN & IRS LISS IV provided by RRSC, Bangalore.

- Existing resource GIS layers.

- Attribute information from stakeholder departments.

- Software used – ArcGIS, Erdas Imagine and Adobe photoshop

The methods of generating the output involved the following steps

- Procurement of cadastral sheets from Dept. of Survey & Land Records
- Indexing, Coding & Scanning of cadastral using raster scanner at 200 DPI
- North orientation of the cadastral scanned
- Vectorization of individual sheets with topology for point, line and polygon features in Arc/INFO environment.
- Mosaicing of vectors and rasters to form single reveune blocks and village.
- Geo-referencing of mosaiced raster and vector with orthorectified PAN data.
- Seamless mosaic of the village maps to form a taluk level and then a district.
- Value addition to the maps by linking the spatial and non-spatial information at the village level.

Database Generated in GIS Environment

The information from the cadastral maps is extracted and organized in GIS environment as polygon, line and point layers. After the completion of digitization, cleaning, editing, topology creation & geo-referencing, the following database generated in GIS platform under this project are as follows:

- i. Scanned cadastral .tiff files and rectified .tiff files with name and proper code structure.
- ii. One to one Vectorized individual cadastral maps at sheet level and village level.
- iii. Vectorised village level map after sheet mosaic with point, line and poly coverage.
- iv. Geo-referenced thematic data at village level, with all the features captured with unique IDs.

- v. Taluk wise mosaic *coverages* of Geo-referenced village maps with non-spatial information attribute data integrated (Figure.2.1 to 2.5).

Accuracy of Geo Referenced Cadastral Maps

The cadastral maps are geo-referenced using the high-resolution satellite data, which is rectified by the identical points derived from both data. The accuracy of the geo-referenced cadastral maps pertain to the low land , midland and highlands of Pamba river basin were analysed through the accuracy of the transformation models, location accuracy and finally the area accuracy. The accuracy is represented by the residual error, measured as the difference in the projected coordinates and the user defined coordinates, at each of GCP and rms error of the transformation model-first order polynomial (Affine). These values represent the accuracy of the process, i.e. lesser the value, more the accuracy.

The accuracy of the transformation models were analysed for the Kurattissery, Mannar, Niranam, and Kadapra village in the lower reaches, five blocks in Ayiroor and Cherukol village in midland and chittar seethathode village within the pamba river basin boundary (Figure.3). The analyzed result is summarized in Table.1.

One of the observations from the transformation models is that the image distortion due to registration is very less, signifying the fact that the geo-referencing is very stable. This indicates that in the high resolution data the residual errors are very low. In other words, with finer spatial resolution 2.5 m satellite data has the high precision. The RMS error of the transformation model varies from 0.00011-0.00008 in lowland, 0.00014-0.00003 in mid land and 0.00025-0.00023 in high land. Another sample is given below in Fig. 4.

Figure. 2. Taluk wise mosaic of Geo-referenced village maps with non-spatial information data integrated.

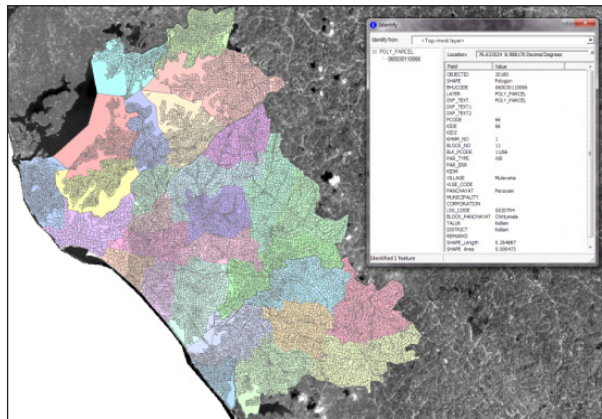


Fig. 2.1. Villages of Kollam taluk.

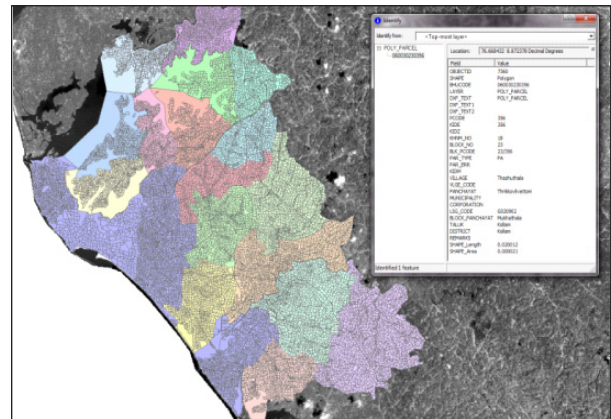


Fig. 2.3. Block Panchayaths.

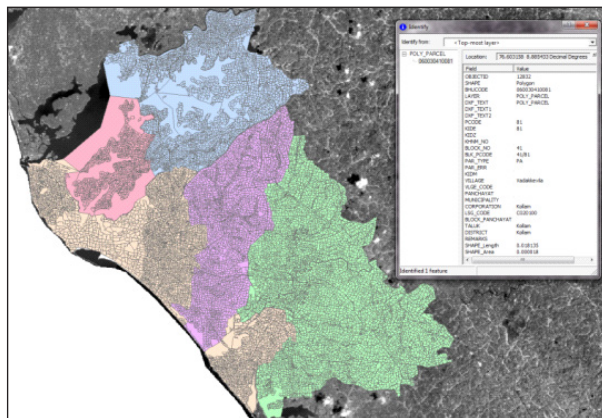


Fig. 2.2. Villages of Kollam taluk.

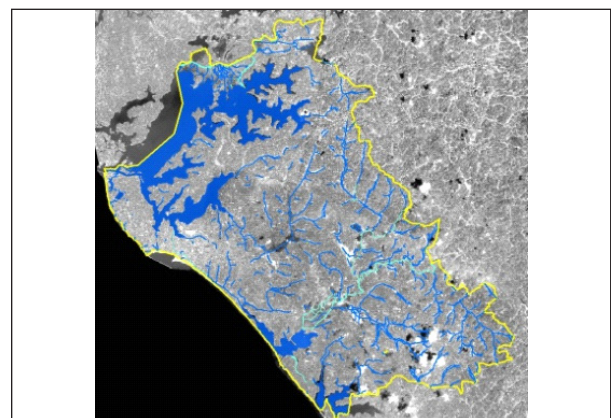


Fig. 2.4. Drainagenetwork Kollam taluk.

Data on Demographic and Socio-economic are integrated to the generated spatial database

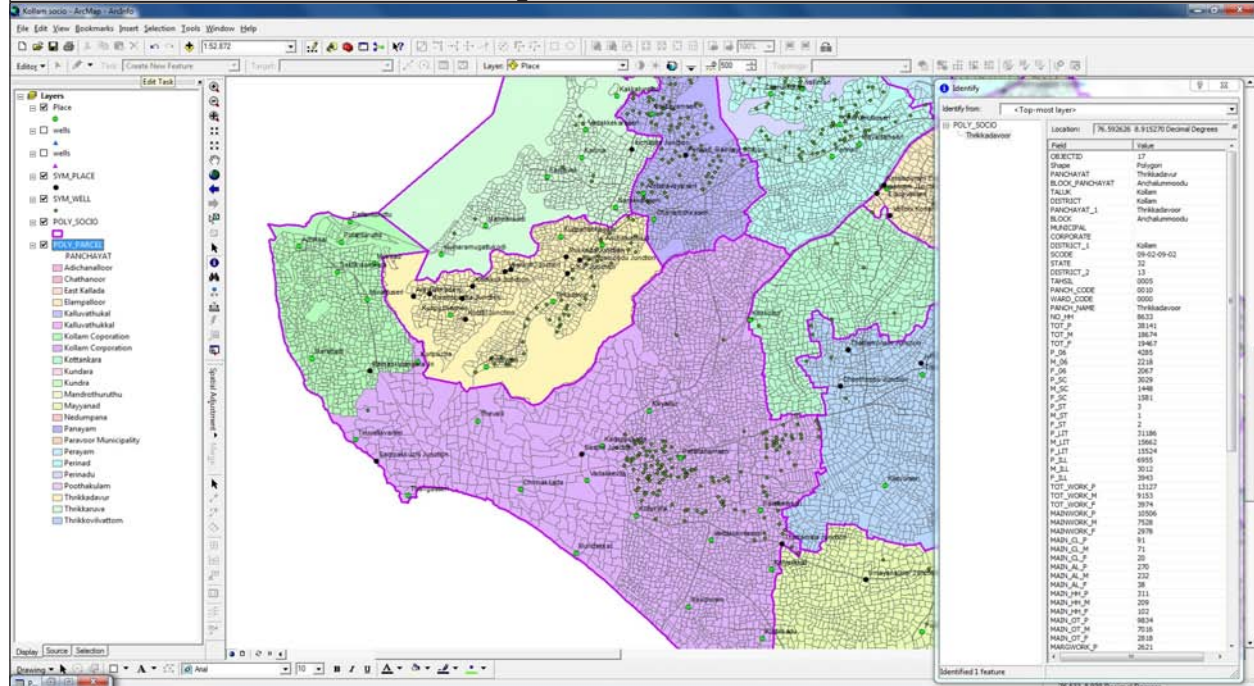


Fig. 2.5. Non-spatial information attribute data integrated.

Conclusion

Digital spatial information at cadastral level is essentially required for Integrated Decentralized Planning. Seamless digital data base generation at cadastral level is a huge task. The digital cadastral database has tremendous potential to address the issues at large scale using high spatial and spectral resolution satellite data. High

resolution satellite imagery from Cartosat-1(PAN) orthorectified imagery with 2.5 m spatial resolution as basic common input for resource themes has become proven source for generating resource information in a virtual seamless manner at cadastral level. The dynamic information provided by the high resolution satellite data compatible with the cadastral maps has tremendous applications in decentralized planning processes.

Table 1. Transformation accuracy of Cadastral Map vs. ortho-rectified IRS data in pamba river basin. Projection-GCS,Datum- WGS84,Transformation method- first order polynomial (Affine)

Pamba river basin	Village/block	Points	Area Sq.Km Sheet	Area Sq.Km Transformation	Residual Error (RMS)
Low land	Kurattissery	20	9.9627	10.056	0.00009
	Mannar	16	8.004	8.029	0.00008
	Niranam	11	10.925	11.152	0.00011
	Kadapra	12	8.904	9.169	0.00008
Midland	Block 1. Ayiroor	13	8.826	8.796	0.00007
	Block 2. Ayiroor	11	9.658	9.657	0.00007
	Block 3. Ayiroor	14	6.848	6.859	0.00006
	Block 4 Cherukol	10	7.446	7.396	0.00014
	Block 5 Cherukol	11	8.639	8.751	0.00003
Highland	Block 1. Chittar Seethathode	14	16.837	16.912	0.00025
	Block 2. Chittar Seethathode	16	12.638	12.713	0.00024

Fine matching of Parcels surrounded by water body on CARTOSAT image



Fig. 3. High precision matching of cadastral and satellite data.

The following utilities are envisaged from the generated cadastral database. (1) Archival and dissemination of cadastral maps in digital format. (2) One of the important outputs from this project is the accurate and precise revenue and administrative boundaries in digital format with real world coordinates of the parcels. (3) Facilitating generation of natural resources information at cadastral level. (4) Facilitating micro level decentralized planning and management of natural resources with

necessary, the action plans of land and water resource development in the execution of decentralized planning.

Acknowledgement

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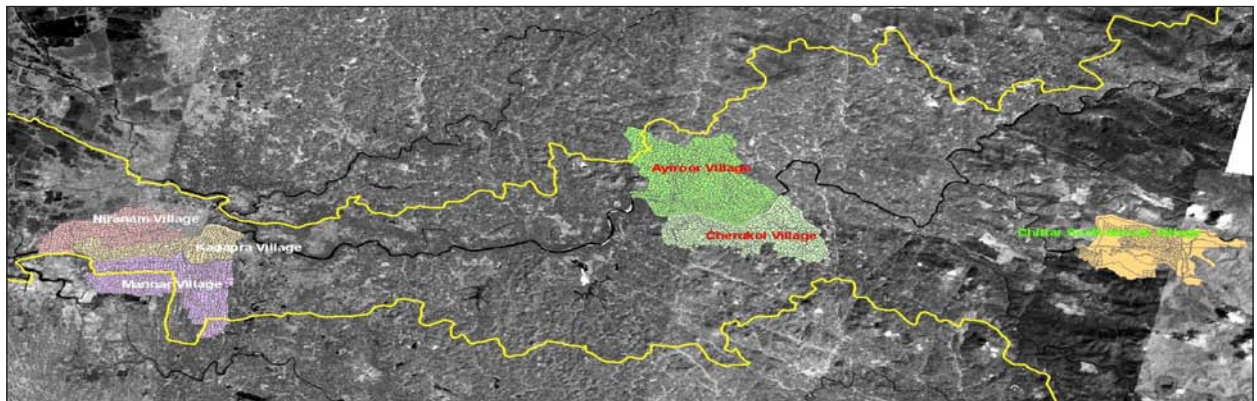


Fig. 4. Geo-referencing accuracy assessment of Villages within Pamba river basin at different elevation. Niranam, Kadapra and Mannar villages in lower reaches, Airur and Cherukol villages in midland and Chittar seethathodu village in High land.

accurate boundaries integrated with thematic maps of soil, slope, land use/land cover, ground water prospects, etc.(5) Temporal updation can be done using high-resolution satellite data.

To sum up, the digital cadastral data based action plans can give a breakthrough in reaching the people, understanding their requirements and modifying, wherever

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Decentralized Planning with Application of GIS: Issues and Options

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Keywords: *Decentralized planning, Remote Sensing & GIS, Local Planning Area*

Abstract: The paper examines the ways in which urban planning is studied by scientific approach using remote sensing and GIS (RS & GIS) in the state of Punjab. Department of Housing & Urban Development adopted RS & GIS to prepare their proposed land use plans with the aim to enable planners to foresee and visualize the changing requirements of urban and regional planning. With the application of RS & GIS it is easy to demarcate the spatial distribution of residential use zone, industrial use zone and also has reduced the restriction of locating industries only in industrial area and for relocating the existing industries. The Government of Punjab has declared Local Planning Areas for 44 cities / towns for providing better planning and regulating the development and use of land in planning areas. Department of Housing & Urban Development entrusted Punjab Remote Sensing Centre (PRSC) for preparing 40 Existing Landuse Plans and 26 proposed landuse plan by using RS & GIS technology and other are in progress. The present study focused on Jalandhar local planning area of Punjab state i.e. 77538 ha. The distribution of land under residential, commercial, industrial use in Local Planning Area, Jalandhar has been found to be about 9684 ha, 721ha, 3465ha respectively and remaining area is under different landuses i.e. recreational, transportation, utilities etc. This work helps to organize the landuse pattern to optimally utilized the resources and develop a better plan with futuristic development.

Introduction

India is on the way to rapid growth and progress. The development is taking place in every sector like agriculture, industry, manufacturing, infrastructure, transportation, communication, etc. Any kind of developmental activity utilizes land and natural resources for its establishment and sustenance. In order to provide more effective and meaningful direction for better planning and development necessary support of the organization has become essential. For this, India adopted economic planning with the launch of the First Five Year Plan in 1951. Since the first plan attempts have been made by the government to introduce some degree of decentralization into the planning process by strengthening local level planning. Sometimes such attempts have been strong and visible. At other times, they have been weak and dormant. Thus, decentralized planning has been evolved in India in fits and starts over the years. For this, the Government of India has taken an initiative to strengthen municipal governance by the enactment of the Constitution (73rd and 74th Amendment) Acts, 1992. Through this initiative an attempt is being made to improve

the performance and ability of municipalities / urban local bodies so that they would be able to discharge their duties efficiently in the planning and development of urban areas. The State Legislative Assembly of Punjab has enacted The Punjab Regional and Town Planning and Development Act 1995 (amendment in 2006) to strengthen the Development Authorities,. Through these initiatives, attempts are made to improve the performance and ability of Development Authorities, so that they will be able to discharge their duties sufficiently and efficiently in the planning and development of urban areas.

In Punjab, Development Authorities are confronted with number of problems, such as non-availability of data, poor recovery from tax and non-tax sources despite devolution of powers. Therefore, there is an urgent need to adopt modern technology of remote sensing which allows collecting lot of physical data rather easily, and in conjunction with geographic information system (GIS) helps to analyze the data spatially, offering possibilities of generating various options to identify and resolve the issues. These information systems

also offer interpretation of spatial data with socio-economic data and thereby provide an important linkage in comprehensive planning process, thus, making it more effective and meaningful.

The linkage between remote sensing and GIS is clear and intelligent for preparation of base map, formulation of planning proposal that acts as monitoring tool during implementation phase. Remote sensing and GIS tools are such that these utilities can be used for managing planning activities. The planner can look for different options and choose the best suited for the end result. The geospatial process is not only faster but also monitors the real time scenario effectively in at any eventuality.

The present effort explains remote sensing and GIS applications in various stages of planning, implementation and monitoring of the urban area. It also aims to facilitate how GIS can be used to prepare Master / City Development Plan in actual planning practice.

Decentralised Planning and GIS

Decentralization, interpreted in simple terms, would mean moving away from the center or *deconcentration*. Decentralization means transfer of power in the matter of formulation and implementation of Development Plans from the state level to local organizations. In a truly decentralized situation such power will include the power to determine goals and targets and to raise resources locally (Mahapatra, 2003).

The big cities attain inordinately large population size leading into virtual collapse in the urban services and followed by basic problems in field of shortfalls in housing and water supply, inadequate sewerage, traffic congestion, pollution, poverty and social unrest, thus making urban governance a difficult task. The high rate of urban population growth is a cause of concern among India's urban planner for efficient urban planning.

Decentralised planning at different administrative level through GIS is represented by different level of scales, like, for state level is 1:1,000,000 or 1:5,00,000 at district level is 1:2,50,000, at tehsil or block level is 1:50,000 and at town level scale is 1:35,000 or 1:15,000.

The above planning exercises have to be viewed in the context of specific problems

associated with developing countries which emanates primarily due to rapid population growth and limited resource availability resulting in regional and intra-district imbalances at the socio-economic development levels. These problems find further manifestation in the form of low income levels, smaller land holdings, poor social services, inferior infrastructure, poor literacy and hygiene, environmental degradation, etc. Also in context of spatial planning support in India, following problems are encountered.

Non-availability of country wide latest topographic and cadastral database

Non-availability of technological know-how at working level

Lack of institutional back-up for implementing and monitoring the Development Plans

Security restriction problems related to the use of topographic database or high resolution spatial data.

Decentralized planning is a complex phenomenon that requires enormous data to support the decision. It is a process of identifying problems and finding solutions using an information system. It is a dynamic phenomenon, which keeps on changing with time. Therefore, accurate and timely data is required for proper planning. Urban planners use variety of data and methods to solve the problems of urban areas. With the launch of artificial satellites and availability of remotely sensed data, which gives synoptic view of the planning areas, the urban planners are equipped with new tool.

Today, very high resolution data such as 1m PAN from IKONOS, 0.6m PAN from QUICKBIRD, 0.5 m from worldview and 2.5m and 1m PAN from CARTOSAT-1 and satellites are available at reasonable cost. This spatial data combined with other data can provide better ability to understand the urban problems clearly and arrive at suitable solutions. The urban planners need authenticated and accurate data and sophisticated computer tools for making dynamic decisions. Remote sensing and GIS are such tools, which help the planners to accurately create and manage data. GIS is used as analysis tool to specify logical and mathematical relationships among map layers to get new derivative map layers. Any new

data can be added to existing GIS database easily. Thus, remote sensing data provides reliable, timely, accurate and periodic spatial data while GIS provides various integrating tools for handling spatial and non-spatial data to arrive at solution for decision making. GIS allows integration of multiple maps/images with geo tagged tabular data and enables to determine spatial pattern and choice based on spatial criterions. The information system has the capability of not only representing the data/information but also analysis, put to query and manipulate the urban information.

Urban Punjab and Master Planning

Like elsewhere, in Punjab growth of urban areas is a dynamic and continuous process. The pace of physical development of cities of Punjab can be seen from its urbanization rate (Table 1). The census data of 2011 strengthen the fact that urbanization level of state is 37.49% which is higher than the national average i.e. 31.16%. Class I cities have share of 57% of total urban population and 68% of total population in Class I cities live in only four cities namely Ludhiana, Amritsar, Jalandhar, and Patiala.

Urbanization in Punjab has largely taken the form of unplanned and uncontrolled private colonization and massive building activities in and around the cities. As a result, slum, uncongenial environment, only nominal civic amenities, choked city roads, encroached public lands and congested highways are common features visible anywhere (Chawla, 2009).

The difference between towns and cities has decreased at rapid pace due to growth of new towns and expansion of urban area limits. To arrest the ugliness and chaotic development of Punjab the State Legislative Assembly enacted

one comprehensive law i.e. the Punjab Regional and Town Planning and Development Act 1995 (amendment in 2006). The Master Plans in the state are prepared under this Act. The basic purposes for the enactment of this Act are as follows.

- To make provisions for better planning and regulating the development and use of land in planning areas;
- Preparation of Regional Plans, Master Plans, Zonal Plans, Town Development Schemes;
- Constitution of State Regional and Town Planning and Development Board for guiding and directing the development process in the state; and
- Constitution of State Urban Planning and Development Authority and Special Urban Planning and Development Authorities.

Procedure for the Preparation of Master Plans in Punjab

Master Plan is an instrument to guide and manage the growth of towns and cities in a planned manner. To arrest the unplanned development in Punjab, Master Plans for different cities have been prepared. Preparation of Master Plan in the whole state has become one of the key objectives of the legislative framework. The Punjab State Legislative Assembly perhaps is the last to enact a comprehensive law on the subject of urban and regional planning. The procedure for the formulation of a Master Plan in the state is as follows.

- Study the existing scenario of urban centers.
- Identify vision of the city for next 20-25 years.

Table 1. Growth of Urban Population in Punjab

Census Year	Total Number of Towns /UAs	Total Population	Urban Population (in millions)	% of Urban Population
1951	110	916500	1.98	21.72
1961	106	11135069	2.56	23.06
1971	106	13551060	3.21	23.73
1981	134	16788915	4.64	27.68
1991	120	20281969	5.99	29.55
2001	157	24289296	8.24	33.95
2011	216	27704236	10.38	37.49

Source: Census of India, 2011

- Project the population and accordingly calculate the requirements of both the physical and social infrastructure.

Declaration by State Government through gazette notification any area in the state to be a local planning area under the Punjab Regional and Town Planning and Development, 1995 (amended in 2006).

Prepare draft plan of city after the demarcation of Local Planning Area, with vision, projections and requirements.

Publication of the Plan by the Planning Agency for inviting objections

Modification of Master Plan or its approval with modifications by the Planning Agency. The designated Planning Agency after approval of State Government shall publish the final Master Plan in the official gazette after carrying out the modifications.

On the footing of these legislative measures, till date State Government has approved a number of Master Plans for various towns and cities in Punjab such as Ludhiana, Jalandhar, Amritsar, Patiala, Bathinda, Tarntarn, Khanna, Pathankot, Sangrur, Abohar, Sri Hargobindpur, Rajpura, Batala, Gurdaspur, etc. The remaining Plans are in the process of preparation and approval.

Under the Punjab Regional and Town Planning and Development Act 1995 (amended in 2006), the Punjab Urban Planning and Development Authority (PUDA) is set responsible for the preparation of Master Plans in Punjab. But as per the requirements, PUDA has assigned this duty to various agencies or authorities such as Greater Ludhiana Area Development Authority (GLADA), Jalandhar Development Authority (JDA), Amritsar Development Authority (ADA), Patiala Development Authority (PDA), Bathinda Development Authority (BDA), Greater Mohali Area Development Authority (GMADA) and Punjab Remote Sensing Centre (PRSC), Ludhiana. Department of Housing & Urban Development entrusted the PRSC to prepare 40 Existing Landuse Plans and 26 Proposed Landuse Plans by using RS & GIS technology and many more are in progress.

Master Plan Jalandhar

Jalandhar city is located in District Jalandhar which is almost centrally located district among the 20 districts of Punjab State (Fig. 1.). It is situated on the National Highway 1 viz., the Grand Trunk Road and has an access to main Railway Line of Amritsar – New Delhi. River Beas flows at a distance of about 35 kms to the North of city. Jalandhar is situated at North

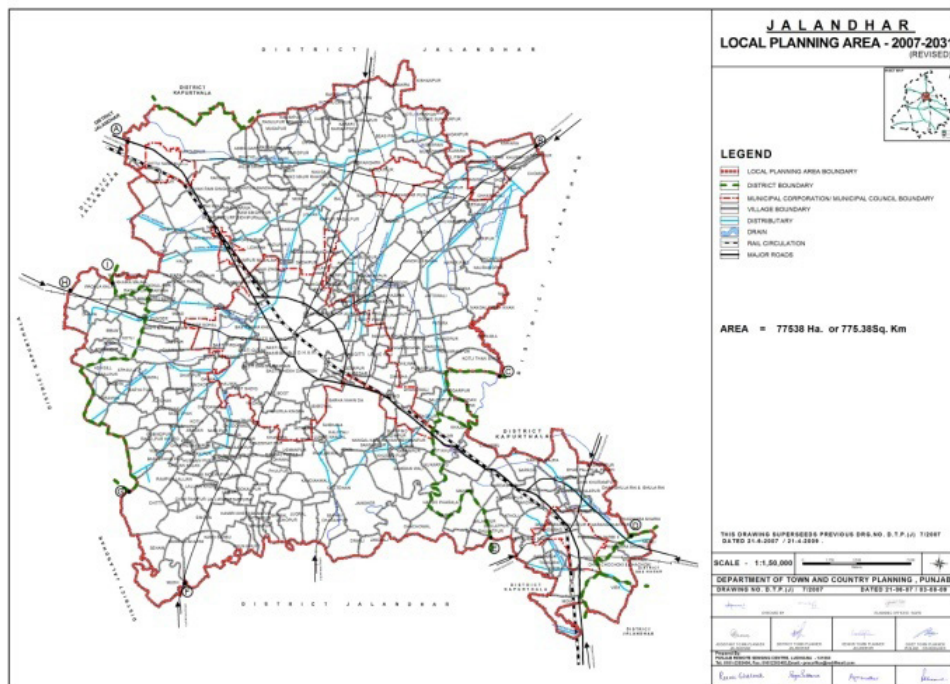


Fig. 1. Local planning area Jalandhar.

Latitude of 30° 19' and East Longitude of 75° 36' 48" with the general elevation of 780 m above mean sea level.

As a first step towards the preparation of Master Plan Jalandhar, Local Planning Area has been delineated and notified under section 56 (1) of "The Punjab Regional and Town Planning and Development (Amendment) Act, 2006" in the official gazette. The Local Planning Area Jalandhar includes 5 cities / towns namely, Jalandhar, Phagwara, Adampur, Kartarpur and Alawalpur and Jalandhar Cantonment Board along with 268 villages. Out of these settlements, 4 towns and 229 villages fall in Jalandhar district, 2 villages in Shaheed Bahagat Singh Nagar district while Phagwara town and 37 villages come under the administrative boundary of Kapurthala district. The total area of Local Planning Area is 77538 hectares (775.38

sq kms); out of which 65893 hectares fall in Jalandhar district, 618 hectares in Shaheed Bhagat Singh Nagar district and rest of the 11027 hectares come under Kapurthala district. Jalandhar.

The procedure followed in the preparation of Master Plan, Jalandhar with RS and GIS techniques is as follows: (Fig. 2).

- **data used:** Cartosat I (2.5 m) data is used for rural areas and for the urban areas Quickbird (High Resolution data 0.6m) has been used for preparing Existing Landuse Plan.
- **cadastral mapping:** The Cadastral maps or land records have been evolved for village boundaries. These maps have become obsolete due to irregular statutory surveys. A cadastral map essentially comprises of land records of each village. A village is the smallest

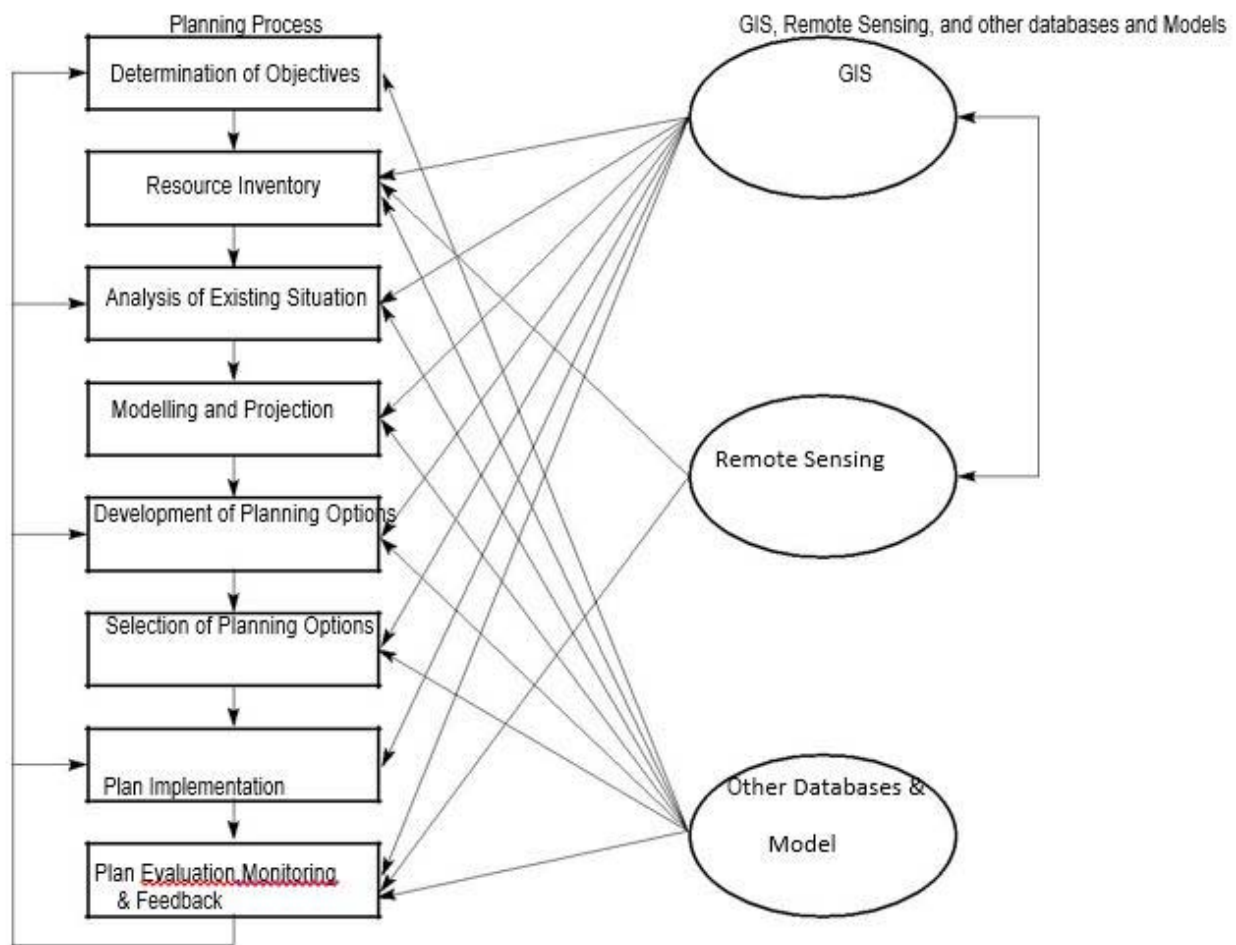


Fig. 2. Integration of GIS, Remote Sensing, and other databases and models in the planning process

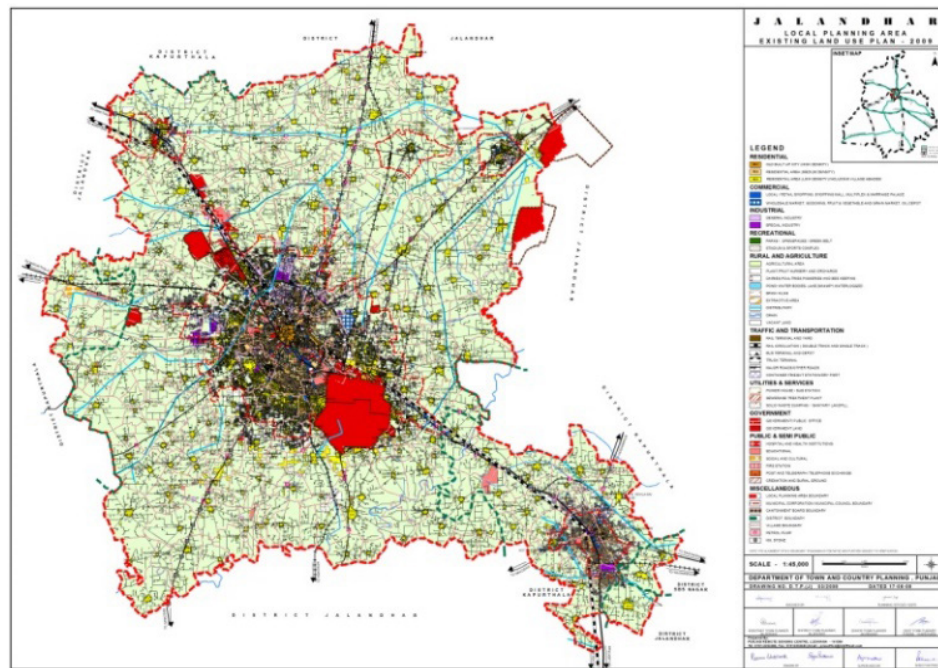


Fig. 3. Existing local planning area Jalandhar

administrative unit having well-defined geographical boundary and separate land records. The total 229 village boundaries have been demarcated with reference to cadastral maps.

- **existing landuse plan:** The existing land use distribution determines the nature of development of a settlement. The study of existing land use distribution helps in fixing the priorities and for evolving a strategy for the future development of the area. The existing land use scenario guides a planner to allocate land for different land uses viz., residential, industrial, commercial, public / semi public, etc. rationally and optimally so as to achieve the high level of efficiency of land

which is limited. The existing land use plan for Local Planning Area, Jalandhar has been prepared by Punjab Remote Sensing Centre using satellite data and field verification done by Department of Town and Country Planning officials (Fig. 3). The following table shows the existing allocation of land under different land uses in Local Planning Area, Jalandhar:

The distribution of land under residential use in Local Planning Area, Jalandhar has been found to be about 12.49% (Table 2), out of which the major share of about 9% is of five urban settlements namely Jalandhar, Phagwara, Kartarpur, Adampur and Alawalpur. The existing villages in Local Planning Area

Table 2. Existing land use distribution of LPA, Jalandhar

Sr. No.	Land use	Area (in ha)	%age
1	Residential	9684.50	12.49
2	Commercial	721.10	0.93
3	Industrial	3465.95	4.47
4	Recreational	155.08	0.20
5	Traffic and Transportation	4497.20	5.80
6	Utilities	139.57	0.18
7	Governmental	2799.12	3.61
8	Public and semi public	1729.09	2.23
9	Agriculture and water bodies	54346.39	70.09
	Total	77538.00	100.00

takes up about 3.49% only. The concentration of population is mainly in Jalandhar and Phagwara cities which signify a bigger need for more built up areas for residential use to sustain the growing employment opportunities in the field of trade and commerce in these settlements and to provide adequate housing for about 25 lakh persons of LPA by 2031.

The commercial activity is also mainly concentrated in above said urban settlements and rural areas falling within LPA are devoid of high level of commercial activity. The rural population has to depend upon nearby urban areas to meet their day-to-day shopping needs. Although Kartarpur town specializes in furniture marketing even then for the rest of commercial business, it has to depend upon nearby Jalandhar city. Hence a balance has to be created in this regard so as to minimize the dependence on urban settlements for this purpose (Fig. 3)

The industrial activity is mainly concentrated in Jalandhar and Phagwara. The furniture industry at Kartarpur is having significant role in the economic well being of this town but the rest of the areas in LPA have very low proportion of land under industries.

The road circulation comprises National Highways, State Highways and railway lines

passing through the area and a good road network of local roads. But the missing road hierarchy, encroachments along roads, road conditions, etc especially in urban areas is resulting in chaotic traffic condition. Hence concrete measures are required to improve the traffic and transportation system by way of provision of new roads, construction of flyovers / ROB's, subways, etc.

The public facilities and utilities are also concentrated in urban settlements and the rural areas are devoid of these facilities which need to be taken care off in the Master Plan.

Vision: The vision has been formulated as "To make LPA Jalandhar an economically vibrant city with quality infrastructure and housing for all its citizens in environmentally sustainable manner achieved through effective partnership between the public, private and community sector", so that Jalandhar must become a centre of rapid economic and physical growth. The above stated vision is to be achieved through better urban governance, providing sufficient land for economic and social activities, through higher order of economic productivity, rationalized land use pattern, improved transport network, introducing eco-friendly economic and physical activities and through provision of social and physical infrastructure etc.

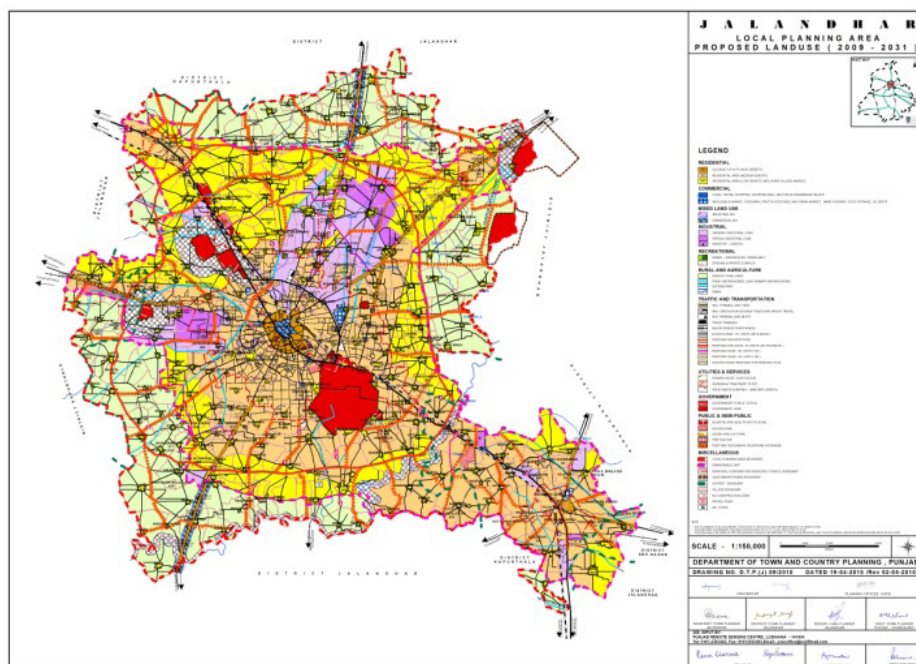


Fig. 4. Proposed land use plan of Jalandhar

Proposed Landuse Plan: On the basis of study of existing land use distribution under different land uses the Department of Town And Country Planning, Punjab allocates the scarce land optimally under different uses. To accommodate the projected population the urban/built-up areas in the Jalandhar Local Planning Area has increased from 12.49 % to 30.94% (Fig. 4). Remote Sensing and GIS has the capability of monitoring spatial changes, extracting the change information from satellite data in existing landuse plan and proposed landuse plan which relies on effective and accurate change detection techniques.

Issues and options

The Master Plan planning procedure adopted for Jalandhar raise the following issues and options for its better planning and implementation framework.

- Lack of readily available data remains one of the major hindrances in the application of GIS. The State Remote Sensing Centre should directly approach agencies for procuring data quickly (Yeh, 1991).
- Socio-economic data, which are vital to urban and regional planning, are generally lacking and often limited only to population census data. This type of data requires field surveys which are expensive and time consuming.
- There is lack of real-time and reliable data for planning as some departments are slow in the acquisition of data. Also, coordination among various departments and institutions in the flow and exchange of information has been very weak.
- The base maps which are more essential than textual data to GIS are often lacking or are outdated. There are usually many types of base maps, each compiled by different agencies with different accuracy and map scales. This makes them difficult to integrate into GIS.
- There is an urgent need to establish an institutional framework to ensure that the required data are regularly collected and updated.
- Most of the officials are not yet aware of the benefits and potential applications of GIS. They should be trained in this regard.

- There is a shortage of human resources who are experts in remote sensing and GIS.
- GIS courses and training programmes should be carried out to train the officials so that they are better equipped to read the maps and diagnose potential problems and assess the desirability of alternative plans.
- There is also a general lack of GIS courses in planning schools. To use GIS more effectively in planning, planners must be trained not so much in the operation of the system, but in how to make use of the data and functions of GIS in different processes of planning and plan evaluation.
- High degree of organisational and environmental stability.

GIS is becoming an important component in the planning support system. Recent advances in the integration of GIS with planning models, visualisation, and the internet will make GIS more useful to urban planning. Today, the main constraints on the use of GIS in urban Planning are not technical issues, but the availability of data, organisational change and staffing.

Acknowledgement

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Capacity Building and Awareness Generation on 'Open Source GIS' for Rural Development Sector of India - A Case Study of NIRD Jaipur Center

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Keywords: *Open Source GIS, NIRD Jaipur Center, Rural Development, OSGeo, Training & Capacity Building, Rural Development Sector of India*

Introduction

Training and capacity building is the prime need for propagation of software/utility to the common users. Open Source projects are voluntary driven and most of the persons involved in these projects have their responsibilities somewhere else to earn their living, so for these projects, training and capacity building is relied upon forums, mailing lists, IRCs etc. On these platforms, answers depend on time availability, expertise and interest of other users, so need is there to have organisations with clear-cut mandate to support Open Source GIS projects/users, with need based, class room trainings for providing direct contact with participants and create confidence in them towards working of software/utility. National Institute of Rural Development (NIRD) is an apex autonomous organization under the Ministry of Rural Development, Government of India. In its regular mandate, it has training and capacity building programmes for Rural Development and Panchayati Raj functionaries, elected public representatives, functionaries of line departments, reputed NGO representatives, research scholars, faculties etc. As sub centre of NIRD, at NIRD Jaipur centre training and capacity building programmes for Rural Development sector in the area of Open Source GIS are conducted along with its other regular programmes. Since November, 2010 total 26 programmes of 5-6 days duration, with 631 participants, 139 training days and 3391 training man days, have been conducted at NIRD Jaipur centre, mainly for applications of Open Source GIS in flagship schemes of Ministry of Rural Development, Government of India like MGNREGS and Watershed etc.

Need of Open Source GIS for Rural Development Sector:

Open Source GIS is not a new word to the persons involved/known to GIS. With the support of reputed and dedicated organisations and universities, it is growing very fast and widely popular in GIS users especially in Government, NGOs and Researchers/Scholars. Commercial applications/software cannot satisfy the needs of large rural development sector of India from 35 States/Union Territories (UTs), 640 Districts, 5924 Sub Districts [1] and 2,56,000 Gram Panchayats (Lowest administrative unit in India with population more than 750) [2]. Commercial software/utilities may be suitable for National/State headquarters of Departments but not at lower administrative levels (Districts/Blocks/GPs) levels, due to large and scattered requirements and constraints related to budget, operation, maintenance and upgrade etc., whereas Corporate or business sectors can afford to have commercial software/utility for GIS & Remote sensing operations due to profits in projects.

Today GIS users are well equipped with good quality Open Source GIS software and codes for further development. Moreover, Open Source GIS is now being supported by dedicated non-profit international organisations like OSGeo Foundation [3], Free Software Foundation (FSF) [4], Open Geospatial Consortium (OGC) [5], and Open Source Initiative (OSI) [6] etc. so users can remain assured about perpetual support and development of standard Open Source GIS projects. Easy availability of pirated products and more possibilities of jobs with

knowledge of commercial GIS software, and myths about Open Source GIS are some factors which limit adoption of Open Source GIS in general.

Training/Capacity building in Open Source GIS:

Training and Capacity building with commercial GIS products is generally bundled with the product for a limited period and upgrade of product or release of new version is always associated with a cost, while in Open Source GIS products the support is limited to forums, mailing lists, IRCs etc., but upgrade/new version does not bear cost.

Further Open Source GIS projects are voluntary driven and in this situation trainings/capacity building part of Open Source GIS becomes critical. It is required to have sufficient training and service support individuals/organisations for this sector to sustain users, helping them in their day to day work and create faith in prospective users.

NIRD & NIRD Jaipur Centre:

National Institute of Rural Development (NIRD), Hyderabad is an apex autonomous organization under the Ministry of Rural Development, Government of India. It has mandate of providing Training, Research and Consultancy to Rural Development sector of India and partner countries. Through its training and research activities, NIRD endeavours to upgrade the knowledge, skills and to bring in required attitudes among its clientele group. The clientele of NIRD include rural development functionaries at district level and above, elected representatives of Panchayati Raj Institutions, NGOs, Bankers, Community-based Organizations, Research Scholars and Academicians from Universities and Institutions. [7]

To cater the regional needs, a centre of NIRD was established at Jaipur with the name of NIRD Jaipur Centre. The centre is currently engaged in various activities, facilitating capacity building of various stake holders in the field of Rural Development. Since its inauguration on 22nd August 2010 by the then Union Minister of Rural Development, Government of India and the then Chief Minister, Government of Rajasthan State, It has embarked on a set of

key initiatives focusing on capacity building, knowledge building, participatory research and citizen centric rural development. With a combination of training, research and consultancy, the Centre is actively engaged in capacity development of the functionaries of various sectors of rural development in the fields of Rural Development namely Watershed Management, MGNREGS, Open Source GIS, Livelihood, Microfinance, Rural Entrepreneurship, Panchayati Raj, Gender Empowerment etc. The centre is also in the process of taking up certain research studies in the relevant fields [8].

Open Source GIS Trainings at NIRD Jaipur Centre:

Open Source GIS Applications in Rural Development schemes of Government of India is major area which is being dealt by the Centre. Trainings are provided at free of cost to the regular clients of NIRD, but some trainings are sponsored by respective organisation, if related to their specific needs.

Since November 2010 total 26 practical lab based training programmes with 631 participants, 139 training days and 3391 training man days, have been conducted at NIRD Jaipur Centre on 'Applications of Open Source GIS (QGIS) in various Rural Development programmes/schemes of Government of India', for senior and middle level functionaries of client departments/organisations. Out of these trainings, three trainings were conducted in collaboration with university and research institutes namely Maharana Pratap University for Agriculture and Technology (MPUAT), Udaipur, Arid Forest Research Institute (AFRI), Jodhpur and Department of Forest, Government of Rajasthan and one training was conducted under sponsorship of Department of Watershed Development & Soil Conservation, Government of Rajasthan, for their specific needs.

About Open Source GIS trainings, an article has been published on main Website of QGIS project, available in case studies section [9].

It has been observed during trainings that Open Source GIS can satisfy all the GIS related needs of Rural Development Sector of India at District and below. It is being messaged and advised in all trainings that no commercial GIS software should be purchased at District and

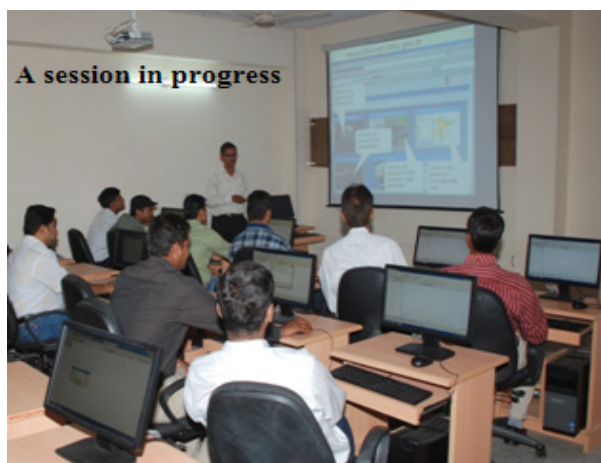
Year wise trainings conducted, with further details, are shown in the table below:

Details of Trainings Conducted through NIRD Jaipur Centre Based on Open Source										
Financial Year	Participants Category								Number of Training Man Days	
	Number of Training Conducted	govt. Officials	ZP & PRIs	Vol. Orgns/NGOs	Natl./State Instts for Res. & Trg	Univ./Colleges	Total number of Participants	Training Days	Female	
2010-11	4	101		3			104	23	7	603
2011-12	8	168		11	7	22	208	46	25	1190
2012-13	9	182		19		7	208	46	17	1061
2013-14 (Upto Nov, 2013)	5	97	1	4	2	7	111	24	5	537
Total	26	548	1	37	9	36	631	139	54	3391

below, if real requirements are not felt after exploring Open Source GIS. This saving may be used for purchase of hardware like GPSs, computers etc.

Procedural Details & Major Areas Covered:

Trainings are conducted with practical/hands-on, and seeing the practical nature of trainings almost all the trainings are conducted as single/main resource person by author. As exercises are based upon previous exercises, it does not allow interference or deviation from sequence of sessions, however, some eminent resource persons working with Open Source GIS from agencies outside, like OSGeo, Regional Remote Sensing Service Centre, Jodhpur, and State Remote Sensing Application Centre, Jodhpur, are invited for special lectures. The trainings are conducted with 5-6 days duration (including one day for handheld GPS practice in field).



The thematic areas for the trainings mostly remain related to flagship schemes of Rural Development sector of Government of India like Watershed and Mahatma Gandhi Rural Employment Guarantee Scheme (MGNREGS) etc.

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) is an Indian job guarantee scheme, enacted by legislation on 25 August 2005. The scheme provides a legal guarantee for at least 100 days of employment in every financial year to adult members of any household willing to do public work-related to unskilled manual work [10]. It is supposed to be the biggest scheme of its kind in world (Reference is not available)

OSGeo incubated QGIS software is used for practical hands-on during trainings as development of OSGeo projects are faster, choices of suitability are wide and associated with large number of users and developers. Moreover QGIS is user friendly software with capability of linkage to GRASS, SAGA, SEXTANTE and R software.

Freely available Raster and Vector data of nearby area are used in exercises. General contents of trainings remained as possibilities and status of use of GIS in respective departments, introduction to geo-informatics, GIS data types, projection systems, working with raster/vector data, geo-referencing, clip/merge operations, creating/editing vector data, working with tables/attributes, vector layer properties (style, labels), print composing etc.

One day is kept to make participants aware and capable of using handheld GPSs in field and download and synchronise GPS data to QGIS/Google Earth etc. utilities, which ensures enhanced utilisation of GPS hardware available with client organisations/departments.

Broadly the training contents are finalised based on level of participation, previous feedbacks/observations, and duration of trainings.

Participants are encouraged to come with their own or departmental data, if available, to increase the interest in exercises. Trainings are provided at NIRD Jaipur Center in computer lab equipped with 15 computers of i5, 8GB RAM and Windows7 32 bit OS. Per training number of trainees remains 20 to 30.

Certificates are provided to the participants after completion of training. Presently tutorials and handouts are being provided to the participants in hard copies, latest version of software and practice data are being provided in DVDs, but plan is there to create screen-recorded lectures/demo of various topics in Hindi and English language. Graphic User Interface (GUI) of QGIS software is also being translated in Hindi by the centre. Author is official coordinator for Hindi translation of QGIS interface. Latest translation status may be found, and used in latest weekly releases of QGIS software [11].

Utility of Trainings:

In official guidelines of Rural Development schemes (MGNREGS, Watershed etc.) mandatory uses of GIS and Remote Sensing are mentioned at several places [12,13] and in accordance to those instructions most of the States have got various thematic layers prepared through capable agencies like RRSSCs, SRSACs etc. These GIS databases are lying at District, Block and Project levels with limited or no use due to lack of relevant software and expertise at lower levels. Moreover the work of agencies is being checked and approved mostly by the GIS illiterate officials posted at District and Project levels. A proper strategy is required to make the field executors capable of understanding and editing/modifying/analysing these data as per their local needs, which can be concretise only thorough use of Open Source GIS software and proper capacity building of functionaries.

These programmes at NIRD Jaipur centre provide participants an introduction to GIS with practical hands-on. Participants' myths related to Free and Open Source GIS Software is also cleared. Consequently the message goes to their offices and colleagues, towards strength and power of Open Source GIS and they can compare Open Source GIS with Commercial GIS vis-à-vis their requirements.

The immediate outcome of trainings is to remove fear of officials from Geo-Informatics and breaking the myth that GIS work can be handled by costly commercial software and highly trained personnel only. Eventually this leads to considerable saving of public money.

Post Training Support:

For helping the users each OSGeo project is having separate user and developer mailing list and IRC. 'Geographic Information Systems Stack Exchange' web site is also a dedicated and free site to solve queries related to Open Source GIS as well as Commercial GIS software [14].

Apart from introducing participants with regular helps, author has created a group 'My GIS (Open Source) Training Participants' on LinkedIn Website to provide post-training support platform to training participants [15]. The group is presently having 270 active members with growing numbers. Further, if participants stuck somewhere in the task at their place and need immediate help during office hours, online support is provided by remote access to their systems using remote support software like Team-Viewer.

Road Ahead & Expectations:

- To conduct seminars/workshops on use of Open Source GIS in various thematic areas of rural development sector
- To make NIRD Jaipur Centre as a hub of professional short and long term courses on Open Source products of Desktop/Web utilities, Open Database (PostgreSQL/PostGIS) Management, GIS Customisation using open Languages like Python etc., to provide a committed and competent cadre of Open Source GIS experts for serving Government and Corporate sector

- To translate manuals, GUI, website and other related documents in Hindi and other major languages of country. The work of QGIS GUI Hindi translation has been started and mentioned in previous sections
- To create pool of Open Source Professionals from India for helping organisations in selecting professionals according to services required by them
- To generate awareness in schools upto XII standards, towards Geo-Spatial. It is already planned to hold 'Geo-Spatial Awareness Day' in some schools of Jaipur city initially, which will be extended to schools of rural areas also
- To provide Virtual training support to the participants
- To promote FOSS4G/OSGeo activities at NIRD Jaipur Centre

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Community Based Participatory Resource Mapping

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Keywords: *Decentralized Planning, Asset mapping, Crowdsourcing*

Introduction

It has been observed that the development, conservation and management of natural resources can best be done if local populace is involved. A proper blending of modern technologies and community knowledge can lead to optimal use of natural resources. Participatory mapping involves spatial drawing of an area, drawn on ground, paper or other material by local people to show and depict their locality and other related areas. Proper blending of some of the simple techniques may lead to better management of the resources. Venn diagrams are visual methods to indicate mutual relationships and role of individuals/institutions/groups in decision-making. The method of joint walk relates to learning about selected areas from local communities through undertaking joint walks to those areas. Vector scoring is a visual method and involved scoring of criteria items for assessing their relative importance so as to prioritize problems, benefits, dangers or damages or opportunities. This method can be used by individuals as well as groups. It involves listing of criteria and scoring of such criteria/item using indigenous materials. The methods help in decision making by prioritizing concerned criteria.

Community Driven Resource Mapping

In India during the mid-1980s, investigators found that many large-scale, government-initiated development programs, such as, schooling, health, credit, irrigation systems, are not performing as envisaged. Many a times they are rapidly degrading common pool of resources in addition to creating negative environmental and poverty impacts. In their opinion the top-down perspectives were both disempowering and ineffective. Community-

driven development is the fastest growing mechanisms for channeling development assistance. It refers to community-based development projects in which community have direct control over key project decisions, including management of investment funds. It acts as catalyst for enhancing sustainability, improving efficiency and effectiveness, allowing poverty reduction efforts, making development more inclusive, empowering poor people, building social capital, strengthening governance.

In Indian culture there is a long history of community driven development. In recent years clearly significant movement is the Gandhian notions of village self-reliance, small-scale development and cooperative movement. The participatory development approach may solve some of these problems to small-scale development in ways that would allow the poor to be informed participants in development, with external agents acting mainly as facilitators and sources of funds. The inclusion of participatory elements in large-scale development assistance came quickly at the World Bank, in social investment funds and other forms of assistance. Initially focusing on targeting, these projects have moved toward a more holistic attempt at inducing participation through institutions that organize the poor and build their capabilities to act collectively in their own interest. Community-based development relies on communities to use their social capital to organize themselves and participate in development processes. Thus, concepts such as participation, community, and social capital are critical to how community participation is conceptualized and implemented.

Participatory mapping involves map making of an area by the community to show

their locality and other natural resources. It is a simple drawing which may be drawn on ground, paper or any other material. Participatory mapping may include a variety of themes for example, such as households, livestock, farm size, water bodies, field, forest, trees, road, amenities, and literacy. Such mapping can be theme-specific such as a resource map indicating natural resources of the area or a social map showing households and other buildings in the area. In participatory mapping community is actively involved. Some one from the community starts preparing the map. Other members contribute by extending active facilitation to those who draw it. Other watches it getting done and reminds them the details if leave out. Community members also cross-check map such prepared. Hence, although at times, the key informants are those who actually do the mapping, others around them help in such drawing by providing clues and suggestions and even drawing a part of such a map from time to time. The persons who draw the map and other community members present during mapping sessions discuss and explain the map so drawn.

Possible Application Areas

The areas for application of community based mapping are varied and large. It may be used for depicting community habitat, natural resources, forest land, households, trees, water bodies, soil, farms, amenities, hand pumps, schools in the locality, land-use of the locality, spatial areas of people-forest conflict, cooperation, grazing areas, areas for social forestry, common property and wastelands, Areas for collection of fuel wood, and Water. Community based maps are mental maps of individual, group, community and are different from professionals' maps. They reflect relative perceptions of individual, group of the items mapped and hence, are different from professional maps which carry explicit reference to size and scale. Mapping on ground involves active participation of greater number of people than mapping on paper, the latter, however, is convenient to retain. Process of participatory mapping, once started, can continue on its own.

It will be of much use if participatory mapping to also carried by different groups. Participatory mapping may be influenced by

other community group. Maps made by men and women, child, old and young, rich and poor can vary widely depending on their relative perceptions leading to differential analysis of the same theme. Data generated through participatory mapping may vary from individual to individual, group to group and community to community, depending on their knowledge base and experience. Illiterate people can draw maps and explain different items with selected symbols. Sometimes it is difficult to map big localities as a single entity due to insufficient knowledge of key informants.

Sometimes on account of relatively big size of a locality such mapping is not efficiently manageable at a single location or by a single group and such activity may also become time consuming. This can be suitably done by mapping (locality) in parts, mapping of localities by different individuals, maps carried from one part of locality to another for further additions and alterations. Participatory mapping can be presented to community in different sessions and cross-checked on that basis. It can also be checked from household to household for validation of various kinds of data. If many enthusiastic people are available to map, they may be involved in different ways in the mapping process. One way for them is to help these persons who do the mapping. The other way for them is to get involved in their own mapping. Hence small groups can be initiated for mapping on ground or paper rather than many trying to get involved in mapping done by one or two persons. Different maps so generated may be used for mutual cross checking. Those not wishing to map may like to remain as on-lookers, intervening from time to time.

Community Groups

From social considerations community is generally heterogeneous. There may be different groups, sub-groups within the same community. It is important to recognize their identity to the extent possible. Amongst local communities, diversity of perceptions can significantly differ from group to group. There can be different ways of doing it, some of the ways are as detailed below. Key informants can be asked about socio-economic relationships and existing groups in a community. One

can elicit views of key informants regarding different groups/sub-groups in an area and then find out about local group dynamics and cross-check the results from other sources. Similarly other target groups e.g, poorest of the poor or marginalized women group in a community can also be identified by key informants.

Community social mapping is another method which can indicate existence of different socio-economic groups in an area. Based on which further probing can be undertaken to learn about criteria for such grouping. Such mapping can be undertaken to learn about criteria for grouping. Such mapping can be of significant use in identifying different social groups. The lowest strata of poverty or the bottom group included widowed households and single widows who were maintaining livelihoods with practically no assets, no regular source of income and not enough to eat throughout the year. Such group also included agricultural labourers neither having any land, nor any regular source of income or food. The number of dependents may be taken as an indicator for socio-economic grouping.

Wealth ranking is another method which can be used for group-identification. Card-sorting is a method for wealth ranking where a list of households is prepared with each household having a separate number along with the name of head of that household. Each household's name and number is transferred on a separate piece of paper and these papers are ranked by key informants according to their criteria. In the process, a set of criteria for wealth ranking emerges where each household has an allotted rank. Wealth ranking helps in understanding socio-economic disparities amongst households and reveals local criteria for wealth classification. Venn diagramming session on groups and their relationships help in identifying groups. Venn diagram can be used as a tool to show the existence and importance of different groups in a community. It helps in learning about social relationships and groups at local level so as to create space for electing different viewpoints in a local community for further interaction.

Social matrix is yet another method for identifying groups and their characteristics. In a grid-like set-up, different criteria of different groups can be listed by key informants, which

can then be scored. This would provide a rough idea of the existence of different groups. This can then be cross-checked from other members of that community. Diversity of perspectives and existence of groups is a reality in local participation and often participatory processes get jolted by heterogeneous forces within communities. Hence it is important to appreciate local level diversities as reflected through local groups and their dynamics.

The Experience

Community Based mapping is concerned with the community development. It helps in rapport-building within the community. It also helps developers to learn from a community and furthers mutual interaction. It involves local communities, groups and empowers them to map, illustrate and explain their own region. It enhances group participation particularly when maps are drawn in open spaces and common meeting places. It helps in foretelling spatial view of localities and related natural resources. It helps in generating a wide variety of data in a relatively short period of time. It provides an overview and background material, data significant for probing into any relevant theme.

Venn or "CHAPPATI" diagram

Venn diagrams, also known as "chappati" diagrams are visual methods to indicate mutual relationships and role of individuals, institutions, groups in decision-making. Circles of different size representing different individuals, institutions, groups show their importance in decision-making. Such circles can be drawn on ground, paper, or alternatively, circular shaped papers of different size can be used for symbolizing such relationships. The distance of the circles indicate the relationship of individuals/institutions/groups which such circles represent. Over-lapping of circles indicate their over-lapping in decision-making. The length of the lines of different organizations may shows the social distance of individual organizations from them. Whereas, the size of such circles represent "closeness" or importance of such organizations for the village community.

Walk through surveys

Walk through surveys relates to learning about selected areas from local communities

through undertaking joint walks to those areas. Such walking with communities helps in observing different aspects of a selected area in a locality which require greater attention and detailed discussions with community members. For example, a degraded forest area, identified through a map can be jointly surveyed by community members and outside agencies for discussion in terms of causes, nature and action for regenerating such forest area.

The walk may be summarized as per land-use, where for each land-use, the summary table describes soil conditions, trees, crops, animals, birds, kind of soil erosion, water sources, fodder species, problems and opportunities. Joint walk with local communities helps in directly observing and probing on different issues. In such a method an outside team of professionals walk with local community members from one selected point in an area to another selected point and talking while walking. The community members explain and discuss the nature of the issues related to that area, whether of natural and or social resources involved in that area, the problems, priorities and opportunities. Such joint walks involve detailed understanding of issues related to selected areas from local people. A sequence of such joint walks can be organized depending on locations in question.

The Significance

It helps intervening agencies to observe directly and to have a first-hand knowledge about any location/item/situation/condition. It leads to in-depth probing of an area and intricacies of the issues involved. It takes account of micro-environments in a locality which tend to get overlooked in maps. It helps to directly observe, describe and cross-check points for discussion with local community members. It helps in concretising discussions and demonstrates ability of local people with local knowledge to show physical locations/items while describing them verbally or through maps. It also helps in improving communication likes with local communities.

Walk through Surveys may be undertaken to have better physical understanding of an area. The area for joint walk is generally selected in consultation with local community, either on the basis of group discussions, semi-structured interview or on the basis of participatory

mapping. Some areas for joint walk are natural resources mapping, land degradation mapping, land use planning, Environmental mapping.

Experience Gained

An area for joint walk with local people is required to be within manageable limits of walking so that in-depth observation and discussion can take place without such walk becoming tiresome. It can involve joint walking to selected spots and covering areas which constitute focal points for discussion. Joint walks with men and women, young and old, rich and poor tend to give widely differing perceptions and hence, can raise points for differential analysis. Joint walks with different key informants from a local area can help to explore a topic from different angles. Joint walks with different key informants from a local area can help to explore a topic from different angles. Joint walks in people-forest conflicts in an area with different parties to the conflict can enable a mediator to directly observe and discuss different aspects of such conflicts and their spatial basis. A joint overview of the area concerned whether by participatory mapping or otherwise helps in selection of an area/spot for joint walk which leads to better probing of that area under discussion. A joint walk can be repeated if required. For large areas involved, multiple joint walks over a large area can be tiring and time-consuming.

Vector scoring

Vector scoring is a visual method and involved scoring of criteria/items for assessing their relative importance so as to prioritise problems/benefits/dangers/damages/opportunities etc. This method can be used by individuals as well as groups. It involves listing of criteria and scoring of such criteria/item using indigenous materials. The methods help in decision making by prioritising concerned criteria/items.

At the beginning, intervening agency's team to local community, generally take help of semi-structured interviews with groups of local people who generate different criteria/item which they think are important for consideration by groups. The groups subsequently score on such criteria. Such criteria can be either a set of problems, a set of benefits, a set of preferences, a set of activities/items, on which a group

wishes to score according to its priority. Once a tentative list of such criteria is prepared it is re-checked for additional criteria, if any. Such a list of criteria is placed before the group members who are concerned with such scoring. They can make further deletion or addition to the list or criteria according to their views. It is often observed, that, local groups add new points to a list of criteria while not scoring for those criteria which they do not consider to be relevant. Such scoring can differ individually and also in groups. Such a list of criteria also tends to differ with age, gender, caste, class etc. Hence, the method of vector scoring involves considerable flexibility in generating criteria and also flexibility in terms of scoring.

Once probing starts, it is best to arrive at an agreed theme on which community members wish to generate criteria, for example, problems in a locality, problems in people-forest relationship in a locality, benefits flowing from a project etc. Once such a list of criteria is generated, it can be transferred to the ground, in a column or a row, either on small pieces of paper or with the help of different indigenous symbols (as agreed with the group/groups). It is quite important to have agreed symbols for representing criteria especially where group members are illiterate or semi-literate. This would empower them to understand each criterion on their own and think about it before scoring. The individual/groups may use seeds, stones etc. to score on criteria.

Scoring for criteria placed in a column can be explained to group/groups involved by asking them to place highest score on a criterion which they consider to be most significant and then on a criterion which is less significant than the former and then on others according to their intensity. The individual/group either score, or alternatively, rank criteria instead of scoring them. This leads to prioritization of such a list of locally generated criteria.

To start with, scoring of criteria can be done separately by individuals in a group before they rank or score them as a group. This helps individuals in their thought-processes so as to start thinking with regard to the criteria generated. This also helps in "warming up" for group scoring. In such a case, there exists scope for individual scoring to be influenced by each other. However, individuals desiring

to score can be reminded by facilitators of how important it is important to know the age and background of those engaged in the scoring process since that helps in explaining the relative importance of individual scoring. Once scoring takes place, the individuals may be approached to explained the kind of scoring that they undertook.

Individual scoring can be followed by group scoring. The individuals may be requested to perform group-scoring of criteria, either by falling into one group or in different small groups as per their preference. Much depends on how the community wishes to fall into groups. In any case, it is important to encourage group-interactions and discussions before group-scoring takes place. Once such scoring takes place, the group/groups can explain the basis of such scoring.

Scoring by seeds, stones, pebbles or other indigenous material can indicate the relative importance of a criteria. Scoring of criteria can be free or fixed. Infixed scoring, a fixed number of scores say ten scores are used while in free scoring the number of scores are set free without any limit. In free scoring, the relative amount of scoring for each criterion shows its importance. Fixed scoring is fixed in terms of the number of scores used an also shows relative importance of criteria. Free scoring has no limit on scores used for each criterion, and greater scoring indicates relatively greater significance of a criterion under consideration. Much depends on what local people prefer to adopt. In case they find difficulties with fixed scoring, they go in for free scoring. Much depends on their choice and convenience.

Significance of Vector Scoring

The method of vector scoring helps in generating list of criteria whether in terms of problems/prioritizing can be done by both individual and group. It provides a flexible way of scoring where both free and fixed scoring can be used and scores changed, if required. It helps in arriving at group consensus.

Experiences of Vector Scoring

Greater the clarity in discussing issues relevant to local communities, greater is the clarity in listing of criteria and scoring them. It is important to spend adequate time in

conducting discussions with different groups in learning about an issue and in listing of relevant criteria for scoring. Scoring is best achieved when focused on a theme with comparable criteria. Focusing upon a them is important in arriving at meaningful results through scoring.

If scoring is not focused in terms of a comparable set of criteria then it may become difficult for people to prioritise their criteria through scoring. The method is a powerful one and can involve a large number of individuals, within a given space and time. It also simultaneously raises community expectations especially in case of scoring done for prioritizing its problems.

Such expectations are generally to do with the solutions to the problems where community might expect some action to take place as a

result of such an exercise. The method has great scope for involvement of individuals and groups to enable them to score (by visual scoring or cast vote for a problem) and field experience shows that it is better to conduct such scoring/voting in an open setting where many can be involved especially for validation of such results of scoring. Scoring on the ground can be changed an revised by individuals as well as by groups as and when they wish to do so. It is a relatively simple method unlike other methods like matrix scoring (discussed later in this chapter) since it is choosing between one column of criteria which makes matters easy for local community members. It is transparent and offers scope for many to participate and present their views on a selected list of criteria, add/delete criteria from the list and also refrain from scoring on particular criteria

Take Geospatial and Earth Sciences to Schools to put Decentralized planning on Sound a Footing

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Keywords: *Geospatial Science, Earth & Environmental Science, Advanced General Science, Higher Secondary School Education, Conceptual Explication, Bi-lingual Textbook, Science/Non-science Dichotomy vs. Trichotomy with a middle group*

Abstract: Amid loud drum beating about what Geospatial technology can contribute to decentralized planning as also to umpteen other fields of application, there is much talk of training, education and capacity in this technological complex in the higher echelons of education. All these efforts will however fall short of their cherished aims because there are focused merely at the limited target groups, and do not cater to the root segment of technical and generally educated gentry. The present paper therefore proposes to introduce Geospatial and Earth & Environmental education at High or Higher Secondary school level, which will enable the general educated public to support and appreciate decentralized planning process at the district level and further down. It will in fact create a public mindset conducive to spatial thinking and poised to participate in the local planning process.

Rest of the paper presents approaches and strategies of implementing the geospatial education at Higher Secondary School level and grapples with the problems and gropes the prospects thereof. It conceives a bold new subject group with Geospatial Science, Earth & Environmental Science, and Advanced General Science as its principal subjects, principally available to all students passing out high School with good grades, who will be geospatially oriented and may further pursue pertinent subjects for higher studies. It is our basic conviction that only such a radical approach will provide the broad societal base to the otherwise high position of Geospatial technology in the country, and also infuse geospatial thinking among the people at large, so essential for the successful implementation of decentralized planning process.

Introductory – Several components of what is now called Geospatial Science/Technology are already full-fledged fields of study, e.g. Remote Sensing, GIS, GPS, Mobile Mapping, etc. and their umpteen applications. And there are coming up full-scale programs like PG Diplomas or Masters programs in this complex of technologies and its application. As this subject complex is essentially based on science, all these programs are naturally oriented to science streams of students. This deprives a large section of society from an exposure to this upbeat science and undermines its universal applicability and ubiquitous position.

Universal Applicability of Geospatial Methodology Warrants its Access to All – However as science & technology of universal applicability, Geospatial methodology is pervading all spheres of life in its application. And the tools of its application are now

part of everyday and everybody's personal gadgetry. Hand-held smartphone with Internet connectivity, GPS and some mapping or GeoWeb tools is soon going to be the total outfit of personal equipage. Practitioners and professionals from vastly diversified fields need must utilize these modern tools and techniques. However a great number of practitioners and professionals just are cordoned off from any training in these tools and techniques. Moreover, not everybody going in for higher education is likely to be exposed to its training. It is therefore imperative that an exposure to Geospatial education should be made part of the general education to all students at High or Higher Secondary school level; and then avenues should be open for all for higher education in it at graduate or post-graduate level. General educated gentry with this educational background will better

appreciate and participate in decentralized planning as is purported in this XXXII INCA Congress at Jodhpur in 2013 and as stipulated in development planning process.

Other contributions of Geospatial School Education - Besides helping decentralized planning process in the country, the implementation of geospatial education in schools will bring about geospatial thinking at the societal plane, will render very high position of ISRO and other pertinent institutions of the country commensurately broad-based also, predispose the common people to Earth & Environmental management concerns, and in the overall effect will bring the geospatial revolution full-circle in the country with a measure of parity between the ways of offices/institutions and the ways of the people at large.

Problems of Geospatial School Education - School education in India is a rigidly structured system, more so in its higher segments. Already newer branches of learning are clamoring for some space in the High or Higher Secondary school syllabi, which are already jam-packed, particularly in science streams of subjects. Again there is need to train select faculty of schools to sustain this program in the long run. Also, the appropriate data, S/W and H/W may also need to be provided. However, the most resilient problem will arise from the non-geospatial outlook of people and parents who may not readily appreciate or opt for the new move. Even the school setup may feel ill disposed to support the move. This has deep historic roots in our cultural outlook, further accentuated by the colonial British rule. Of course, the pertinent websites show some latest topics, like Geo-Web, as part their syllabi in the some top-notch public schools. My conviction and contention on the point is that these few top-end schools cannot and will not produce the mass impact so indispensably needed.

Geography at Odds in Schools - So far all geospatial or map concepts have been left for Geography to take care of and explicate them at the very introductory level at least; and it would be naturally the parent subject from which the Geospatial Science would branch off. However, and ironically enough, whereas the level and content of geospatial concepts has only advanced in recent years, the position of Geography as an important universal subject

of school teaching has visibly dwindled and declined. At high school Geography is included as a part of Social Studies, which is often taught by a non-Geography teacher who just cannot do justice to the intricate geographical concepts, nor do they requisition proper wall-maps, atlases, globes or other equipage. These students hardly will opt for Geography as a major subject at the Higher Secondary level, nor is the subject frequently available in schools at this level. Perhaps one pragmatic reason for this is that Geography does require a good deal of maps and other equipment for its teaching, whereas other components of Social Studies e.g. History, Economic, Civics hardly require any special equipage for their teaching. Therefore most schools find it more convenient to offer these pure social science subjects and dispense with Geography among the optional subjects. Thus, it is against all such odds that one has to make a head start for bringing in geospatial education in the school system.

Approaches and Modalities - Three approaches are contemplated for incorporating geospatial education in Higher Secondary level.

1. Geospatial Science as an extra subject available for students of any stream.
2. A new stream of science with Geospatial Science as a major optional subject, like Biology or Agricultural Science, to be combined with Chemistry and Physics.
3. Geospatial Science, Earth & Environmental Science, and Advanced General Science (a integration of Chemistry, Physics and necessary level of Mathematics) available and digestible to all streams of subjects - Science, Humanities, Commerce, or any other.

Each approach has its greater or lesser impact and contribution and commensurate problems of implementation. First approach is but a moderate, experimental beginning; but makes Geospatial education accessible to all students. The second approach only introduces a new stream of science students without much problem. Only, the Geospatial stream should look worthwhile and promising enough (which it certainly is), and should have enough avenues for higher pursuits. It serves its purpose well; only it does not address the basic cherished aim of reaching the geospatial exposure to the students of all streams.

A New Stream of Subjects – The third one envisages a bold new and radical approach conceiving a new stream of students moderately or fairly versed in basic Science and Maths and having a good exposure of not only Geospatial Science but also of Earth & Environmental Studies (including earth resource management). These two broad subjects are to be founded on an Advanced General Science base as a generalized integration of Chemistry, Physics and Mathematics. It is our firm conviction that this way it will be accessible and acceptable to all good students passing high school. It is also supposed that proper avenues in these subjects will be available to matriculates passing with this subject group. It has great potential to impact the Geospatial as well as Earth & Environmental management scene of the country. It will potentially effects the geospatial mind set and attitude among the educated public at large, and will help geospatial revolution come full circle in the country. It will thus serve the twin purpose of catering to both, geospatial as well as the earth environmental & resource management concerns.

Specific Challenges of the Proposed New Stream – However the problems and challenges besetting it are quite daunting indeed, as spelled below:

- a. It calls for integrating all geospatial technologies and applications into one organized discipline; and the whole thing brought to the Higher Secondary school level.
- b. Similarly, the Earth, Environmental & Resource management topics are also to be properly integrated as one subject, and simplified appropriately. It covers Earth Science as well as Environmental & Resource Management.
- c. Finally, combining Chemistry, Physics and Maths as one Advanced General Science is again an equally challenging task.
- d. Even after this exercise and preparing faculty to sustain these new syllabi, it still remains a bold, mute question: will these matriculates find proper avenues of higher studies and amicable job eventually; and will this new stream command adequate respect among all concerned.

- e. The Geospatial school education should be broad-based – emphasizing conceptual clarity and explication in general terms, so that it is affordable and intelligible to all students of good caliber.

New Geospatial Stream is Worth the Challenges – It is again our firm conviction and contention that there is immense demand for professionals in geospatial and environmental & resource fields – with jobs of many and varied grades. Rather the geospatial revolution is hampered in India for lack of proper manpower to support it. So far only science & technology people have monopolized the training & education in it and hogged all the burgeoning jobs stemming from geospatial methodology; but they alone cannot meet the great and diversified demand. Again they often do not have proper grounding in social and economic-commercial application areas. Therefore, besides B Tech. and such other technical programmes, there is need for rather more conceptual programmes at graduate and PG levels for students of this new stream, who can man many a teaching, research and application position, which is technically less demanding.

The New Stream to Redress Tardiness of Some Subjects – Moreover, this radically new stream of subjects available to good students at the High school, will redress one more major lacuna of our education system, e.g. improving teaching-learning attitude of the so-called non-science students and teachers, so far marked with utter tardiness, and thus bring these students nearly at par with the patent science streams. The callous, tardy and lack-luster attitude towards teaching of so-called non-science subject, typically found in many a teaching institution, greatly accentuates the initial insipient differences of mental levels of students, and leaves them rather unfit for any serious higher studies or for any worthwhile jobs.

Science/Non-Science Dichotomy Overdone – The dichotomy of students with and without Sc.&Tech. moorings has too much and too rigidly marked our school education system; and this has done serious damage to the education as a whole, and particularly to subjects like Geography, which are rooted both in the natural as well as the social

sciences. Stark difference in the gravity and earnestness of education of science subjects on one hand and of the so-called non-science subjects on the other, as seen in many an educational institution, is utterly baffling and bewildering. This monstrous dichotomy stands overdue to be replaced with a trichotomy – adding a new stream with conceptually sound, moderate science background, and conversant with concepts and applications of geospatial methodology as well as with the Earth environmental & resource management. Earth Science component redresses umpteen Geo-Carto. Glitches in the build up of umpteen resource scientists branching off from basic science stem.

This stream will not only redress the utterly tardy attitude to studies by a large section of students and teachers and bring them in the main stream of vibrant progress, but will also eventually eliminate the unhealthy, eliminative competition between the science and non-science lobbies – because the science people are hogging very many of the jobs that traditionally belonged to the so-called non-science professionals; and that is solely by virtue of the geospatial methodology from which latter people are cordoned off.

Tragedy with Geography – Slotting Geography with Social Science or Humanities has bereft geography of its scientific analysis and insight, and rendered the subject more descriptive. Nevertheless, the subject and its proponents remain much interpretative and have sound conceptual understanding. In the final analysis, Geography – the mother of all sciences of yore – has its core concepts rooted in science, but it has lately has come to have its very huge body or superstructure extensively extended over the realm of social sciences and humanities. And this has rendered Geography rather ambiguous and lop-sided. An essentially and innately spatial subject dealing with most diverse aspects and therefore most widely interfaced with geospatial methodology thus stands divorced from its most inherent ally, e.g. the geospatial science.

The overly technical garb of geospatial training & education, and the internal hitch and diffidence syndrome of geographers have conjoined to keep geographers out as ringside viewers of these newer developments in this

country. This may partly be ameliorated by highlighting the innate advantages of geographers with their early grounding in most of the geospatial concepts, and the stumping success of very many geographers in Europe, America, Australia, China etc.; and by underscoring that application of geospatial tools and technique is often not a highly technical job. The real redress will, however, come through combining Geographic and geospatial education with some moderate level of science education and a touch of humanities as well.

Catering to Earth & Environmental Concerns as well – This idea of a new stream of subjects covers another urgent areas of universal concern, e.g. the Earth & Environmental management concern – issues, strategies, methodology and life styles that make them sustainable on a long-term basis. These topics scattered over other subjects may be clubbed here and ease the jam-pack elsewhere. Needless to say that Geospatial methodology comes most handy and useful in managing earth environment & resources. Moreover, the Earth Science part covers well much of Physical Geography and all the vital Geo-Carto, concepts so essential for Geospatial sciences. It may be underscored here that Earth & Environment includes its resources management also. Actually a demand for incorporating pertinent geographic or geospatial concepts in the syllabi of sciences is occasionally heard, because most of them have to face them squarely in their profession through geospatial methodology i.e. rather early in the build-up of the potential geospatial or resource scientists. Many a practical points like these are to be covered well in the Earth & Environmental segment of this stream.

Roadmap of Geospatial and Earth & Environmental Stream in School Education – As noted earlier, introducing Geospatial Science as an extra subjected available to all is only a minor experimental or exploratory move. It only involves developing a moderate level syllabus, a textbook, a set of experiments, and some extra source material for teachers. Most of these things can be culled out from existing sources at higher levels. Introducing the subject a new science stream like Biology is perhaps simpler still. Only it should be ensured that these matriculates have an amicable position I other science streams. Its impact will be limited

to only science students and will only cater to Geospatial Science.

The radical, new line of a whole new stream of subjects available to all good students throws many daunting challenges, and we focus our tenor at materializing it. It will be rather long-range program, as outlined below:

- a. Apprise and liaison with policy and decisive bodies like NEUPA, NCERT or State Boards, with a draft curriculum and draft textbook, and seek appraisal of the pertinent bodies to run it eventually in select schools with good computer resources.
- b. Generalizing broad and complex sciences like Geospatial, Earth, and Environmental, as well as integrating Chemistry, Physics, and Mathematics as Advanced General Science call for very bold efforts. At least some draft version of text/source books and workbooks must be presented to these bodies and they may give it a final touch.

These books must earnestly integrate components of their subject matter, and be simple yet conceptually sound, and technically less daunting, so that students are not bogged down in formulae and calculations but can deploy the concepts and methods in applications.

- a. Seek funding for some guest resource persons and all along train at least a local teacher in each select school – tapping retired local faculty of pertinent teaching institutions. Local members of bodies like INCA, ISRS, etc. can be of much avail.
- b. Procure other illustrative reference source materials, which are now easily available.
- c. Periodically evaluate the scheme and it's functioning.
- d. Prepare a textbook in Hindi, or in English-Hindi by-lingual mode with face-to-face or close-by presentation – as an auxiliary resource. Such a text is usually structured and organized as a series of rather short topics which are each presented as one- or two-page spreads; each to be followed immediately by its Hindi version or rather Hindi rendering. Figures, diagrams, tables, etc. may be sorted and presented as two-page spreads in between.

Such a textbook should be conceptually explicative and technically less demanding. Hindi version of the by-lingual textbook may be replaced with other major regional languages in respective regions of the country.

- a. Mobilize specific Computer S/W and S/W for schools for EDUSAT facilities and for geospatial exercises.
- b. DECU or UGC may be requested for presentation of somewhat simplified lessons on pertinent sciences on regional channels for schools.

Asset Situation for Implementing the New Stream in School Education –

- a. Computer education and computer lab. is usually available in good schools. Only it may be enhanced with some specific items.
- b. Good quality geodata is readily, and rather inexpensively, available from our own IRS series, and from Survey of India, NATMO, or NSDI
- c. Like Google Earth, ISRO has launched its own free geoportal, e.g. the BHUVAN.
- d. NM Short's 'Landsat Tutorial Workbook' can be adapted for teaching and can be supplemented with Charles Sheffield's illustrated twin books, 'Earth Watch'. Besides several Satellite Atlases of the World, NATMO has published a moderate 'Satellite Image Atlas of India'.
- e. 'Landsat TM Data Applications' and 'Remote Sensing Data Users Sourcebook' from NRSA are good, simple sourcebooks. Similarly 'Working with Maps', and 'Map Education' are good popular books from Survey of India.
- f. Indian Geomorphologist, R. Vaidyanathan, has brought out 'a Set of 60 Topo Maps', and 'A Set of 70 Steropairs' of typical Indian landforms, which are excellent teaching resources.
- g. Commercial GIS S/W's were white elephants to procure and run. Major vendors like ESRI and ROLTA are providing working or demo./simple versions of their major S/W's gratis for schools – sometimes with data sets for exercises – and at very subsidized rates

for other teaching institutes. ILWIS from ITC is now freely downloadable. ESRI of US started a newsletter, 'Arc School Reader' for promoting GIS in schools; its ArcView S/W is fairly suitable for schools and colleges. ROLTA India has entered MOU with the CBSE to train school teachers/students and to provide its Geomedia S/W gratis to all CBSE schools that would exert to get students and the concerned teacher trained in that S/W.

- h. Some geoportals offer advanced feature like DEM, and virtual flu-through over 3-D image.
- i. There are good electronic Atlases, like Encarta's 'Virtual Earth'.
- j. NRDMs of India has developed its own working GIS S/W package, e.g. GRAM++, and P. Vankatachalam has developed a 'GISTUTOR based on it.
- k. NCGIA in US and AGI in UK have had commissions on GIS in Schools since long – D R Green has edited a landmark book 'GIS: A Sourcebook for Schools'.
- l. Excellent electronic atlases like MS Encarta Virtual Earth.
- m. Local teacher at school can help students play with geospatial data from GeoWebsite.
- n. Local teacher at school can help students play with geospatial data from Geo Websites or avail mashups.

Conclusion – Thus we find that radical idea of introducing a whole new stream of subjects with a moderate base of science but available and digestible to all students passing High School with overall good grades can cater to: 1. Poise and orient the senior students to geospatial concepts and method as well to Earth and Environmental issues and concerns; and 2. Also take upon the monster of Science-non-Science dichotomy and turn it into a more conducive and amiable trichotomy. It thus brings both the geospatial revolution full circle and brings it and the earth environment & resource concerns to the entire educated public of the country, which then better appreciates and participates in the decentralized planning, and also supports cherished policies like sustainable development.

Obviously, the proposed idea is fraught with daunting challenges; however, given the urgency of situation and the earnest societal will to do it, there are leads to be explored and headways made. Also, there are ample assets and opportunities for carrying out this radical, bold idea. The old order – of dichotomy – must change, yielding place to the trichotomy fresh and new and in tune with the changing times.

Anticipated Criticism

1. My conservative science chauvinist friends may feel shaky that a diluted/simplified teaching emphasizing conceptual understanding that essentially circumvents analytic part dealing with formulae and derivations, indiscriminately to all will only produce a mushrooming boom of dubious, rather spurious, quality – something like 'jhola-chhap doctors', which will do dis-service to both the sciences and student so taught. They would not budge an inch from their genetic conviction that some people are 'science-wise disabled'; and it is no use pouring science on them as they cannot imbibe it.
2. Many segments of Geospatial Science are involve advanced concepts and notions based on several up-end technologies; as such it would be rather premature to expose the school students to it them, and they may find difficult to grasp them. They may then perforce just mug up things, and will only carry some tit-bits of some concepts and lots of names in their heads, rather than grasp the whole thing properly. It would be better that they continue to grasp the fundamentals of basic sciences, through the school stage, and then take upon the geospatial sciences on their sound foundations of basics sciences, as the current arrangements provide for.

A Firm, Humble Reply – Firstly, even if their genetic conviction partly – yes, only partly – holds good, their stance in the matter is untenable. Mathematical derivations of a subject and its sound understanding are not synonymous things. Conceptual explication, while navigating mostly clear of the mathematical whirlpools by just telling their essence in general terms, is neither spurious nor even a black box approach. There are other scientists of different genre and caliber

to design satellites or sensors, or launch and control satellites, or even to receive and process the satellite signals at the receiving stations. In essence, geospatial application, by itself, is not an extremely technical job. Suffice it usually for them to know the potentials and limitation and other characteristics of their tools and techniques as well as the methods of their application field. They should however explicitly understand the concepts without ambiguity or confusion. Even then, there are various types of educational programs for people with different backgrounds and orientations, and befitting many and varied shades and grades of jobs in this vast and varied world.

Secondly, in India the schism between the Sc. & Tech. subjects and other subjects is too conspicuous, doing great harm to the intellectual health of the country. In the modern usage of high-tech. tools/gazettes in all walks of life by common man, it is imperative that the general education system of the country should enable average educated person to use them efficiently. And that is one of the guiding tenets behind this presentation. Therefore, transforming the dichotomy of Higher Secondary school subject into a trichotomy is itself a major redress of our school education system, which will be a milestone in its march with the modern times. Certain Boards of schools (such as ICSE) actually continue all subjects as compulsory right up to class XII. Other contributions include helping geospatial revolution run full circle at societal plane in the country. Earth environment and resource management constitute the primary, vast field of application of geospatial technology; and the two go harmoniously and hand-in-hand with each other.

In the incessant progress of knowledge, many new things are making headway in the school curriculum. In today's world of Sc. & Tech.-based life-style, people must perforce grapple with concepts and technologies and their application in all walks of life. Today this is best manifest in the little, hand-held thing called smart mobile phone, which is going to be the total personal out-fit for everybody, as its umpteen applications are pervading all walks of life. Therefore, our school education must enable every educated person to deal or handle this little gadget to one's best

advantages. Moreover, living in the geospatial era, every educated person should be enabled to successfully move in this era and surf the surging geospatial waves successfully; or be downed under them. We do not question the value of sound foundation in basic sciences. We do not denigrate or underrate the value of such a foundation for solid breakthrough in fundamental research. Only, it is immensely due and desirable that the science/non-science dichotomy need must be replaced with a trichotomy – admitting a new stream with a moderate base of science but exposed to new, more relevant subjects like geospatial, and earth environmental sciences.

It is our conviction therefore that this science of universal applicability should be part of the general, besides specialized, education. And it is the onus of the pioneers of this move to simplify and generalize the subject – concepts, notions and methods – to the Higher /Secondary school level, and prepare the curriculum, textbook, exercise-workbooks, and other resources accordingly, and preferably in the regional language medium, or in the bilingual arrangement of English and some regional language, for the benefit of most student of India.

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Geo-hydrological Study for Agriculture Development of Dungra Sub-watershed through Geoinformatic Platform, Bankura and Puruliya district, West Bengal

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Keywords: Watershed, Management, Panchayat, Geo-hydrology, Multi-temporal, Socio-economic, Sustainable development, Alternative land use, Nala bund.

Abstract: Watershed is the natural boundary of a particular drainage area. It's appropriate management invites close participation of the Panchayat Raj Institution at local government level. The present study was conducted on Dungra watershed situated in part of Bankura and Puruliya district of West Bengal. The techniques of Geoinformatics have been proved to be efficient in identification of geo-hydrological aspects for watershed management. IRS LISS-III of 2009 and 2011 multi-temporal data was used for land use / land cover change analysis. Besides the important environmental parameters, critically sensitive socio-economic conditions of the said watershed were taken into considerations for an all-round sustainable development. The study synthesizes the interdependent physico-socio-economic parameters and works out a detailed land capability analysis for the various sectors within the watershed to suggest a viable alternative land use plan. This proposition would not have been feasible unless the instant run-off and the resultant seepage get arrested by practicing contour bunds (aals) and constructing nala bunds across minor and major streams to cater local irrigation needs.

Introduction

Agriculture resources considered being one of the most important renewable and dynamic natural resource. The ability of the world's natural resource to provide the needs of its growing population is a fundamental issue for the international community (Rasheed and Venugopal, 2009). Soil resource are very much essential for India, where agriculture is the mainstay one our national economy in coming decades; the world community will face an enormous challenge concerning food security, food supply and sustainability in agricultural development environmental conservation, and preservation. But the population growing process with an increasing Variety of demand being made on land resources have creates enormous pressure on the available resource of the country. Such issues as food security can only be address through the capability to define changes in agriculture production. Local land-use and land-cover change can influence environmental and ecological changes and further more contribute to global change. All of these changes, especially the loss of agricultural

land, have the potential to undermine the long-term harmony of humans and their environment and threaten the food security. Obviously urbanization produces a permanent loss of productive land. A secondary but important question relates to the quality of the lost. Given that agricultural land is affixed quantity and that not all land is equal in its productive capacity, the ability to relate land use changes to the soil on which they occur is an important capability.

The use of sophisticated Information technologies such as Geographic Information Systems (GIS), Remote Sensing (RS) and Global Positioning Systems (GPS) offers many advantages. In this study productivity of soil, Land use / Land cover map, Relief, Drainage Density, Ground water, Slope help to delineate crop suitable zone.

Location of the study area: - The Darakaswar watershed at Tilabonihill in Purulia district, West Bengal, flow easterly through the padimental landscape that enters into the deselected lateritic terrain in Bankura district and further

down stream into the Gangatic alluvial plain debouches in the Rupnarayan River it is the part of chotonagpur plateau. This area consists by four blocks under Bnkura & Purulia district, namely Chatna, Kasipur, Raghunathpur-I and Snturi, The total area is under study 210² km. This sub-watershed geographically located between 23°20'N to 23°30'N and 86°45'E to 86°55'E (Fig:1).

Location Map of Study area

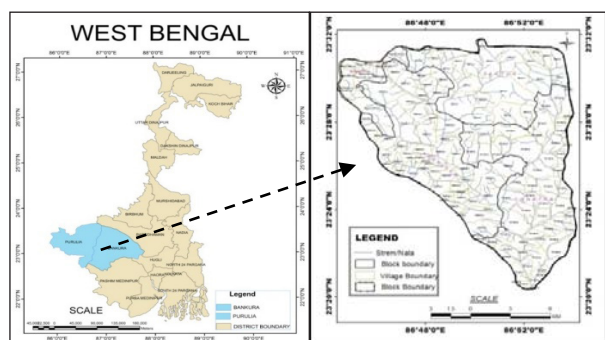


Figure 1.

Physical background

1.1 Relief: - Relief of the study area shows as a plateau region. In the north part of the study area is very high (>200m) and the south part of the relief is low with a gentle gradient form north to south. The gentle gradient form 90 to 250 meter. (Fig. 2) with argental gradient form upper to lower part. Mostly the area covered by scrub land and also some part protected forest.

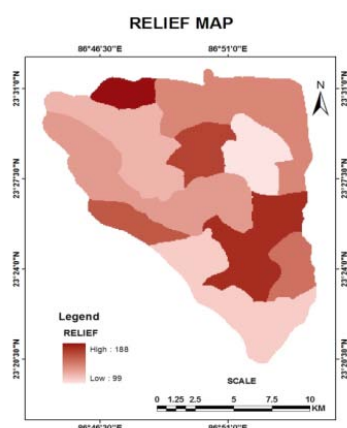


Fig. 2

1.2 Soil: - The soil map of the study area is mainly divisible in two groups-

- Reddish yellow soil,
- Young alluvial soil.

The major part of the basin area is cover with red and yellow soil and the western part of the Dungra watershed is covered with yellow soil. Mostly the soil is infertile of scrub land. The radish yellow soil is not very fertile and due to minor availability of water productivity is less. Maximum season fallow land is shows in respect of land use. The agriculture is restricted practice (Bera and Bandhopadhyay, 2011).

1.3 Slope: - Slope of the study area plays important role for agriculture activities in general and specially crop suitability study for agriculture. The maximum part of the study area slope is moderate. The slope of study area was derived from DEM which was obtained from the SRTM data. The dark black indicates the low elevation and gray to white color represent high elevation. Slope value ranges from 0.00111207 (Low) to 1.28274 based on the SRTM data information.

1.4 Climate: - Climate of study area is tropical dry humidity. The annual rain fall is 1100 mm to 1400 mm/year. The temperature is range from 12°C (in winter) and maximum 46°C (in summer). The variation in the no. of rainy season and soil moisture limitation are common. Severe drought period lasting for week adversely affects the crop growth & yields during main cropping, kharip season.

1.5 Drainage: - Drainage is most important factor of agriculture. In this study area Main River is Dwarkeswar which originate from western up land of Chhotonagpur plateau region & meet Damodar River. The Dwarkeswar River flows from north-west to south-east of

Table 1: Data source

TYPE OF DATA	YEAR OF PUBLISHED	SOURCE
IRS LISS-III	February and September, 2011	NRSC
SRTM DATA	2000 (90mtr Resolution, path/row-54/08).	SRTM Website (Bhuvan)
Top sheet	1972 (First edition)	Survey of India (Kolkata)
Block map & Village map	1981 (Census hand book)	District Statistical Hand book (Kashipur block)
Socio economic data	2013	Census office, field survey.
Soil characteristics	2013	Collect sample by lab test

the study area. The flowing system is seasonal mainly monsoon period. In this flow one of the left bank tributary Dunga, meet Dwarkeswar near Malpara village.

1.6 Geology: - The study area is under Chhotonagpur granitic gneisses complex, which is mainly consist of -

- Granite gneisses (cover most part of the study area).
- Plutonic gabbro and anorthositic rock.
- Pegmatite vein, quartz vein & d) Laterite.

The geology of upper most area granite grano-diorite pegmatite igneous sand stone shale and conglomerate schist is present. The most part of the study area cover by gneiss rock.

1.7 Ground water: - Ground water is most important factor of the rabi crop. The ground water is deferent layer of the study area, like 60 to160 feet. Irrigation is depending on ground water table. District minor irrigation facilities are available in some part of study area. The ground water table is high in lower part (south) moderate in middle part, low is upper part (north) (Fig-3).

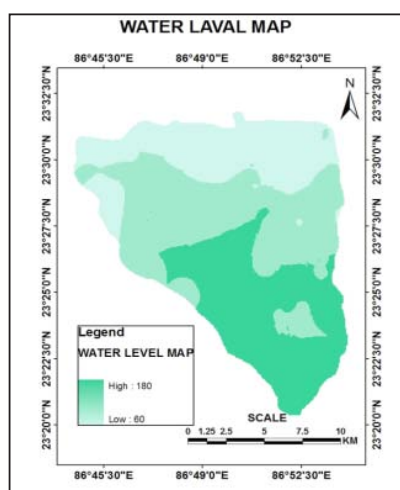


Fig. 3

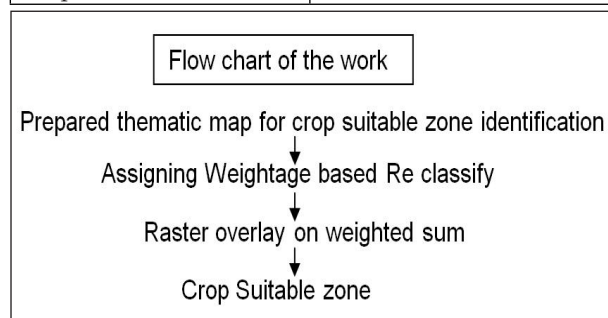
Aims and Objectives

- Present land use land cover Condition.
- Soil properties (Productivity)
- Crop calendar (Kharif & Rabi)
- Alternative land use practices by crop suitable zone.

Data & Methodology

Table 2: Software used

Image Processing Software	ERDAS IMAGING 9.0;
GIS Software	ARC-MAP 9.3
Documentation, calculation and presentation	Microsoft office -2007



Result and Discussion

1). Soil Productivity: - Soil is important factor for land suitability evaluation of agricultural crop. For the study, the soil mapping unit of this area is used for analysis. The physical and chemical properties of soil get from lab test which are collect from field survey and assigning productivity weightage value (Table 3) and then prepared a map of soil (Fig. 4).

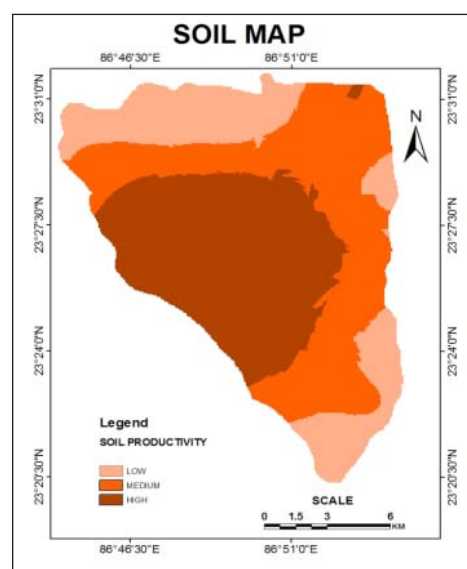


Fig. 4

Table 3: Soil productivity Weightage (37)

Category	Weight -age
High productivity	15
Medium productivity	12
Low productivity	10

2). Land Use / Land Cover:- The land use / land cover of the study area has been obtained by performing supervised classification on the LISS-III satellite imagery based on field observation. Accordingly training points identified to represent the various land use classes were marked using GPS during field visits. These GCP point were used to sample representative signatures for different land use used class. The categories including single crop area, double crop area, deep forest, open forest, water body, plantation, scrub land, settlement. These land use land cover map were reclassified to make it compatible with other parameters use for the analysis (Fig. 5). The weightage of land used/land cover category are given in Table 4.

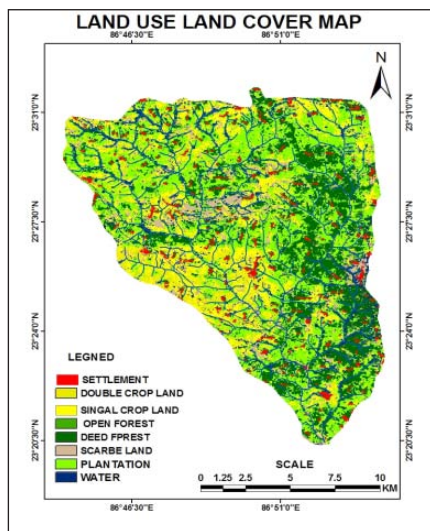


Fig. 5

Table 4: Land use land cover (23)

Land use Class	Class Weight
Double crop	5
Single crop	4
plantation	3
Open forest	2
Dense forest	1
Water body	6
Scarab land	1
Settlement	1

Table 5: Relief weightage (14)

Category	Class weight
High	2
Medium	5
Low	7

3). Relief:- Relief is an important determining factor for land suitability evaluation of agricultural crops. For study, the relief mapping unit of this area is used for reclassify crop suitability zone. The relief category is high, medium, low. The High class weightage are 2, Medium-5, Low class weightage-5 (Fig. 6)

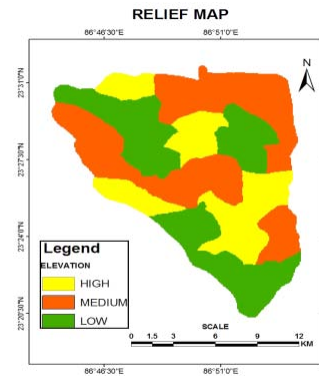


Fig. 6

4) Drainage Density:- Drainage condition is important as it controls the soil-cum-water relationship and the supply of nutrients to plant. The drainage density is high, moderate, and low of the study area. Where drainage densities are high, there are most suitable soil for the agricultural crops (class weights-5), moderate drainage density class weights 3 and low drainage density class 2 (Fig-7).

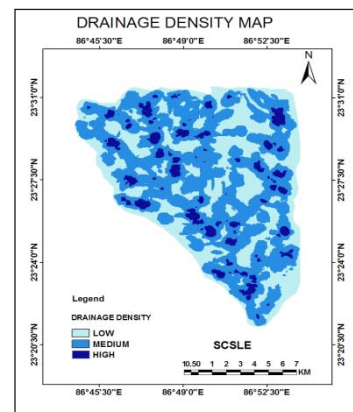


Fig. 7

Table 6: Drainage Density weightage (10)

Category	Class weighted
High	5
Medium	3
Low	2

5). Water Availability:- As it is a plateau region, therefore water availability is so much low. The average lope of the study area is 4-6%

ad at river side some time it 10%. The ground is being recharge directly by infiltration of rainy water. Surface water bodies, river, channels, etc. Since the terrain is rocky in nature, rock fracture and weathered rock act, as place of accumulation of underground water. Due to the existence of high slope, surface run off is much higher than the rate of ground water recharge. Though, the quantum of annual rain fall is considerably high. But it has not been distributed over a period of time. Rather it occurs intensely on a few days during rainy season (Fig. 8).

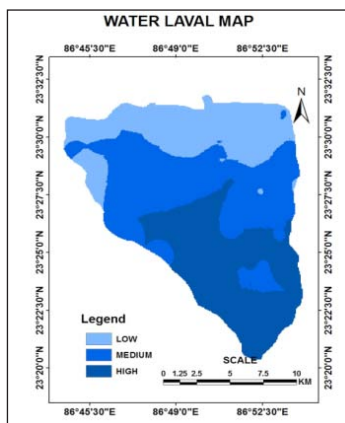


Fig. 8

1. River: Here rivers are non perennial. So water availability is only in rainy season. Other time rivers are dry.
2. Pond: Here pond condition is very poor. Whole year water is not available in all the ponds. Few ponds have water availability on all month. Their location is given in the map.
3. Well: Here well condition is also very poor. All year have water availability. But this water is not used for drinking purpose. Well depth is 30-40 ft.
4. Tube well: Here tube well condition is medium. Tube well is used for drinking purpose. Water availability is round the year. The depth of ground water is 60 ft to 180 ft.

Table 7. Water availability weightage (9)

Category	Class weighted
High	5
Medium	3
Low	1

6). **Slope:** - Slope of a given area plays an important role for agriculture activities. Slope

defines if an area is workable at all or not, its erosion hazard too. Thus the study area of slope is an important factor for the land suitability study for agriculture crops. The slope of study area is 4% - 10% (Fig. 9). Slope of the study area was dived from DEM which was obtained from SRTM data Low slope area is better than the high slope area for agricultural activities. The slope category class weight are low-5 middle-3, high-2.

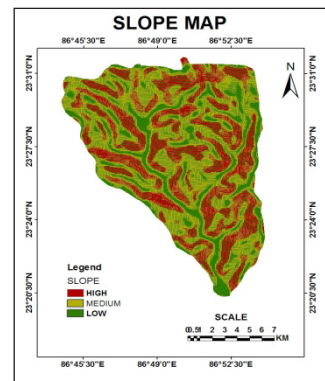


Fig. 9

Table 8: Slope weighted (7)

Category	Class weight
High slope	1
Medium slope	2
Low slope	4

Crop Suitability Zone: - Different parameter of soil properties, land use/land cover, relief, drainage density, and slope are the most important category of crop suitable zone mapping. This category sum weightage overlay creates the suitable cropping zone. This map is representing the six classes of crop suitable

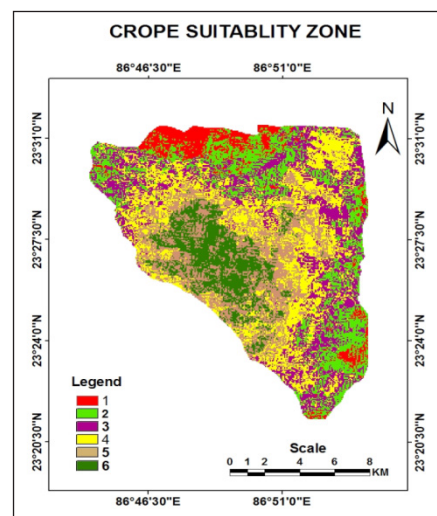


Fig. 10

zone. Among the classes 5 & 6 classes are high suitable zone. 3 and 4 classes are medium; 1 and 2 classes are low suitable zone. Kasipur and middle part of Chatna is high suitability zone. North – western part of the study area (Santuri and Raghunath pur) and south eastern part is under low suitability. All others part is under medium suitability (Fig-10).

Conclusion

The overlay analysis method is applied for specialist's alternative and reliable approach to demarcated suitable area for crop through a GIS context. Weighting factor is used to define important factor, which could be use full for crop suitable zone. Study area Kasipur and middle part of Chatna is high suitability zone. North – western part of the study area (Santuri and Raghunath pur) and south eastern part is under low suitability. All others part is under medium suitability. But this medium suitable zone could not cultivation due to lack of irrigation water. For development of agriculture, necessary to increase water availability/ develop irrigation system at list

side select for reservoir or nala bund for live saving agriculture purpose. This approach can be further enriched by incorporating other socio-economic and environmental variable to obtain the optimum result.

Acknowledgement: A numbers of people have assisted us, directly or indirectly, in the preparation of research. Namely Dr. Parthasarathi Chakrabarti (Former Chief Scientist-DST Kolkata Govt. of West Bengal) and also thankful Ms. Soma Das (Research Student, Dept. of RS&GIS, V.U).

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Radar Vegetation Index as an Alternative to NDVI for Monitoring of Soyabean and Cotton

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Keywords: Radar Vegetation Index, Vegetation monitoring, RISAT

Abstract: The study explores the possibility of Radar Vegetation Index (RVI) for vegetation monitoring in Cotton and Soya bean fields as an alternative to monitoring with Normalized Difference Vegetation Index (NDVI). The RVI is the measure randomness of scattering has been proposed as a method for monitoring the level of vegetation growth, particularly when time series of data are available. The SAR can penetrate the clouds thus it has the potential to monitor the crop growth in all the seasons. This point is very important in the context of Indian subcontinent since monsoon clouds hampering the monitoring of crops in such season. The present study carried out in Vidharba region of Maharashtra, India using four Radarsat-2 data sets acquired in the monsoon season of 2011 (ie: 13th July 2011, 06th August 2011, 30 August 2011, 23rd September 2011). The derived RVI was compared with the MODIS NDVI product of same date. The research shows some significant improvements in the RVI technique than NDVI in some context. The RVI is linearly increasing as crop grows unlike the NDVI becomes saturated after level of growth in the crop. The Cultivation started in the first week of July 2011, the NDVI becomes saturated mostly in second week of August, 2011 however RVI shows further increase in 30th August 2011 with the growth in the vegetation. These particular findings attributed to the fact that maximum randomness of scattering in microwave signal occurs where plant spread fully whereas peak greenness (NDVI) occurs before that. The present study found that RVI can be utilised in place of NDVI for vegetation monitoring thus monitoring of crops is possible even in the monsoon season of India. This method can be better used with RISAT descending mode since its acquiring image on optimum incident angle of around 360 look angle thus it is highly suitable for vegetation monitoring. The Radar Vegetation Index can also have the prospect of using in soil moisture models in vegetated fields where NDVI is a critical one (Kim and J. Van Zyl, 2009). The result of this study can be effectively used for monitoring soyabean and cotton and also can be used as a vegetation mask for soil moisture monitoring. The further study is required to derive biophysical parameters from RVI and application of RVI in soil moisture estimation in vegetated fields..

1. Introduction

There are several vegetation indices available to monitor Vegetation growth such as Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1973), Leaf Area Index (LAI). There are few studies so far reported in Radar Vegetation Index (RVI).

The RVI has been proposed as a method for monitoring the level of vegetation growth, particularly when time series of data are available. (Yihyun Kim et al., 2012). RVI generally ranges between 0 and 1 and is a measure of the randomness of the scattering and it is sensitive to the biomass, Vegetation water

content also low sensitivity to environmental condition effects. RVI is near zero for a smooth bare surface and increases as crop grows (up to a point in the growth cycle). (Y. J. Kim et al., 2012, Kim and J. Van Zyl., 2009).

The RVI can be related to biomass, Kim and Van Zyl (2009) predicted that $RVI > 0.35$ corresponds biomass of above 2.5kg/m³ for a corn field. The RVI can be correlated well with the VMC, LAI, and NDVI. The RVI is increasing with the increase of crop growth and decreased with the reduction of Vegetation water content (VMC). It is also promising to have low sensitive to environmental effects. (Y.J. Kim et al., 2009).

The RVI is useful technique for soil moisture estimation in the vegetated area since many models require vegetation bio physical parameters such as Leaf Area Index (LAI), NDVI, and Vegetation Moisture Content (VMC) for accounting the vegetation in the model development. Deriving NDVI, LAI, and VMC with optimum spatial resolution is a difficult task with the limitation of optical sensors towards the clouds.

1.1 Theoretical background for Radar vegetation index

The RVI is the measure randomness of scattering and can be written as (Kim and van Zyl 2004, 2009)

$$RVI = \frac{8\sigma_{HV}}{\sigma_{HH} + \sigma_{VV} + 2\sigma_{HV}} \quad (1)$$

Where σ_{HH} and σ_{VV} are like polarized backscattering coefficients and σ_{HV} is cross polarization coefficients in power units. RVI generally ranges from the 0 to 1 mostly just like NDVI may exceed 1 in some cases when double bounce scattering encountered. The RVI is near zero for a smooth bare surface and it is increases as crop grows (up to a point in the growth cycle). (Y. J. Kim *et al.*, 2012, Kim and J. Van Zyl., 2009).

Charbonneau et al. (2005) assumed that $\sigma_{HH} \approx \sigma_{VV}$ thus equation was reduced to the form of

$$RVI_{HH} = \frac{4\sigma_{HV}^{\circ}}{\sigma_{HH}^{\circ} + \sigma_{HV}^{\circ}} \quad (2)$$

The assumption is valid when the interaction between the soil and vegetation is negligible. (Melanie Trudel et al., 2012).

The RVI extensively studied by the Melanie Trudel et.al. 2012 and the study concluded that RVI HH is a good approximation of the surface scattering when only two polarizations are available

2. Study area and data used

2.1 Study area

The study area is located in of Vidarbha region of Maharastra, India centred at 21°07'N/78°55'E (Fig. 1). The majority of the

area comes under raidfed with major crops of cotton, soya beans, oranges and gram. The climate of Nagpur usually dry, temperature ranges from 480 C in summer and 70 C in winter. The annual rainfall is around 1100mm with south east monsoon (June to September) contribution almost 80% to this region. The topography is ranging from 280m to 340m. The fields were in ploughed in the month of July, 2011 and soil moisture condition was less. Most of the study area spread with clay soil mostly. The cultivation used start in the month June end in September. The cultivation of second crop is common in the study area wherever the ground water is available.

2.2 Data used

2.2.1 Satellite data

There are number of satellites currently operating from the space with the C-band configuration (RISAT-1, RADARSAT-1and RADARSAT-2). In this study four RADARSAT-2 data sets were acquired in the HH and HV polarizations with standard1 beam mode (Incidence angle ranges from the 20°-27.2°) with Standard Georeferenced Fine format (SGF). The period of acquisition of the data ranges from July 2011 to September 2011 keeping in the view of Kharif cultivation season (south west monsoon) of India. The spatial resolution of the RADARSAT image used in this study is 12.5m meter with 100 km swath. The detailed of the data acquired is given in table1.

Table.1. Radarsat-2 Satellite image acquisition time and data description

Date	Pass Time	Incidence angle	Polarization
13July 2011	Ascending 6.00 am	20-27.2	HH, HV
06Aug2011	Ascending 6.00 am	20-27.2	HH, HV
30Aug 2011	Ascending 6.00 am	20-27.2	HH, HV
23Sep 2011	Ascending 6.00 am	20-27.2	HH, HV

The MODIS data were downloaded from the <http://earthexplorer.usgs.gov/> site pertaining to study area for the four dates of SAR data (Table. 2). Global MOD13A1 MYD13A1 data are provided every 16 days at 500-meter spatial resolution as a gridded level-3 product in the Sinusoidal projection. The data were

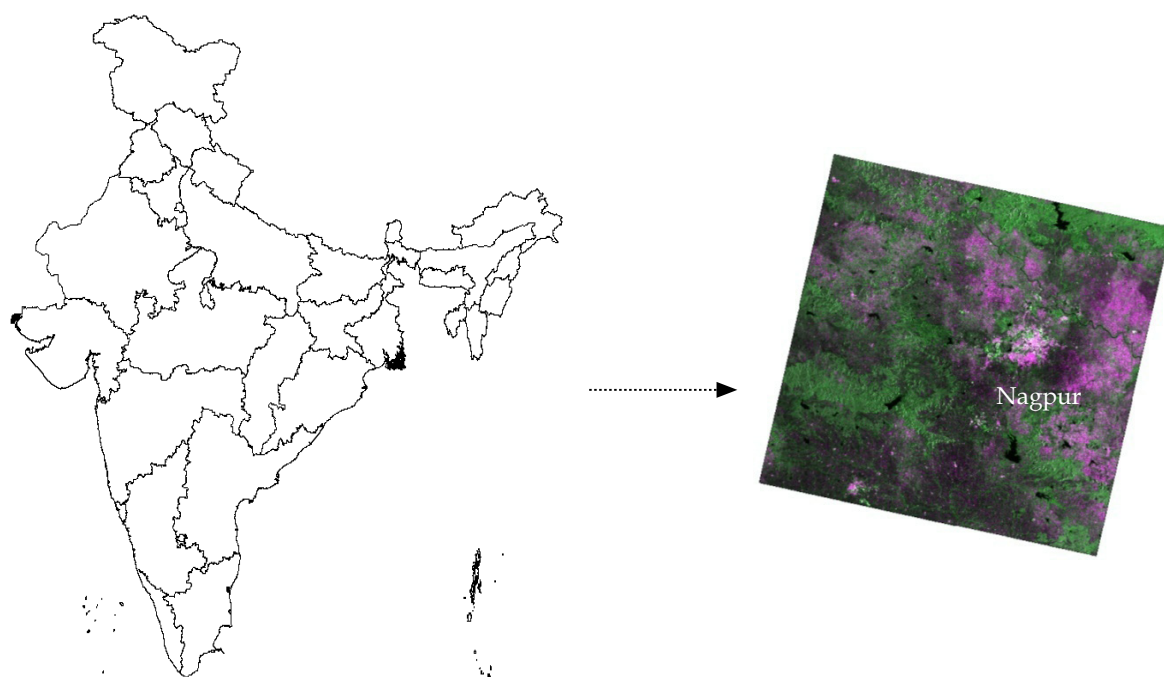


Fig. 1. Study area located at Nagpur, India centred at 21°07'N/78°55'E, Radarsat-2 image with RGB combinations (HH, HV, HH) of 13th July, 2011.

downloaded and converted to same projection of SAR data (i.e. UTM WGS 84). The resolution of data was 500m which is much poorer resolution compare to the SAR data used in this study. However due to monsoon season we were unable to get finer resolution data from other satellite like Resourcesat.

Table.2. MODIS Satellite image acquisition time and data description

Date	Satellite	Product name	Resolution meters
13July 2011	MODIS-Terra	MOD13a1	500
06Aug2011	MODIS-Aqua	MYD13a1	500
30Aug 2011	MODIS-Terra	MOD13a1	500
23Sep 2011	MODIS-Aqua	MYD13a1	500

3. Data Processing

3.1 Radarsat-2 data processing

Four Radarsat-2 was acquired with the configuration as given table-1. Initially data were in the format of Standard Georeferenced Fine (SGF) hence data is already georeferenced but not geocorrected. Geocorrection was done using elevation source of Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM). The backscattering coefficient (σ_{HH} , σ_{HV}) were obtained by radiometric calibration.

3.2 RVI and NDVI calculation

The Radar Vegetation was calculated using the equation (2)

$$RVI_{HH} = \frac{4\sigma_{HV}^{\circ}}{\sigma_{HH}^{\circ} + \sigma_{HV}^{\circ}} \quad (2)$$

The output of RVI for all four season is shown in figure 4. The NDVI was calculated from MODIS using the formula given in https://lpdaac.usgs.gov/products/modis_products_table/mod13q1.

3.3 Extraction Ground Truth points from satellite data

The ground truth which was used in this study was collected under RISAT-UP soil moisture project. Out of all GT points we were restricted to use only 16 due to the courser resolution of MODIS data. GT points were chosen such a way that filed is almost unique for more than 500 meters. However this is a hectic process since we can't assure this 500 meter area will lie on exactly in one pixel of MODIS data. Thus it may introduce some error in the subsequent process. The NDVI value was extracted from MODIS based on ground GPS value. Similarly RVI is also extracted based on AOI which were drawn based on the shape of the field.

4. Results and Discussion

The Figure 2 shows the RVI variation in the monsoon season of 2011. The average radar vegetation index of the all study points stood with lower value of 0.15 in first week of July, 2011 it was increased linearly 0.29, 0.56 in last week of August. Then the RVI is decreased to 0.47 in the last week of September. This trend is attributed to the fact of growth in the crop increases the randomness of scattering i.e. volumetric scattering, thus RVI increased with the growth of the plant. Then it is decreased with to some extent as crop growth decreases.

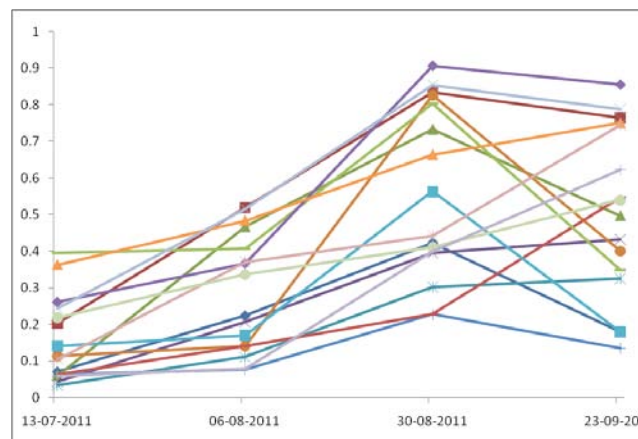


Fig. 2. The RVI derived from SAR plotted against the date of pass of satellite from July, 2011 to Sep, 2011

However trend of the graph is not common between the points since graph was not plotted against the life cycle of vegetation rather it was against the date of satellite pass. Since plantation date for each is varying so the RVI too.

Fig. 2 was plotted NDVI derived from the MODIS data with nearby dates. The NDVI was increased from the mean value of 0.35 to 0.62 between 13, July, 2011 and 06th Aug, 2011. Then the NDVI stood almost same value in remaining period since NDVI is a measure of greenness whereas RVI is a measure of volumetric scattering thus plant obtaining the maximum greenness before its becomes matured volumetrically (S. Dinesh Kumar *et al.*, 2013). This particular finding made RVI is highly suitable than NDVI and it can be used for the monitoring of crop throughout the crop cycle.

The derived RVI output is shown in Fig. 3. The figure represents the same as RVI graph (Fig. 2). The RVI was linearly increased from the low level in initial stage of crop 13th July, 2011 (Fig. 4a) to the high level in matured crop (Fig. 4b, 4c & 4d) in September.

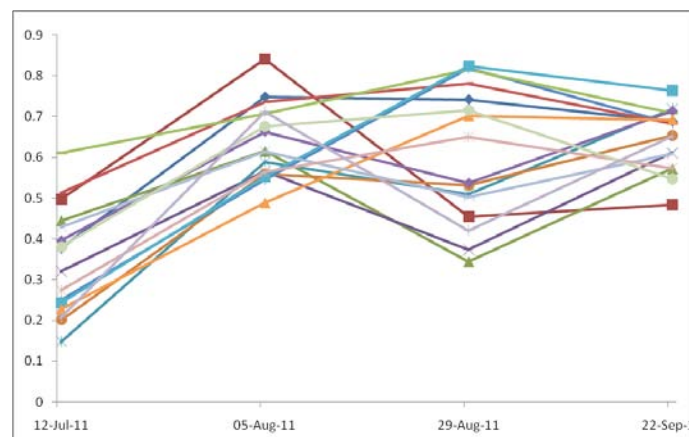
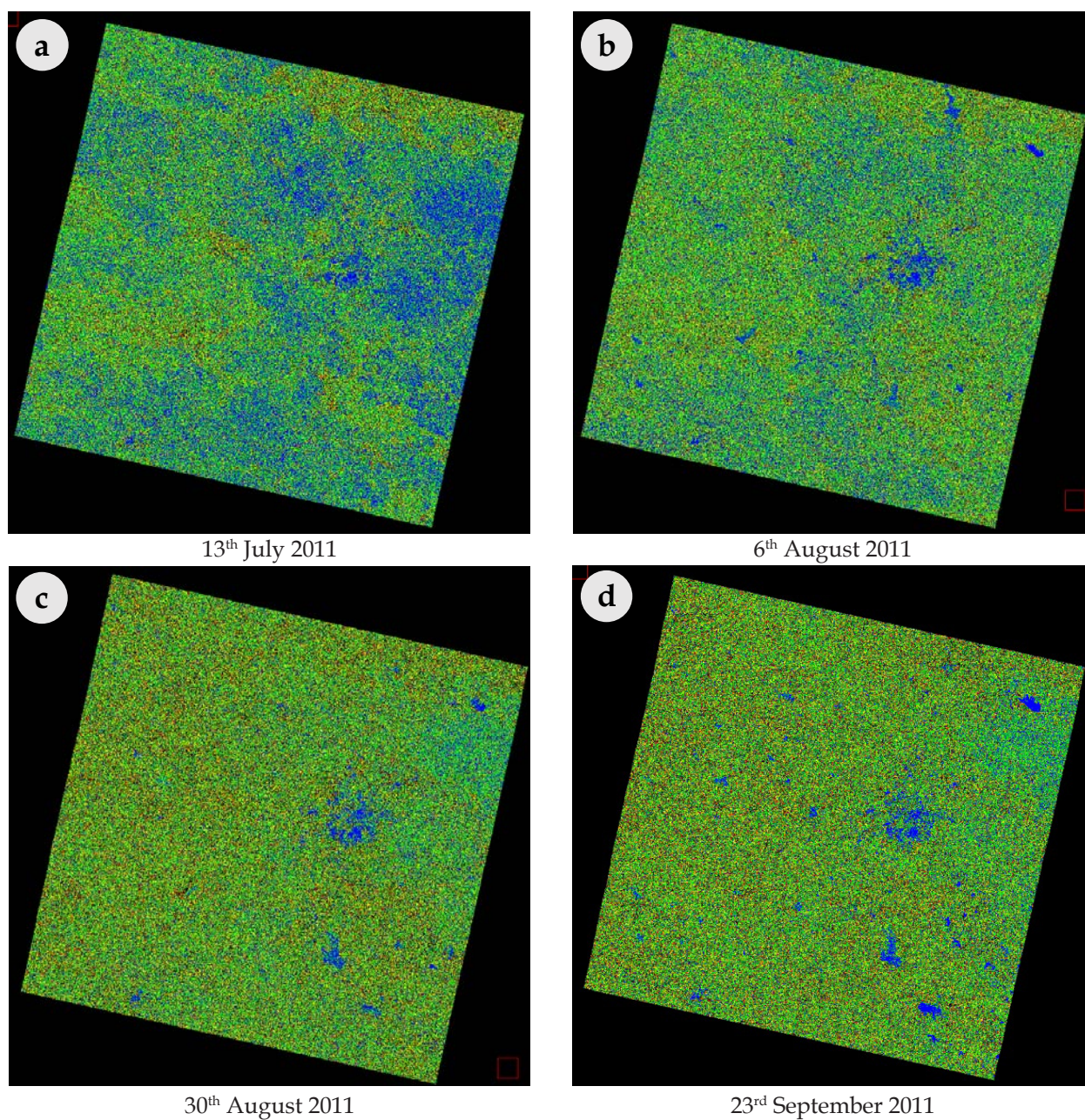


Fig. 3. The NDVI derived from MODIS plotted against the date of pass of satellite from July, 2011 to Sep, 2011.



Colour	RVI Value
	0-0.2
	0.2-0.4
	0.4-0.6
	0.6-0.8
	0.8-1.0
	Out of range

Fig. 4. Radar Vegetation Index derived from Radarsat-2 for the monsoon season of 2011 with classified into five classes.

5. Conclusions and Further work

The study concludes the following

1. The RVI can be used for monitoring of crop in place of NDVI throughout the season since RVI which is not going saturates as NDVI.
2. However the RVI can't replace NDVI simply since it can't represent greenness as NDVI.
3. The retrieval of bio physical parameters from RVI needs to be established.

The result of this study can be effectively used for monitoring soyabean and cotton. The study recommends use of RVI with RISAT descending mode for monitoring crops due to capability of image acquisition at 360 with revisiting period of 21 days.

The RVI can also used as a vegetation mask for soil moisture monitoring to know where the soil moisture model fails due to vegetation. The further study is required to derive biophysical parameters from RVI and application of RVI in soil moisture estimation in vegetated fields.

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Implications of Rain-water harvesting for Gurgaon

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Keywords: Radar Vegetation Index, Vegetation monitoring, RISAT

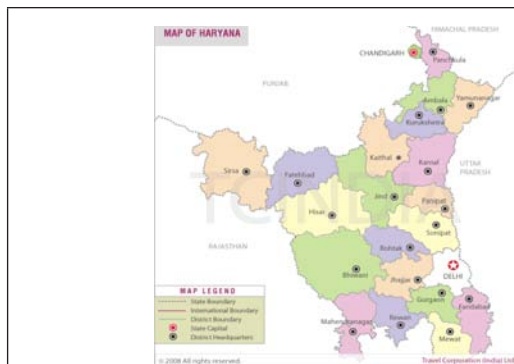
Abstract: Water is the prerequisite for the socio-economic prosperity of any society or country at large. Availability of good quality water in adequate quantities for drinking, domestic and industrial purposes is essential for good health, social security and economic progress. The objective of this research paper is to study the current requirement and supply of water in Gurgaon district of Haryana in general and the city in particular. This paper attempts to analyse and propose measures to counter the future water crisis that is looming large on the city. This city has seen an unprecedented growth in population due to migration of people from nearby states in search of employment. The future prospects of growth and development of any city lies in its ability to provide world class civic amenities to its residents.

Statement of the Problem: The total volume of the water is about 1.4 Billion Km³. The population of Gurgaon has rapidly escalated during the last two and a half decades. During the last decade the population has increase from 8 lacs to more than 15 lacs. Gurgaon has witnessed a decadal growth rate of 73.93 per cent during the period of 2001- 2011. The ground water is under stress and the level is declining drastically. Overdraft of ground

water has resulted in critically low level of water table. Global warming, climate change and changing rainfall patterns will further aggravate the problem of regular supply of groundwater.

Methodology and Data -Base

The methodology applied for the present paper is simple mathematical techniques.



Study Area:

Gurgaon is the second largest city of Haryana. It is located 30 km southwest of Delhi. Its latitudinal extent is 28°28' North and longitudinal extent is 77°2' East. It shares boundaries with the districts of Jhajjar, Rewari, Mewat and Faridabad. Gurgaon district comprises of five Blocks namely Pataudi, Farrukhnagar, Sohna, Gurgaon and Badshahpur.

Soils: The alluvium in the area comprises silt, sand, gravel, clay and kankar. It has been divided into older alluvium and newer alluvium. The old alluvium occurs in the most part of the district. It comprises of generally poorly sorted silt, sand, gravel and clay. The silt constitutes fine wind blown variety along with kankar. The soil are compact, hard and composed essentially of calcium carbonate and are very common in northern parts of the area between Farukhnagar and Garhi Harsru. Ground water in the older alluvium occurs in the interstices of constituent grains of sand and silt. The presence of kankar in the formation reduces the pore spaces, which in turn reduces the capacity to store and transmit water thus making them poor water bearing formations

These mathematical techniques were used for calculating percentage, arithmetic mean, ratio-proportion and projection of population

The present study entails the use of secondary data. The data of population of Gurgaon has been taken from the Census of India; 2011, Haryana, paper 2. Ground water statistics have been used from the reports of Central Ground Water Board.

Objectives

- To study the current requirement of water in Gurgaon district.
- To analyse and propose measures to counter the future water crisis that is looming large on the city.

Result and discussion 1

Presently, Haryana Urban Development Authority is supplying 47 million gallon day water to 165 villages, 57 sectors and 30 villages of Gurgaon district. The current water requirement for drinking, irrigation etc. is being fulfilled by a mix of groundwater and canal water. More than 96% of water demand is supplied through groundwater. According to Central ground water board, annual replenishment of groundwater is 20215.12 Ham which is far less than net annual groundwater draft which amounts to 43642.75 Ham. Utilisation of groundwater is 209%. This suggests that there is large overdraft of water. Situation is grim and the only ray of hope is rain water harvesting.

Moreover the city has seen an unprecedented growth of population during the last 2 - 3 decades. Decadal growth rate of Gurgaon during the period of 2001- 2011 was as high as 73.93 %. If this continues, and it is likely to happen as the number of people migrating into Gurgaon in search of employment is not going to decline in the near future. In 2011 AD, population of Gurgaon was 15,14,085 and in the next ten years it is projected to cross the 25 lakh mark. 70% increase in population means 70% increase in demand of water for domestic purposes. According to an estimate, each person needs 20-50 litres of water per day to meet his basic needs of cooking and cleaning. If it is assumed that on an average 35 litres of water will be consumed then an additional supply of 350 lakh litres or approximately

10million gallons per day will be required. This burgeoning population is putting additional pressure on the already scarce water supply.

Water table is declining very fast. And recently environmental groups estimated the decline to be around 2m per year. All the five blocks of Gurgaon are overexploited. The whole district falls under the red category of CGWB. The only viable cost effective solution seems to be rain water harvesting. The major part of Gurgaon district is underlain by quaternary alluvium consisting of sand, clay and silt. The alluvium comprises of thick beds of fine to coarse-grained sand with alternating layers of thin clays. Whole of the district is suitable for artificial recharge to ground water.

Result and discussion 2

Badarpur flyover is a perfect display of how large public infrastructure projects can conserve rain water. Badarpur flyover is 4.4 kilometre long, six lane alleviated broad highway connecting Delhi and Faridabad. National Highway Authority of India used integrated storm water management and recycling of water in this project. It is Hindustan Construction Company's first site to adopt the United Nation's Water Mandate initiative, which included water conservation measures and establishing a system to record water usage at the site. Rainwater harvesting system was clubbed with water re-use and recycle methodologies including recharging the groundwater table using the storm water flowing from the elevated highway. In 14 months during construction, as much as 23,149 kilolitre of water has been saved. Recycling of water was done using the water extracted while de-watering and re-used for various purposes, thus saving up to 6500 KL water. In this project 80 KL of water was saved through two rainwater harvesting pits. Similarly such projects can be undertaken in Gurgaon as well. With his diligent effort, Dr. Rajendra Singh, who is rightfully called waterman of India and his society called Tarun Bharat Sangha have revived Arvari river of Alwar and its five tributaries.

Rajendra Singh has helped villagers take charge of water management in their semi-arid area as it lies close to Thar Desert, through the use of johad, rainwater storage tanks, check dams and other time-tested as well as path-

breaking techniques. Starting from a single village in 1985, over the years TBS helped build over 8,600 johads and other water conservation structures to collect rainwater for the dry seasons, has brought water back to over 1,000 villages and revived five rivers in Rajasthan, Arvari, Ruparel, Sarsa, Bhagani and Jahajwali.

Alwar district previously had a flourishing grain market, but by the year 1985, it had become largely dry and barren, because of deforestation and mining for years in the surrounding areas. It had led to a dwindling water table, minimal rainfall followed by floods. Another reason was the slow abandoning of traditional water conservation techniques. Instead villagers started relying on modern day, which simply sucked the groundwater up. Consistent use of water from these bore wells lead to falling of underground water table, till they went dry in ecologically fragile Aravalis. This critical situation led Rajendra Singh to work on johad, earthen check dams, which have been traditionally used to store rainwater and recharge groundwater, a technique which had been abandoned in previous decades. As a result, the area had no ground water since previous five years and was officially declared a "dark zone". Though Rajendra wanted to learn the traditional techniques from local farmers about water conservation, his other city friends were reluctant to work manually and parted ways. Eventually with the help of a few local youths he started desilting the Gopalpura johad, lying neglected after years of disuse. When the monsoon arrived that year, the johad filled up and soon wells which had been dry for years had water. Villagers pitched in and in the next three years, it made it 15 feet deep. These facilitated a rise in the

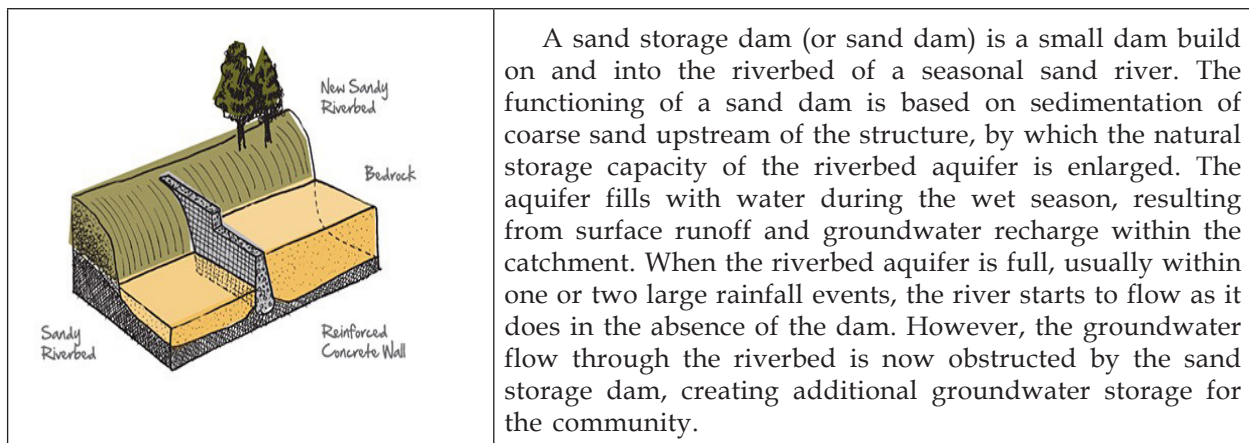
groundwater levels and helped turn the area into a «white zone».

He started on his first padayatra through the villages of the area in 1986, educating to rebuild the old check dams. In 1986, people of Bhanota-Kolyala village through shramdaan (voluntary labour) and with the help of TBS volunteers, constructed a johad at the source of a dried Arvari River, following this villages that lay in its catchment area, and along it also built tiny earthen dams, eventually when the number of dams reached 375, the river started to flow again in 1990, after remaining dry for over 60 years. Gradually TBS built 115 earthen and concrete structures within the sanctuary and 600 other structures in the buffer and peripheral zones. The efforts soon paid off, by 1995 Aravri became a perennial river. Abandoned villages in the areas got populated and farming activities could be resumed once again, in hundreds of drought-prone villages in neighbouring districts of Jaipur, Dausa, Sawai Madhopur, Bharatpur and Karauli, where work of TBS gradually spread.

Results and discussion 3

Kenya is an African semi arid country facing the problem of acute water crisis all the year round. Sand dams are cost effective technology to conserve rain water and satisfy the thirst of dry land. Sand dams become a key tool for combating hunger and poverty in drylands worldwide.

A sand dam is a reinforced stone masonry wall (or a similarly robust and impermeable weir) built across a seasonal riverbed and is one of the world's lowest-cost rainwater harvesting solutions. They are a simple, low



cost and low maintenance technology that provide an improved, year-round, local water supply for domestic and farming use and are widely suited to the world's drylands.

During the dry season, water levels will drop due to abstraction of water, minor evaporation and possibly by leakage through the dam or vertical leakage into the bedrock. Meanwhile, subsurface flow (base flow) from the riverbanks towards the riverbed and through the riverbed itself will slowly and partly refill the riverbed aquifer. Because of the larger storage volume and the slower depletion, the river provides water throughout the dry season (when built under appropriate conditions), whereas otherwise the riverbed would have dried up long before the beginning of the new rains.

A typical Kenyan sand dam is 2-3 metres high from the bedrock to the spillway and spans a 10-30 metres wide river channel. Such dams store in the region of 2-10 million litres of water held in the pores between the sand grains. However this varies considerably.

Sand dams are not check dams. Sand dams do not have an open water surface and consequently do not suffer the drawbacks of shallow, open water dams in the tropics, such as high evaporation losses, sedimentation and water-vector disease. Sand dams are also known as sand storage dams or groundwater dams due to them capturing additional water storage within sand. Sand dams may or may not have a sub-surface section, depending on whether the bedrock is at the surface or needs excavation to be reached. Where a sand dam does not rise above the level of the existing river bed, it may be known as a subsurface dam. However, it is important to note that sub-surface dams can also refer to range of impermeable barriers that are built without cement or concrete and/or sited in rivers with non-sandy sediments.

Sand dams fill with sand and mature more quickly where seasonal rivers have the greatest sediment load. Drylands rivers have the greatest sediment loads, as well as having the greatest water need. Hence sand dams work best where the need is greatest. Sand dams significantly increase productivity resulting in reduced importation of food products and increased exports from the local economy. The

construction of sand dams provides direct and indirect local employment.

Conclusion and Recommendations

According to these reports groundwater potential is being overexploited. Utilization of groundwater is 209%. This suggests that there is large overdraft of water. Projected demand for domestic and industrial uses by CGWB upto the year 2025 is 21386 Ham. The population of Gurgaon has increased from over 8 lakhs to more than 15 lakhs in the last decade.

The stage of ground water development for the district is 209% that means the net annual withdrawal is more than the net annual recharge. During the last 20 years the ground water level has declined in whole of the area of the district and the decline is in the range of 0.77 to 1.2 m/yr. So there is a need to take measures to arrest the decline of ground water level and artificial recharge to ground water is one of such measures. Whole of the district is suitable for artificial recharge to ground water. Excess rain water in agricultural field, surplus canal water and rooftop rain water can be injected to ground water system. Recharging shafts and injection wells are recharging structures suitable for the district.

In order to arrest the declining trend of water levels in the district, the rooftop rainwater harvesting technology should be adopted and recharge structures may also be constructed in depression areas where water gets accumulated during rainy season. This will help in enhancing the recharge to ground water reservoir.

The construction of roof top rainwater harvesting structures should be made mandatory in building bye-laws in all the blocks, which will help in checking the falling water level trend in the district. The abandoned dug wells may be cleaned and should be used for recharging the ground water by utilising the surface monsoon runoff.

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Watershed Management (A Case Study of Upper Mashi River Basin, Rajasthan)

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Keywords: Watershed, Contour, embankment, check dams, Gully, topographical sheets

Introduction

Water is one of our most precious resources and this renewable resource subjected to abuse and misuse. Practically every development challenge of the 21st century – food security, managing rapid urbanization, energy security, environmental protection, adapting to climate change – requires urgent attention to water resources management and one of the best technique of water resources management is watershed management. Watershed management is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary. The study area is located in the eastern part of the Aravalli range and at the heart of Rajasthan encompassing parts of the Jaipur, Ajmer, and Tonk districts of Rajasthan state. The study area lies between latitudes 26°7' N to 27°15' N and longitude 74°49' E to 75°57' E and spread over 20 topographical sheets of the survey of India on the scale of 1:50,000.

In the regional perspective water is crucial resource for development effort in Upper Mashi River Basin, besides being a natural resource forming the basis of human subsistence. The present paper is a humble attempt of watershed management through different methods like as-

- Contour bunding, Terracing
- Construction of earthen embankment
- Gabian structures
- Construction of check dams
- Construction of farm ponds
- Construction of diversion

- Gully controlling structure
- Rock dam
- Establishment of permanent grass and vegetation and
- Providing vegetative and stone barriers with the main objectives to increase infiltration of rainwater to improve and increase the production of timbers, fodder and wild life resource, and to enhance the ground water recharge, wherever applicable.

Study Area

The study area is located in the eastern part of the Aravalli range and at the heart of Rajasthan encompassing parts of the Jaipur, Ajmer, and Tonk districts of Rajasthan state. The study area lies between latitudes 26° 7' N to 27° 15' N and longitude 74° 49' E to 75°57' E (Fig. 1) and spread over 45 M/12, 45 M/16, 45 J/13, 45 N/1, 45 N/9, 45 J/14, 45 N/2, 45 N/2, 45 N/6, 45 N/10, 45 N/14, 45 J/15, 45 N/3, 45 N/7, 45 N/11, 45 N/15, 45 N/4, 45 N/8, 45 N/12, 45 N/16 topographical sheets of the survey of India on the scale of 1:50,000.

In the present study, the area from Kishangarh to Tonk has been considered. The total area of the Basin under investigation is approximately 6987.5 sq. km. Its length from north to south is about 125.83 km and width from east to west is nearly 107.83 km. The base map of the Mashi river basin is shown in Fig. 1.

Methodology

This study has been based on both secondary sources as well as the extensive field study. In the category of secondary sources the information's have been obtained from topographical sheets on the scales of 1:50,000, Journals, Geological atlas of Rajasthan etc. Maps of the study have been prepared using GIS techniques with the help of AutoCAD software.

Hydrogeomorphological Units

The Hydrogeomorphological study has been done regionally using Top sheets survey of India and Ground Water Atlas of Rajasthan to understand the major variations in morphology for the identifying the ground water prospective zones in the Mashi river basin, central Rajasthan. Distinctive hydrogeomorphic units identified on Hydrogeomorphic map are flood plain, Alluvial plain, palaeochannel, valley fill, intermontane valley, buried pediment, sandy plain, Aeolian plain, obstacle dune, Ravine, and plays, these units controls the groundwater regime.

Measures to Increase Ground Water Potential in Different stream orders

The hydrogeomorphological and ground water potential zone study revealed, that the

valley fill, palaeochannel, flood plain and Alluvial plain hydrogeomorphic units have good to excellent prospects of ground water development. The ground water potentiality of these units can be further enhanced through watershed development and rain water harvesting techniques as observed in the Silora hills of Kishangarh tehsil of Ajmer district. It is recommended here that small watershed may more useful than large ones as through small watersheds rain water can be harvested in the local areas. The above recommendations can be supported through the examples of Sukhomajri village in Ambala district of Haryana and Jhohar construction scheme in Alwar district by water man Dr. Rajendra Prasad. Sukhomajri has earned a national wide acclaims for the way in which the people of the village have used their forest and water. It has become a model

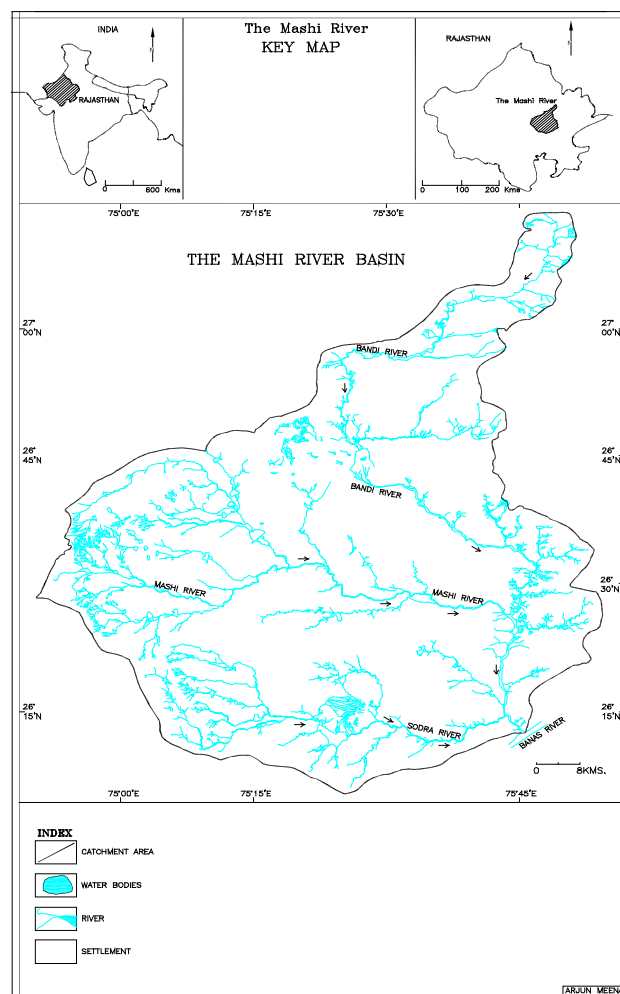


Fig. 1 Map of the study area

of community participation management. Silting up of Sukhna Lake near Chandigarh led to water shortage in the village. Four check dams were constructed and trees planted in the catchments area of the lake. This raised the water level in the village. The income from cutting of Bhabhar grass and harvesting of Mungri or forage grass has changed the face of the village.

The watershed approach can be enabled a holistic development of agriculture and allied activities, such as horticulture, agro-forestry and silvi-culture.

The ravines are the natural small, narrow, deep, depression. These creates badland topography but through watershed development by constructing dykes across the ravines, can be used to recharge the ground water.

The linear ridge, structural hill, denudation hills, pediment have poor ground water prospects but these hydrogeomorphological units can be made viable from the point of water resources through watershed development and rain water harvesting techniques. Rain water harvesting technique of Gabian can be used in the above Hydrogeomorphic units.

Rain water harvesting through Gabian Structure

This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond course. A small bund across the stream is made putting locally available boulders in a Mesh of steel wires and anchored to the stream banks as observed near the Pitamber ki Gall in Silora hills. The height of such structure is around 0.5 m and is normally used in the streams with width of less than 10 m. The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body.

The another method of ground water recharge which can be used in the poorly

ground water prospect area is – ground water dam or sub-surface dykes.

Under-ground water Dams or Sub-surface Dykes

Sub-surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and store water upstream below ground surface. By doing so, the water level in upstream part of ground water dam rises saturating otherwise dry part of aquifer. The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let. After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/concrete walls up to 0.5 m below the ground level. For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauges or low density polythene film of 200 gauges can also be used to cover the cut out dyke faces. Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir take place. The potential disaster like collapse of the dams can also be avoided.

Merits

- Since the water is stored within the aquifer, submergence of the land can be avoided and land above the reservoir can be utilized even after the construction of the dam.
- No evaporation loss from the reservoir and no siltation in the reservoir take place.
- The potential disaster like collapse of the dams can also be avoided. \

Environmental Benefits of vegetation

The green cover of vegetation can be increased in the river basin through water harvesting techniques mention above (a) and (b). This vegetation cover may fight climate change by sequestering carbon dioxide emissions from the atmosphere in trees through photosynthesis, Restores watershed alongside Mashri river basin, Reduces soil erosion, Conserve habitat for endangered and threatened species, protects

biodiversity, and improves local environmental quality.

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Water Balance analysis for Luni upper sub basin using Remote Sensing and GIS

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Keywords: *Evapotranspiration, Runoff, Remote Sensing and GIS*

Abstract: Water is not only a resource, it is a life source. Water balance is the systematic presentation of data on the supply and use of water within a geographic region for a specific period of time. It is the net change in water, taking into account all the inflows to and outflows from a hydrologic system. Remote Sensing and GIS is considered as a vital tool for analyzing the water balance. The availability of multispectral and multi-temporal satellite images provides a clear synoptic view of the study area and can give a good insight into the topographic and physiographic characteristics of the area. Climate parameters measured using the satellite based sensors are also highly useful in analyzing the climate variability. This paper presents the outcome of water balance analysis carried out for Luni upper sub basin with the help of Remote Sensing and GIS. The sub basin covers part of south-western Rajasthan and extends up to Rann of Kutch in Gujarat. Various hydrological components of the Luni upper sub basin have been calculated with the help of satellite derived information along with other ancillary data. Rainfall, Evapotranspiration and surface runoff of the study area have been analyzed for the period 2001-2004. The FAO-PM (Food and Agriculture Organization – Penman Monteith) model is used to derive the evapotranspiration component spatially with the help of MODIS satellite data and other ancillary data. Runoff has been calculated based on land use/land cover, slope and soil texture. IMD grid data (0.5° X 0.5°) has been used to analyze the rainfall pattern of the study area. The analysis carried out over the period from 2001-2004 shows that there is high amount of variation in water balance. Evapotranspiration is very high in comparison to rainfall. Maximum calculated Evapotranspiration was observed in the month of May. The year 2003 shows water surplus but the remaining years were water deficit. The study proves that satellite data derived inputs along with other ancillary data can be effectively used to analyze the water balance of a given sub basin and its temporal variations.

Introduction

Quantifying the hydrological budget in arid and semi-arid regions is important as scarcity of water and climatic variability lead to conflicts regarding water use. Optimum and efficient use of scarce clean water resources is becoming a major concern these days as the inequality between the demands by ever increasing population to these precious resources is widening day by day. In arid and semi-arid region recurrent drought and water shortage are common phenomena. Water balance could be used to determine how well a region has been managed in supply and use of water resources. The water balance is an accounting of the inputs and

outputs of water. Mainly precipitation, surface runoff, evapotranspiration and ground water recharge are the main factors for calculating water balance of a particular region. Water balance analysis helps to identify the quantity of water available in different components of the water cycle. This knowledge will help in better management of water resources and the protection against over exploitation and contamination, cropping pattern – irrigation and drainage practices, analysis of the effect of land use changes on water availability, analysis of the effect of climate changes on water availability, identification of recharge zones and suitable potential rainwater harvesting sites etc.

Remote Sensing and GIS is considered as a vital tool for analyzing the water balance. Satellite data derived parameters like land surface temperature, surface albedo, vegetation parameters etc helps in calculating the evapotranspiration loss from a region and analyse its dynamics. Satellite based climate observations gives the spatial and temporal variability pattern over a wide area. GIS is a powerful tool for integrating and processing large amounts of spatial information, such as the environmental variables needed for evaluating water balance terms and also for analysing the spatial and temporal variability of different hydrologic components. GIS based water balance analysis has been carried out in different basins using various approaches (Julius Nkezeah, 2010; Shahab Moghadas, 2009; Solomon Cherie Mekonnen, 2005; Kamble Baburao Dashrath). A number of methods are available for the estimation of evapotranspiration. The FAO Penman-Monteith (FAO - PM) method is recommended as the standard method for the definition and computation of the reference evapotranspiration, since it considers both the temperature and radiation factors which influence evapotranspiration (Allen et al., 1998). MODIS data has been used for the calculation of

evapotranspiration using FAO Penman-Monteith method in various studies (Chen Min Kuo et.al., 2008; Raghuveer K. Vinukollu et.al., 2011; Alexia Tsouni et.al., 2003; Zhang Y.Q et.al.)

In this paper MODIS data along with other meteorological data has been used for the calculation of evapotranspiration. The attempt was made to calculate the Net Runoff from a catchment using Runoff coefficient (Murthy, V.V.N, 2003). Mainly soil texture map, Land use/ land cover map and slope map were used as the input for the analysis of Runoff.

Study Area

Luni Upper Sub Basin is located in south-western Rajasthan, between latitudes $23^{\circ}32'59.366''\text{N}$ $27^{\circ}18'26.267''\text{N}$ and longitudes $70^{\circ}48'54.221''\text{E}$ $75^{\circ}3'57.517''\text{E}$. The Basin extends over parts of Ajmer, Barmer, Jalore, Jodhpur, Pali, Sirohi and Udaipur districts in Rajasthan state and ends at the lands of Rann of Kutch in Gujarat. The total catchment area of the Basin is 79886.74 Sq.Km. The index map of the study area is shown in Fig.1.

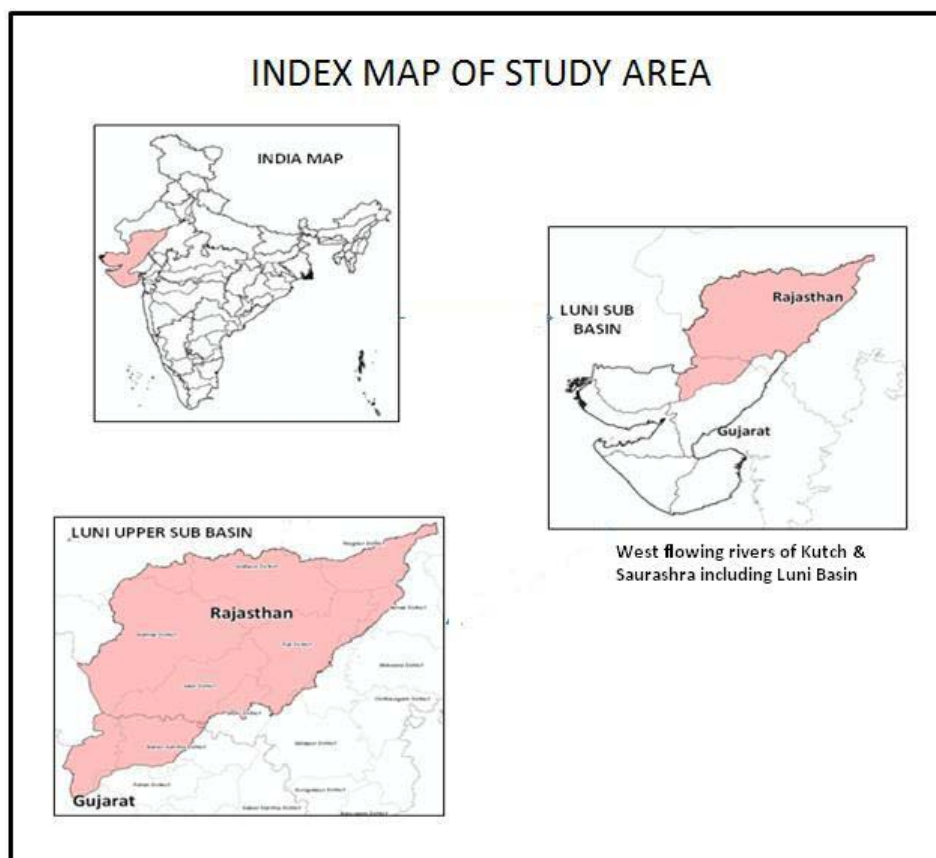


Fig. 1. Index Map of the study area.

Table 1. Data used in the analysis of Water Balance

Sensor/Data	Parameters	Source
MODIS	Land Surface Temperature(LST)	USGS
	Albedo(MCD43B3)	USGS
	Emissivity(MOD11A2)	USGS
Meteorology data	Wind Speed	IMD Station data
	Vapour Pressure(0.5°x 0.5°)	Climate Research Unit (CRU)
	Temperature (1° x 1°)	IMD grid data
	Rainfall (0.5° x 0.5°)	IMD grid data
RESOURCESAT (LISS-III)	Land use/Land cover	ISRO
Soil map	Soil Texture	NBSSLUP
SRTM	DEM	NASA

Data Used

MODIS data is used for the calculation of various parameter of evapotranspiration, mainly Land Surface Temperature (LST), Emissivity and Albedo. For the analysis of meteorology parameters grid and point observation data from IMD and global grid data of CRU has been used. Land use/land cover map has been generated from Resiurcesat-2 LISSIII data and for the slope map preparation SRTM 90m DEM has been used. Following table represent the short summary of data used in the study of water balance.

Methodology adopted

The water balance equation is given below:

$$P = Q + ET + R \text{ (Solomon Cherie, 2005)}$$

Where, P- Precipitation (mm), Q-Surface runoff (mm), ET- Evapotranspiration (mm), R- Ground water recharges (mm).

The methodology adopted for water balance estimation using remote sensing and GIS approach is shown in Fig.2.

Penman-Monteith algorithm (PM-Mu) has been used for the calculation of reference

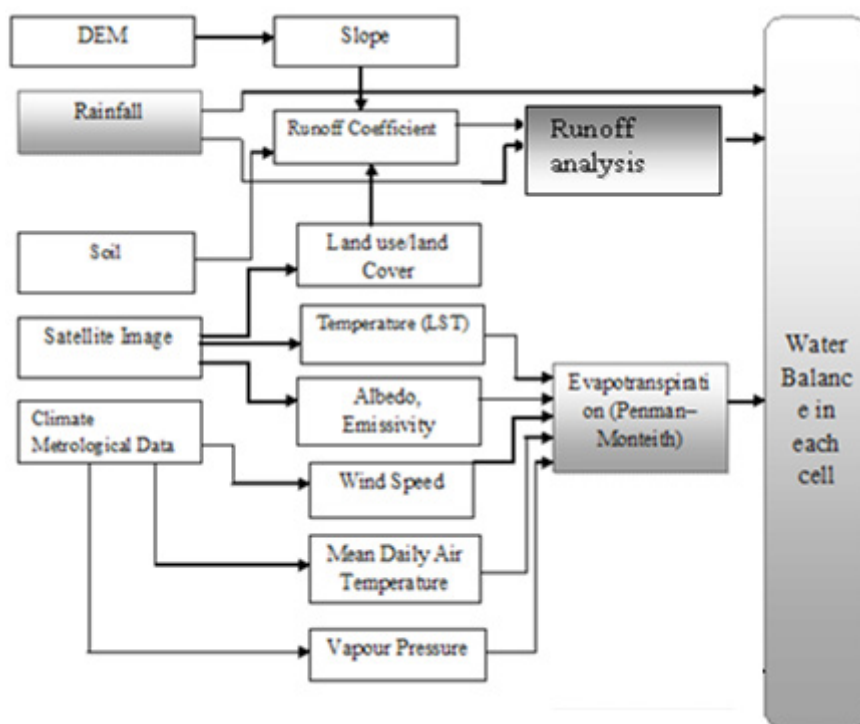


Fig. 2. Methodology for water balance estimation.

evapotranspiration because this is the most consistent method and widely used process. The equation can be expressed as:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

where R_n is the net radiation at the crop surface ($\text{MJ m}^{-2}\text{d}^{-1}$) G is the soil heat flux density ($\text{MJ m}^{-2}\text{d}^{-1}$), Δ is the gradient of the vapour pressure curve ($\text{kPa } ^\circ\text{C}^{-1}$), γ is the psychrometric coefficient ($\text{kPa } ^\circ\text{C}^{-1}$), T is the mean daily temperature ($^\circ\text{C}$), u_2 is the wind speed at 2 m height (m s^{-1}), $e_s - e_a$ is the saturation vapour pressure deficit (kPa), e_s is the saturation vapour pressure (kPa) and e_a is the actual vapour pressure (kPa).

Run coefficient method (Murthy, V.V.N, 2003) is used for the analysis of runoff. Runoff coefficient(C) is defined as the ratio of the peak runoff rate to the rainfall intensity and depends on various factors like- slope, land use, texture of soil. Net Run off can be calculated from this run off coefficient and rainfall as follows,

$$\text{Net Runoff (m}^3\text{)} = \{\text{Catchment Area (m}^3\text{)} * \text{Rainfall (mm)} * \text{Runoff coefficient} / 1000\}$$

The table below shows the values of Runoff coefficient by Murthy, V.V.N (2003) for the calculation Runoff.

Table 2. Showing the values of Runoff coefficient (Murthy, 2003)

Type of LULC	Type of LULC	Slope Range	Runoff coefficient		
			Coarse Texture	Medium Texture	Fine Texture/Rocky and Non Soil
Arable Land	Crop land/Plantation/Fallow / Current shifting cultivation	<5%	0.30	0.50	0.60
		5-10%	0.40	0.60	0.70
		10-30%	0.50	0.70	0.80
Pasture Land	Grass/Grazing/Salt affected land/ Gullied/Ravinous land/Scrub land /Sandy area/Barren rocky/ Rann	<5%	0.10	0.30	0.40
		5-10%	0.15	0.35	0.55
		10-30%	0.20	0.30	0.40
Forest Slope	Evergreen/Semi evergreen/ Deciduous/Forest plantation/ Scrub forest/Swamp/Mangroves	<5%	0.10	0.30	0.40
		5-10%	0.25	0.35	0.50
		10-30%	0.35	0.50	0.60
River/ water body	Inland Wetland/Coastal Wetland/ River/Stream /Canals/Water bodies	<5%	1.00	1.00	1.00
		5-10%	1.00	1.00	1.00
		10-30%	1.00	1.00	1.00
Built-up/ Mining	Urban/Rural/Mining	<5%	0.50	0.50	0.50
		5-10%	0.55	0.55	0.55
		10-30%	0.60	0.60	0.60

Result and Discussion

Rainfall- Average monthly rainfall for 2001-2004 has been analyzed (Fig.3). The highest rainfall is received in the month of July and August. It is observed that the south-east part of the basin receives maximum amount of rainfall. The western part of the basin receives least amount of rainfall. Average annual rainfall for the basin is shown in Fig.4.

Evapotranspiration

Spatial distribution of monthly evapotranspiration averaged over 2001-2004 is shown in Fig. 5. The mean monthly evapotranspiration is found to be varying from 70 mm to 330 mm. It is observed that due to low temperature in the month of January, february, November and December lowest values of ET are observed and they lies between 70 to 150 (mm/month). As this study area lies in semi arid region so in the month of March, April, May and June as the temperature and wind speed are high ET values are highest and lies between 180-330(mm/month). Due to lack of cloud free MODIS images in month of June, July and August we have used PET from CRU dataset for the analysis of water balance. Fig.6. shows the variation of mean monthly evapotranspiration (2001-2004) in Luni upper sub basin.

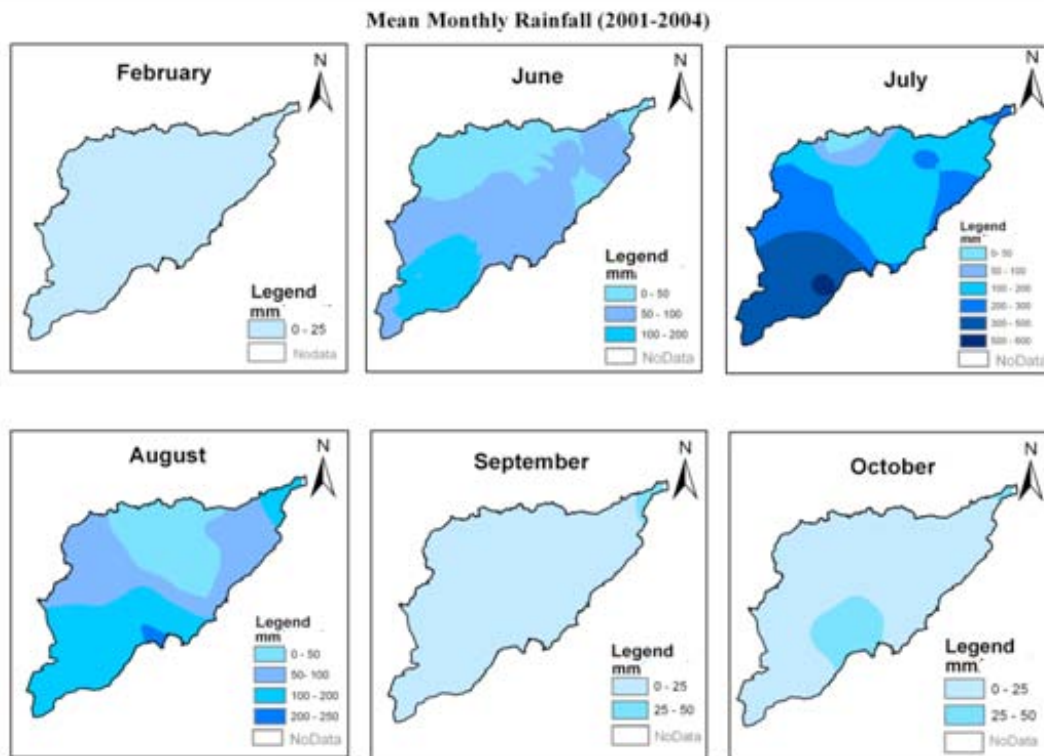


Fig. 3. Maps of mean monthly rainfall from (2001-2004).

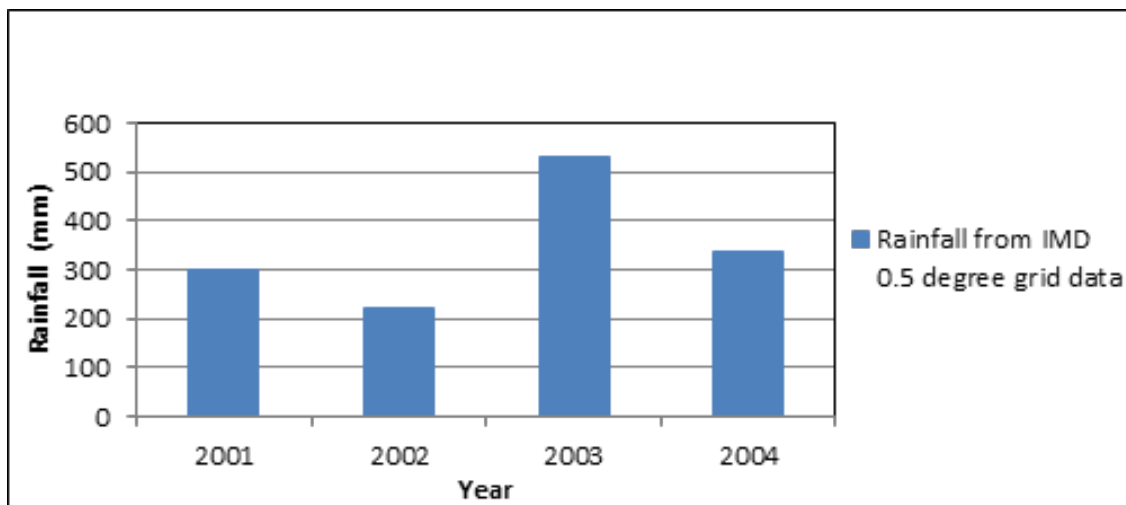


Fig. 4. Annual Rainfall from (2001-2004) of study area.

The trend of mean monthly ET in different years (2001-2004) shows almost same pattern and varies according to different months. We can examine that the highest values of ET are observed in the months of March, April, May and June while lowest values are in January, February, November and December months. There is minor variation in ET value in year 2004 due to increase in temperature and wind speed as ET mainly depends upon these factors.

Runoff - The mean monthly variation of runoff was calculated for the month of February, June, July, August, September and October whereas the remaining months are deprived of rainfall (Fig.7). Runoff depends upon the slope, rainfall and soil texture. Minimum runoff obtained is about 200 m³ in the month of February, September and October.

Mean Monthly Evapotranspiration (2001-2004)

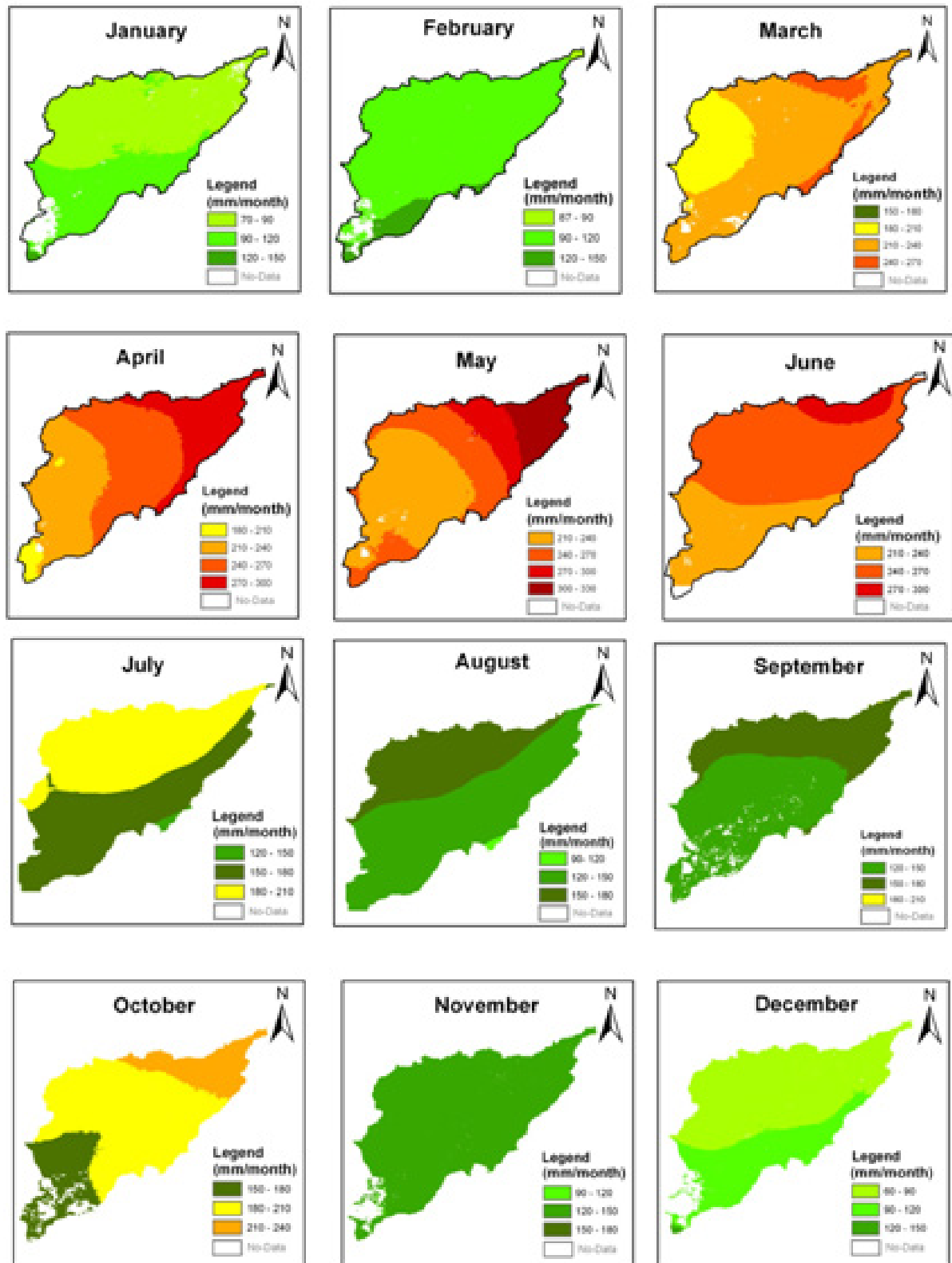


Fig. 5. Maps of mean monthly evapotranspiration (2001-2004).

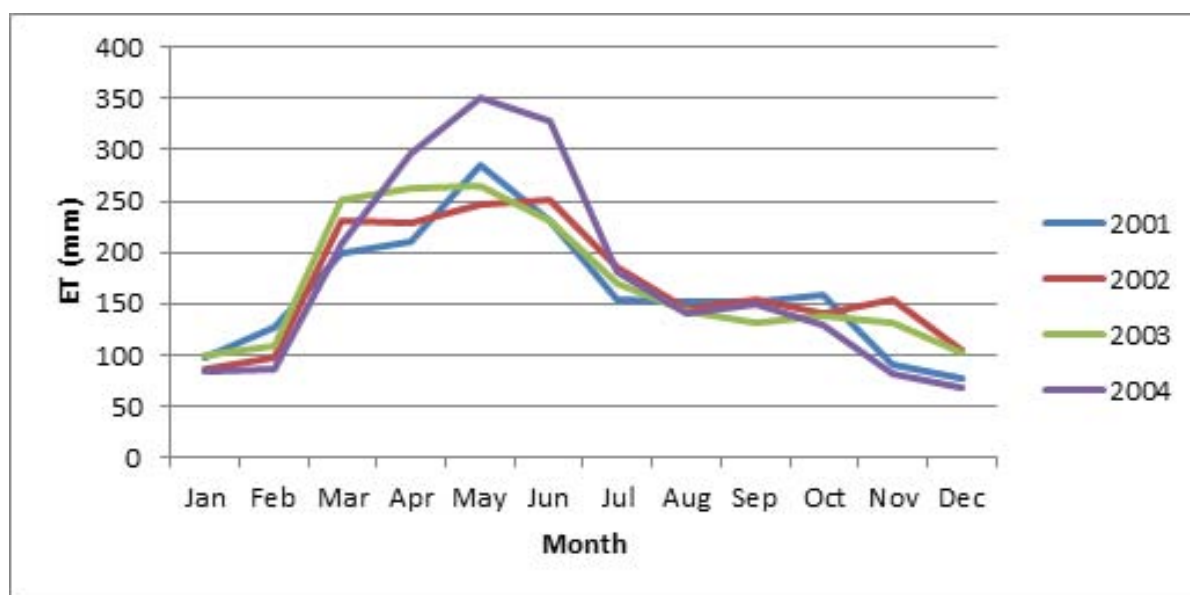


Fig. 6. Monthly Evapotranspiration (2001- 2004) of study area.

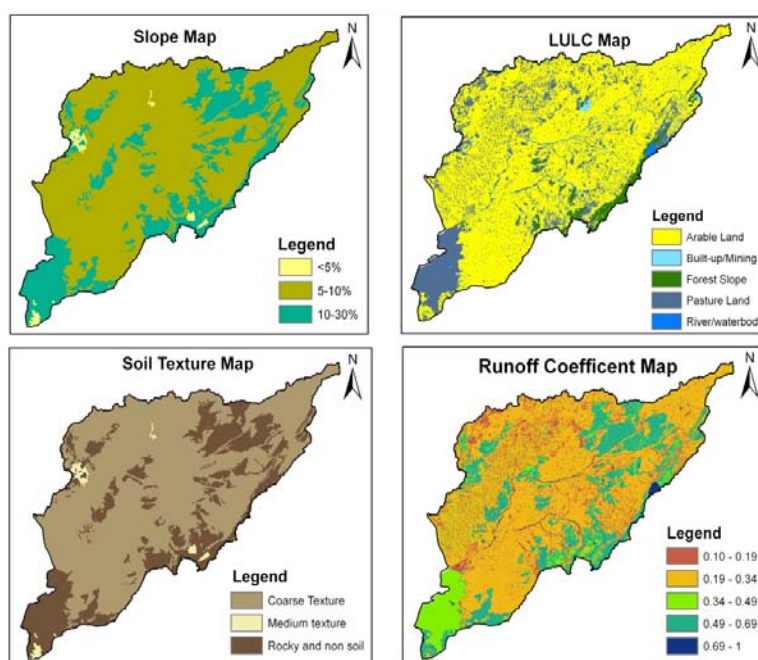


Fig. 6. Representation of Slope map, LULC map, Soil texture map and Runoff coefficient ma.

Water balance analysis for Luni upper sub basin (2001-2004)

The average monthly water balance components were determined for the period of 2001 to 2004. Large amount of water gets evaporated in comparison to rainfall in this study area. In the month of March, April, May and June maximum amount of water gets evaporated due to increase in temperature, wind speed. In month of May it is observed

that 286.31mm/month amount of water from the period 2001-2004 gets evaporated whereas maximum amount of rainfall is received in the month of July which is up to 231.32mm/month therefore some water flows in form of runoff and lesser amount of water gets evaporated. The calculated results obtained in this study shows the variation of the availability of water in the basin, on a monthly time scale basis and it is useful for decision making and the

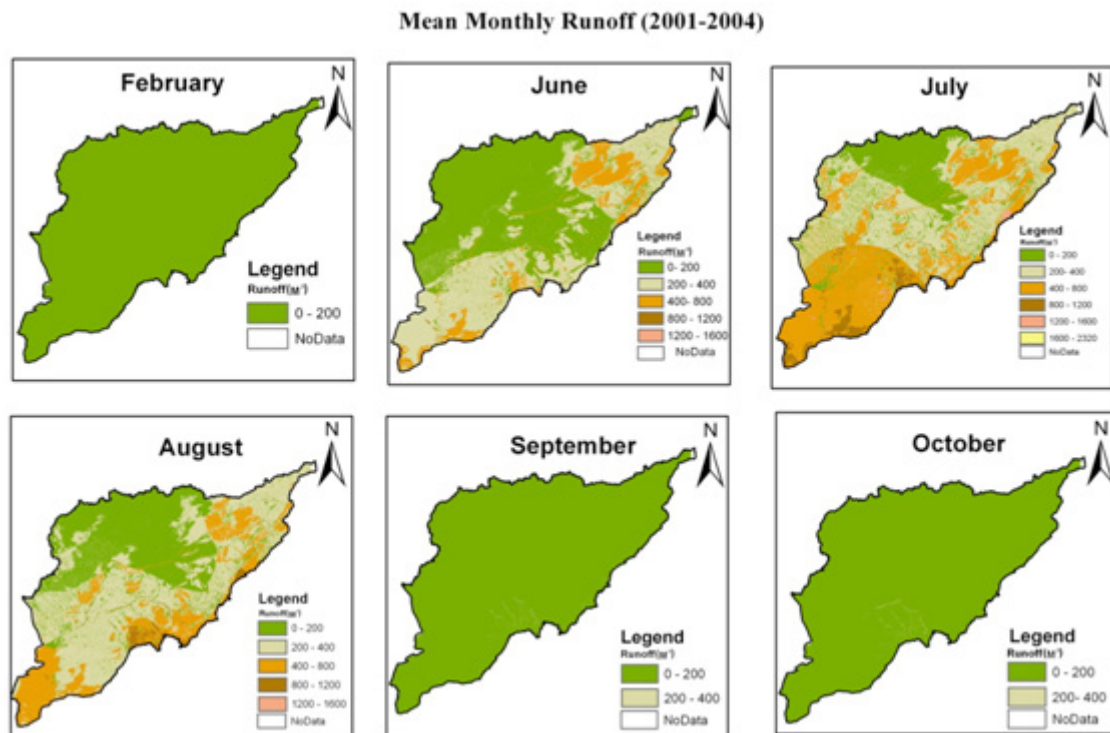


Fig. 7. Maps of mean monthly runoff of study area from (2001-2004).

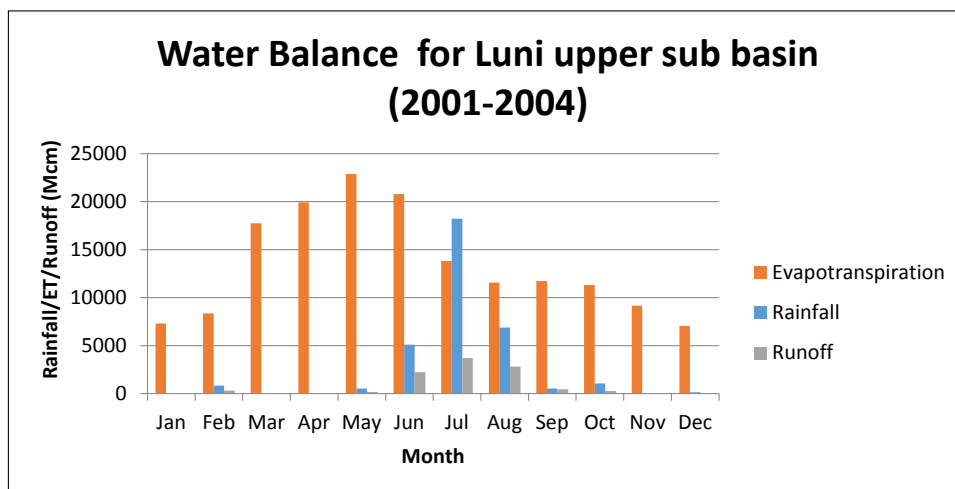


Fig. 8. Water Balance for Luni upper sub basin (2001-2004).

effective utilization of water. Fig.8. shows the water balance budget in Mcm over the period from 2001-2004.

Conclusion

Different hydrological components of study area were analyzed for estimating water budget. Evapotranspiration has been calculated using Penman-Monteith method with the help of MODIS and other ancillary data. Analysis of ET for four years shows that evapotranspiration is

very high in comparison to rainfall. Maximum calculated Evapotranspiration was observed in the month of May whereas maximum rainfall is received in the month of July so only this month have maximum amount of runoff. Analysis over the period 2001-2004 shows that there is high amount of variation in water balance. The year 2003 shows water surplus but the remaining years were water deficit.

The outcome of research will help in understanding the hydrological component and

water budget of the basin and this will also give and insight for better water, management.

Due to limitation of data we restricted our analysis to four years and also ground water component has not been considered. For future scope the study can be repeated for some more years to analysis the climate variability and its impact on water balance .

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Micro-Level Study of Agricultural Resources of Indore Using GIS and Remote Sensing

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Keywords: Agriculture productivity, GIS, RS, Crop yield and Concentration indices ranking coefficient, Rabi crops and Kharif crops, High productivity zone

Abstract: Land being the finite resource and immediate accessible resource which supports the life on Earth requires a sustainable management as well as micro level study. Among different pattern of land use, agricultural land use has its own importance, as it directly as well as indirectly affects day-to-day activity of human being. The agricultural land use of rural part of Indore tehsil has been selected for study. It is located on the southern edge of Malwa plateau, which comes under high quality regur soil. Realizing the soil potential of the agricultural area, in the present study an attempt has been made to study the rural agricultural land use of Indore Tehsil. It has been done with the integration of agricultural data along with theme maps to develop local developmental plans at grass root level. The aim of the study is to assess the agricultural land resource potential of the selected area as it falls under dominance of agricultural activity in rural sector. Therefore the main objective of the study are to estimate the present infrastructure facility for the agricultural development and trend of utilization of land resources in context of physio-socio-economic and environmental factors, analyse the variation in agricultural efficiency with respect to size of land holding in the tehsil, suggest suitable measures for micro-level and area specific plan for better rural agricultural land use. Therefore with the help of the above objectives agricultural scenario of the area can be derived which will further help us in suggesting micro level plan for the sustainable agricultural development of the area.

Introduction

Among various pattern of land use agricultural land use plays an important role especially in rural sectors. Majority of the economy is based on agricultural land use in rural parts of our country. Therefore, land being the finite and immediate accessible resource which supports the life on earth, requires a sustainable management as well as a micro-level study.

For the micro-level study of the agricultural land use, rural parts of Indore tehsil of Madhya Pradesh, has been selected. It is located in southern edge of Malwa plateau, which comes under high quality regur soil. In the present study an attempt has been made to study the rural agricultural land use of Indore tehsil at grass root level.

The aim of the study is to assess the potential of agricultural land use of the rural sector.

The objective behind the study of agricultural land use encompasses the assessment of existing land resources and capabilities and potential of farmers to improve the agricultural productivity; to demonstrate the use of remote sensing, development and planning of rural areas; and to focus on the specific problems and evolve solutions and strategies for sustainable development.

Methodology: For the present study 25% of the total villages of the Indore tehsil have been selected by random method (Fig.1). The data is acquired from various primary and secondary sources. For primary data detailed schedule has been prepared, having general information regarding village, size of land holding, number of farmers etc. To acquire detail information pertaining to efficiency of farmers input, various questions regarding high yielding variety, fertilizers, pesticides, irrigation and use of different innovative techniques has

been structured. To support primary data various secondary sources - census handbook, statistical handbook of different years and land record has been used.

To analyse the agricultural productivity and efficiency we have tried to quantify it with the help of the concept of crop yield and concentration indices ranking coefficient put forward by Jasbir Singh (1976).

Formula :

Following procedure is adopted:

$$(1) Y_i = (Y_{a_r} / Y_{e_r}) \times 100$$

Where y_i = Crop yield Index

y_{a_r} = Average yield per hectare of crops 'a' in a unit

y_{e_r} = Average yield of crop 'a' in the entire region

$$C_i = (P_{a_e} / P_{a_r}) \times 100$$

C_i = Crop concentration index

P_{a_e} = Percentage strength of crop 'a' in total harvested area

P_{a_r} = Percentage strength of crop 'a' in total harvested area of entire region

(2)

$$\text{Crop yield and concentration Indices ranking coefficient for crop 'a'} = \frac{\text{Crop yield index ranking of crop 'a'} + \text{Crop concentration index ranking of crop 'a'}}{2}$$

The result thus derived gives an idea of the level of agricultural production. It is derived from the ranking order, i.e. lower the ranking coefficient, the higher is the level of agricultural production and vice versa.

Out of total area 20.22% area of Indore Tehsil has been studied. For the micro level study of the area, demographic attributes of the area has been studied. At first the 25.27% of total household has been surveyed. These households have been categorized according to the size of land holdings i.e., 0-2 hect., 2-4, 4-6, 6-8, 8-10, 10-12, 12-14 and >14 hect. The overall distribution pattern of population according to land holdings shows higher concentration in small size of landholdings and vice-versa. The sex structure shows that 55.07% of the

population is male and 44.93% is female. i.e. 816 females per 1000 males. The wide gap between the gender is found in < 15 years age group.

Therefore the age-structure of the area shows maximum concentration of population (41.32%) falls under 15 - 30 years age group. It shows there is huge requirement of employment generating units in the study area as the participatory rate of the study area is 36.72% and more than 50% of working population is falling under the age group of 15 - 30 years. The high concentration of population under this age group also demands proper education for better output. The education status of the area shows 73.48% literacy in which 59.45% are males and 40.55% are female.

Out of the total population 16.90% of the population of the study area are farmers. Farming population is found to be low because of less participatory rate and for urban influences. Cropping intensity gives an idea of the extension of double cropped area on net sown area or as a percentage of the total cropped area. It deals with the use of cultivated land within one agricultural calendar. Cropping intensity of Indore shows total intensity is higher in kharif (92.78%) compared to Rabi (85.89%) season.

$$\text{Cropping Intensity} = \frac{\text{Total cropped area}}{\text{Net sown area}} \times 100$$

In the study area, during kharif season variation is found in terms of irrigated land. During kharif season it is 64.27% of total cultivated area is irrigated, while in rabi season 71.74% if total cultivated area is irrigated. The fallow land includes all lands which were taken up for cultivation but are temporarily out of cultivation for a period not less than one year and more than 5 years. In the study area 13.85% of total cultivated area comes under fallow land in kharif season and 17.56% during rabi season. How agriculture land is owned and managed has an important role in agriculture developed. The size of land holding shows the relationship to the productivity of the land in terms of soil, climatic conditions, technique used and the infrastructure used for the cultivation. For the analysis of size and pattern of division of land holdings, it has been divided into 8 categories. Maximum number of land holdings fall under < 2 hectare and minimum in 12-14

hect. of land. The common trend of distribution of land among the population is as the size of the land holding increases the population decreases. For the assessment of agricultural productivity of the study area, 30 villages of the Tehsil have been selected. Crop productivity of the area is evaluated according to the different cropping season of the year i.e., kharif and rabi season. The total surveyed agricultural area of the tehsil is 5622.98 ha and total production of the area is 87105.56 (Tonnes). The percentage of agricultural production in different cropping season i.e., kharif and rabi are 52.22% and 47.78% respectively. During kharif season four major crops i.e., Soybean, Maize, Millet and Tuar, while in rabi season wheat and gram are mainly cultivated in the study area (Table 1).

Table 1: Percentage of area and production of major crops of different season of the study area.

	Kharif Crops			Rabi Crops		
	Soybean	Maize	Millet	Tuar	Wheat	Gram
Area (%)	74.42	12.95	5.15	7.48	81.96	18.04
Production (%)	87.36	6.91	2.24	3.49	86.70	13.30

Therefore we have observed the level of productivity land utilization is higher during kharif season in comparison to rabi season. Another characteristic of the study area is observed that there is direct bearing of capacity and capability of land and infrastructure to the productivity level of the study area. Keeping in mind the importance of infrastructural and institutional factors some of the important factors are evaluated.

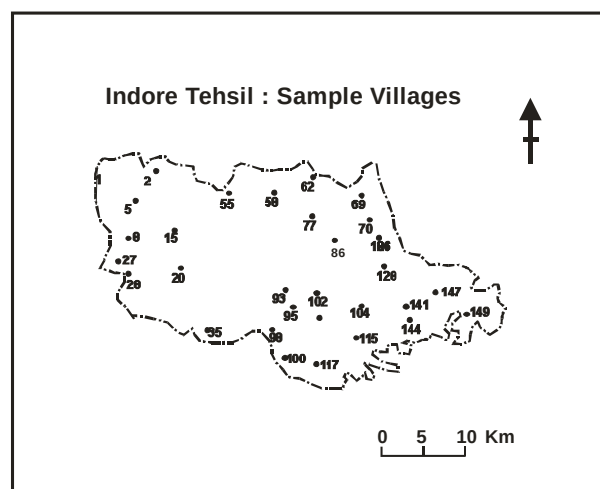


Fig. 1.

The nature of land and its slope is an important consideration. In the study area gentle slope is observed. 90.07% of the area is covered by black soil, 4.23% by dark black soil, 3.48% by brown soil, 0.82% yellow soil and remaining 0.70% of the area has sandy type of soil. Source of irrigation plays an important role in agriculture. In Indore 49.79% of farmers use bore wells, 47.77% irrigate their land by wells and 2.45% use canals. It shows the area is highly dependent on ground water. Equipments which are commonly available and used by the farmers are bullock carts (25.50%), Iron tiller (13.65%), Bakhar (12.68%), Spray pumps (6%), Thresher (5.71%), Tractor (5.55%), Sowing machine (3.57%), Storage house (1.48%), Kutti Machine (0.95%), Charkhi (0.80%), Bio-gas (0.61%) and other equipments are used by 1.10% of the farmers.

In the similar manner various practices are noticed in the area done by the farmers to increase their productivity. Commonly they are soil testing (3.87%), Soil treatment (4.43%), pre-sowing seed test (16.16%), use of manure while sowing (17.66%), application of pesticide while sowing (6.43%) and maximum farmers (92.95%) use rodenticides and 49.13% of the farmers use pesticides to protect their crops. In the tehsil 25.50% of farmers use drought animals for farming. All the year round only 8.65% of the farmers are able to use green fodder while 4.48% farmers use special fodder and 14.54% farmers grow their own fodder. Vaccination for animals (32.08%), artificial insemination (29.06%), collecting information regarding agricultural practice (9.11%) and 89.45% of

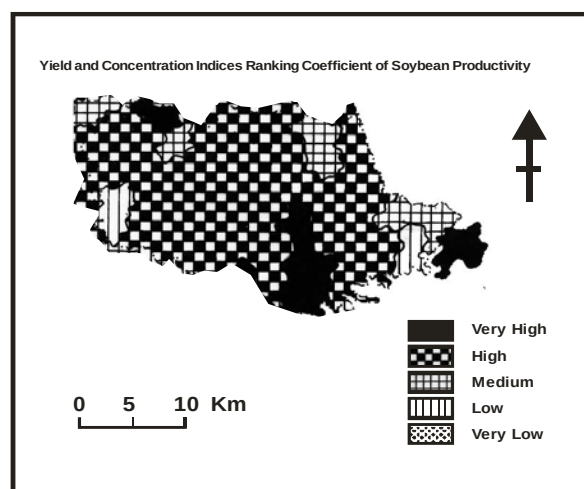


Fig. 2.1.

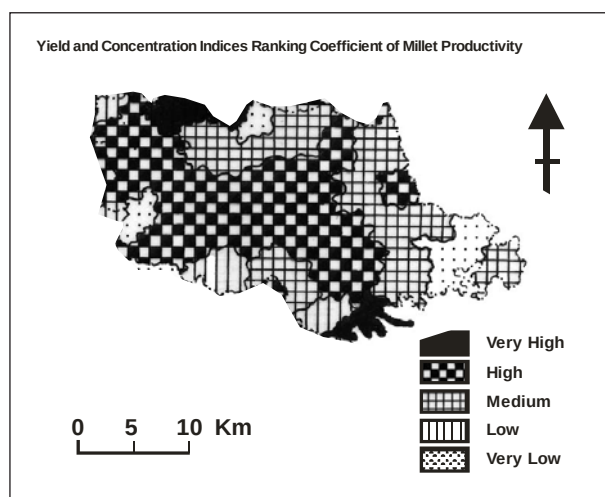


Fig. 2.2.

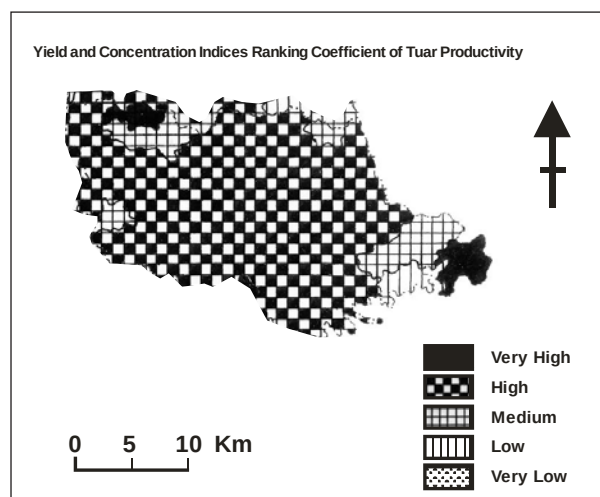


Fig. 2.3.

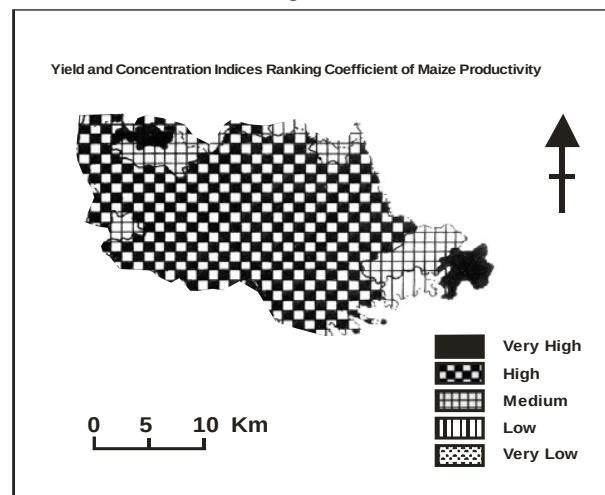


Fig. 2.4.

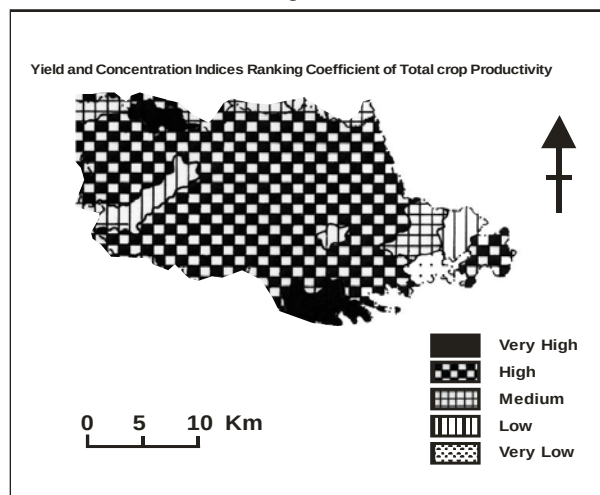


Fig. 2.5.

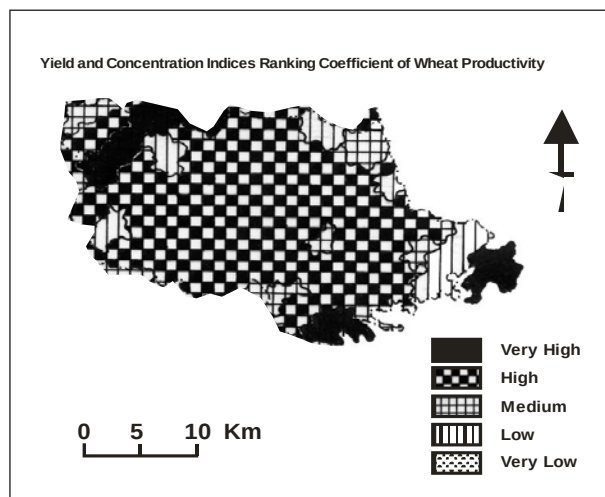


Fig. 2.6.

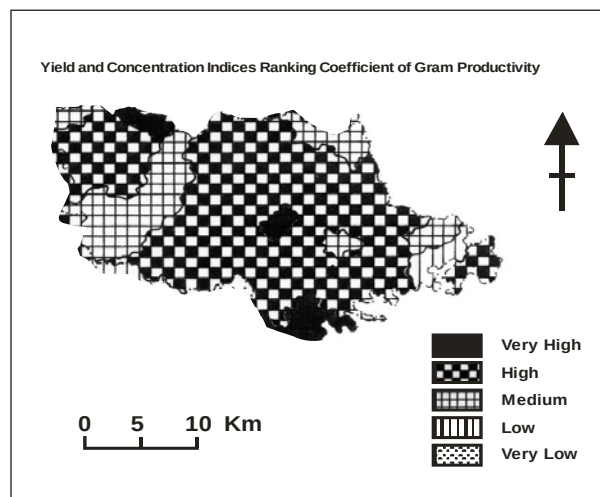


Fig. 2.7.

the farmers interact with agriculture extension officer. In the study area only 21.76% of the farmers receive grant from the government. To fulfil the financial requirements, farmers

draw loan from co-operative society (83.40%), bank (6.29%), local sources (8.14%) and Sahukar (1.13%).

Table 2 : Number of kharif crops producing villages and area in different productivity zones.

Productivity zone	Total Kharif crops		Soybean		Maize		Millet		Tuar	
	No. of Villages	Area (%)	No. of Villages	Area (%)	No. of Villages	Area (%)	No. of Villages	Area (%)	No. of Villages	Area (%)
Very High	2	1.62	4	3.98	3	2.29	2	2.01	2	1.03
High	17	43.22	18	85.42	16	41.80	11	17.66	21	58.44
Medium	8	38.47	6	4.25	8	43.35	10	38.68	6	23.06
Low	3	8.64	1	3.85	3	12.54	3	26.29	-	-
Very low	-	-	1	2.60	-	-	4	15.35	1	17.47

Thus the yield of crop expresses all the physical and human factors therefore, five productivity zones have been formed, i.e., very high, high, medium, low and very low zone on the basis of ranking order derived by ranking indices of coefficients. It helps to measure regional imbalances in food grain productivity.

In the present study major kharif crops i.e., Soybean, Maize, Millet and Tuar and rabi crops i.e., Wheat and Gram are included as they are grown in majority. Yield concentration indices ranking coefficient of important crops are shown in fig. 2.1 to 2.7. Details of kharif crops producing villages are given in table 2 and rabi crops in table 3.

Therefore we can conclude that the area comes under high productivity zone. With this quantitative method we are in position to demarcate regional imbalances and disparity within the study area at micro level. With the help of GIS and RS it has become easier and precise to evaluate the level of agricultural productivity of the area within the given environmental setup which further helped in planning.

Agriculture Planning: Various valuable information and facts have been gathered and compiled regarding agricultural conditions persisting in the study area. The area shows high prospect in agriculture as it comes under high productivity zone. As the trend of the land

use of the region is changing rapidly, there is an urgent need to maintain and improve agricultural activity of the area. Therefore, a comprehensive plan is required for maintenance and improvement of agriculture in the region. On the basis of observation, collected data and local requirements following points are suggested:

1. It is observed that in the study area as the size of landholding increases the number of landholder decreases. This uneven distribution of landholding causes social and economical disparities. To overcome this situation, policies like co-operative farming should be formed. This will increase the agricultural productivity and will also check further fragmentation of land.
2. To curtail fallow land, especially during Rabi season, drought farming should be encouraged. For this practice, proper training should be imparted to the farmers. Other than staple crops, horticulture, cultivation of perishable crops (vegetables etc) should be encouraged.
3. Small and marginal farmers, who are having limited resources should adopt crop insurance scheme (presently lacking in the area), it will provide the needed confidence to invest and gain from technological advances in agriculture.

Table 3: Number of rabi crops producing villages and area in different productivity zones.

Productivity zone	Total Rabi crops		Wheat		Gram	
	No. of Villages	Area (%)	No. of Villages	Area (%)	No. of Villages	Area (%)
Very High	3	3.89	5	5.83	3	3.58
High	17	44.99	14	38.81	17	45.60
Medium	6	28.48	5	24.67	8	39.74
Low	2	10.63	3	13.94	1	3.12
Very low	2	12.00	3	16.73	1	7.96

4. In the study area maximum villages falls under high productivity zone which indicates high agriculture capacity of the region. Villages coming under medium, low and very low productivity level of the study area require more attention. It is observed that villages coming under medium productivity zone are situated near by urban areas or near life lines i.e., railways and national highways, which helps in easy communication with urban areas. Therefore, in these villages people are trying to approach urban sectors and changing their pattern of landuse as well as occupational sectors i.e., from primary to secondary and tertiary. While villages falling under low and very low productivity zone are lagging behind mainly because of undulating topographical features as well as lack of proper infrastructure. Hence special attention is required for these villages. In low and very low productivity villages flow of infrastructure i.e., irrigation, equipments, transport systems, subsidy, credit, measures of improving soil fertility should be increased while in medium productivity zones major stress should be given in creating interest among the farmers to continue with farming instead of changing their land use pattern. To upgrade the capacity of lower zone villages and to sustain the productivity level of high productivity zone following steps should be adopted :

- (i) Regular soil testing of the area should be promoted. Soil should be prevented from concentration of chemicals due to use / overuse of fertilizers, insecticides, pesticides etc. Proper crop rotation and crop combination is recommended.
- (ii) Irrigation of the region is mainly dependent on underground water. Stress should be given to make the existing methods used for irrigation more effective by adopting scientific water management practices.
- (iii) To improve the agriculture performance it is very important to introduce advanced technology and equipments on tenancy basis in the area. Government should form policies which can provide this machinery in low rates.

(iv) Proper and overall infrastructural development is must for the area, i.e., roads, irrigation facilities, cold storage, agricultural market (krishi upaj mandi) etc.

(v) Proper information and training regarding modern and scientific farming should be imparted to the farmers with the help of agriculture extension officers and scientist. This will help them in using insecticide, pesticide, rodenticides, high yielding varieties (HYV) and manure in correct form and at right time.

5. Rather than soybean other Kharif crops should be promoted.

6. As there is lack of electricity other source of energy, i.e., solar, biodiesel, natural gas or other substitute of energy should be promoted.

7. Live stock and dairy should be encouraged which will raise the income of the farmers and will support agricultural practices.

8. Location of villages also plays an important role. Productivity levels of the villages located near urban centers are declining though their agricultural capacity is high. This is mainly because of urban influence. Agricultural land is continuously being converted into urban land use. It is very important to check the urban expansion. Policies such as good and high potential agricultural area or region should be declared as agricultural reserves like forest reserves which will prevent conversion of agricultural land use for other activities.

9. During five year plans all the categories of farmers i.e., rich and poor both should be considered. Facilities incentives, aids, etc., should be provided to each farmer which will maintain interest regarding farming among the cultivators. Therefore, for the overall development and upliftment of agricultural conditions of the study area the main stress should be given to the awareness level of the farmers. It will automatically change as well as improve the attitude and the outlook regarding agriculture practice. For this overall development agriculture requires cooperation with non-rural communities' i.e., planners,

scientists, governing bodies, officers and staff, proper approach to market, financial support, proper infrastructure which will help in improvement of agriculture of the study area.

10. Gender concerns in agriculture need to be mainstreamed. Appropriate structural functional and institutional measures to empower women and build their capabilities and improve their access to inputs, technologies and other farming resources need to be strengthened.

With the help of implementation of these suggestions overall enhancement and rapid growth as well as development of agriculture of the study area is expected. This will ultimately increase the income of farmers and will lead to raise the standard of living. It will also uplift self-reliance among the farmer for adopting innovative techniques and will also help them raise their economic and social structure.

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Geo Spatial Technology for Watershed Management Strategy

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Abstract: A watershed is a hydrological unit bounded by natural ridges which allow the run off to drain through a single outlet within the definite boundary. It aims at improving habitat and inhabitant impoverishment through a holistic approach of conservation and sustainable exploitation of natural responsibility in harmonious manner. Watershed management means the rational utilization of land, water and anthropogenic resources of a defined drainage network area for optimal production with minimal hazard to those in order to maintain the future sustainability in the most effective way. The main objective is to enhance water quality and regenerate natural resources, protect and sustain resource-based economic activities while concurrently managing the pressures of an increasingly urbanized landscape. To ensure food and water security for the ever expanding habitat population in uncontrollable manner, to control ever expanding vertical and horizontal expansion of production and demand, to check the drastic soil erosion progression, an integrated watershed management and development approach has become unavoidable for any country's positive economic gain. Geo-spatial technology generates immense scope of increasing the efficiency of inputs and effectiveness of conservation programs and practices in optimizing manner for accurate and sustainable management of land, water and vegetative properties within the exiting watersheds. Geo spatial technology has played decisive roles in all aspects of watershed management, from assessing watershed conditions through modelling impacts of human activities to visualising the impacts of alternative management scenarios. Moreover this emerging technology can act as a catalyst that could guide policy makers in disaster prediction, mitigation from local through regional to global perspective. With this backdrop the present paper is an attempt to visualize innovative solution for overall monitoring and betterment of a small Himalayan sub watershed. The information emerged from the micro watershed study may be used by the decision makers and planners to restrict the cumulative progressive degradation of land based on future prediction by the technology.

Introduction

A watershed is a topographically delineated hydrological unit bounded by natural ridges which allow the run off to drain through a single outlet within a definite boundary and as it acts as a catalyst for an ideal planning unit its management has emerged as a new paradigm for planning, development and monitoring of land, water and vegetative resources. Integrated watershed management is the process of formulating and executing the strategies within the frame work of implementation of various tools and institutional arrangements, selecting the right course of action, thorough monitoring the evaluating performance and finally suggesting alternative resource management actions for the area and its surroundings in sustainable manner. Recent advances in the field of Geo spatial technology covering acquisition of high resolution satellite data through remote sensing, positional

accuracy through Global positioning System (GPS), data utilization through Geographic information systems (GIS), data sharing and communication through the Internet and web mapping have provided easy access of more information to watershed managers for making positive management decisions. It requires the integration of knowledge, data, simulation models, and expert assessment to solve practical problems and offer a scientific ground for decision making at the watershed scale on sustainable basis. Within the periphery of the platform of Geo spatial technology the paper is to discuss about the incorporation of this emerging technology in support of watershed management, decision making and integrating those technical knowhow for the betterment of a small Himalayan sub watershed.

Study Area

Rongni Chu subwatershed is located in east district of Sikkim covering an area of 258.99

sq.km, is aligned in NE-SW direction and extends between 27°14'15"N to 27°23'49" N latitude and 88°29'25"E to 88°43'19"E longitude (Fig. 1). It is bounded by Dik Chu subwatershed in the north and north east, Rangpo Rangli khola subwatershed in its south and southeast and Teesta (lower part) subwatershed in the west. The region is characterized by ridge, rocky cliff, escarpment, landslide zone, morainic zone, low mountains (< 1,000 m), narrow valley, middle mountains (1,000 - 2,000 m), high mountains (2,000 - 3,000 m), very high mountains (3,000 - 4,000 m) and extremely high mountains (> 4,000 m). The main river draining this subwatershed is Rani Khola which is a tributary of Teesta river also known as Rongni Chu in its initial stretch, is 36 km long and mostly dendritic in nature. Two major tributaries of Rani Khola are Taksom Chu and Re Chu, which respectively joins it on the left and right banks.

Application of Geo Spatial Technologies in Watershed Management

The following parameters reveal some ways in which Geo spatial technology has been exploited by the hydrology and watershed management community.

1. Watershed Characterization and Delineation of Watersheds

Delineation is part of the process known as watershed segmentation, i.e., dividing the watershed into distinct land and channel segments to evaluate watershed behavior which is a pre requisite for modeling and decision making system. Watershed delineation can be done either by extracting watershed boundaries contributing to flow at an outlet based on knowledge of topography from the topographical sheets and stream layers or automatic model generation from digital satellite data, especially from high resolution DEM from which user may set his minimum drainage area required to form the beginning of a stream by determining size and number of subwatersheds and by incorporating a layer of watershed outlets. The watershed delineation is also used to characterize the topography, soil, land cover, and precipitation for each unit. These data can be used to interpret the chemical properties and its effect of non-point sources. They also could guide future sampling or experimental plan by defining topographic, soil, and land use end-members. Watershed

delineation governed by topography only has disadvantages as because the segments are based on the surficial expression of the landscape, groundwater flow paths or drainage depressions that are not consistent with the real situation and may be misrepresented. Further, in areas having subtle topography, the calculation of flow direction is difficult. In this study the watershed delineation has been done by using digital elevation model (DEM) prepared from cartographic data (contour lines of 20 meters interval) of Survey of India (SOI) topographic maps of 1:50,000 scale as well as by the automatic DEM extraction from high resolution data by ARCSWAT (Soil and water assessment tool, an ARCGIS interface) model. The stream networks of the study area were also delineated from the same topographic maps which are essentially used as break-lines during contour interpolation as well as hydrological correction of interpolated and automated DEM generation by the model.

2. Spatial Analysis of the Variability in Landuse, Soil Properties and Rainfall Runoff

Descriptive and analytical studies of spatial land utilisation and its changes are indispensable for any refined watershed analysis. Both qualitative as well as quantitative characteristics of different land use changes are thrust areas for which more thorough investigations of the reason of these changes as well as for policy making to counteract the negative impacts of the changes should be identified.

Prediction of future landuse changes is another important factor which may be conditional or unconditional. Unconditional predictions, also known as trend extrapolations, provide future scenario of the land use patterns in an area that will exist if past trends continue in the future. Conditional predictions of land use change produce alternative land use feature of an area under hypothetical conditions or scenarios. Some analyses are conducted with the purpose of predicting land use changes caused by climatic change or by changes in future population, food and other habits and so on. Conditional predictions, based usually on scenario analysis, are frequently used in the context of policy making on issues of global change.

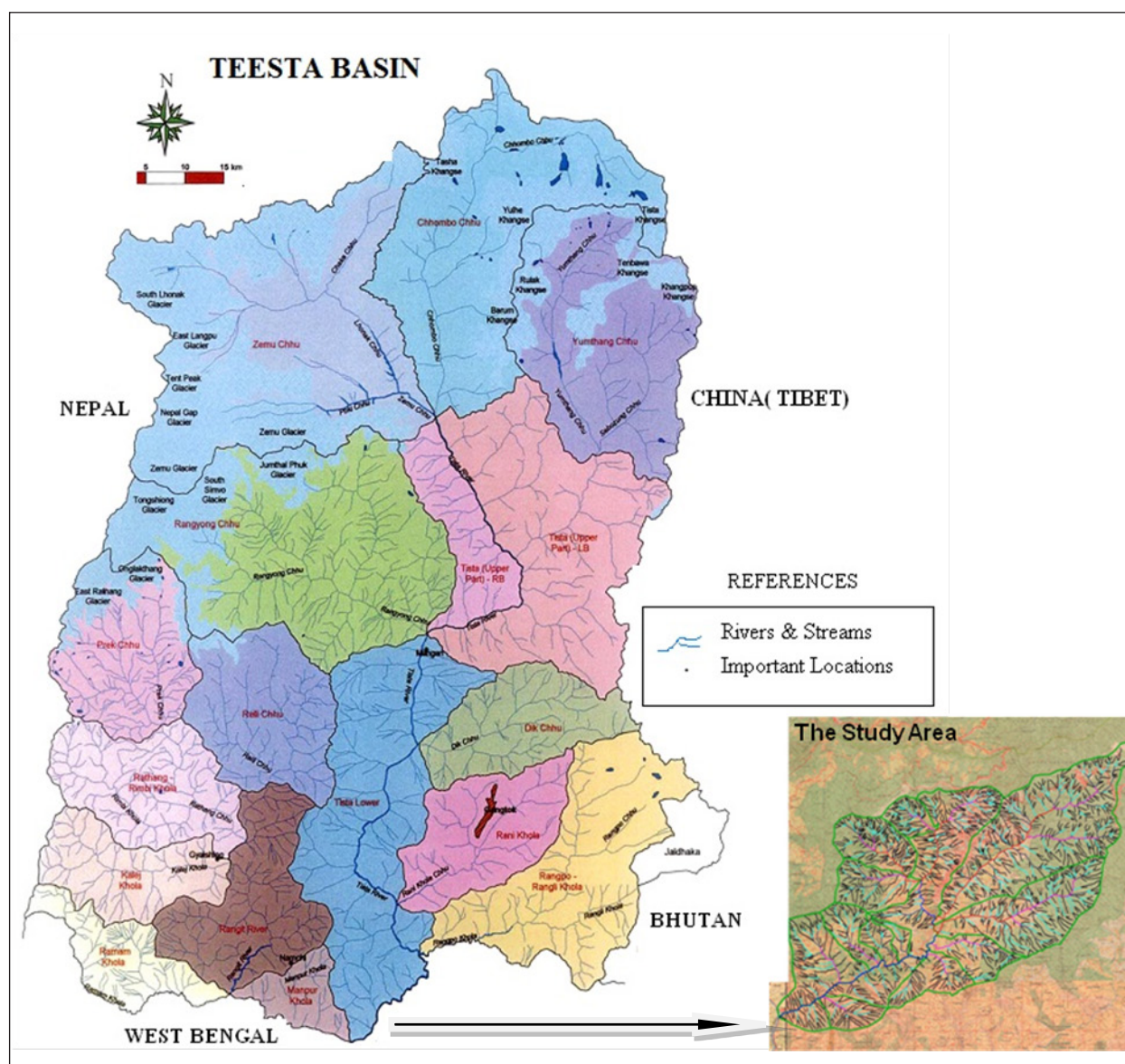


Fig. 1 Study area in Teesta Basin

In the present study **IDRISI's Land Change Modeler** has been used to assess historical land cover data and to use that assessment to predict future scenarios. It has been done by assessing past land transition information and incorporating environmental variable maps that might drive or explain change to create future scenarios and layers of transition potential maps. **GEOMOD** model is used for simulating the transition from one land use state to another. Both of them have been used for projecting and assessing its implications for habitat and biodiversity change to reach a refined model solution and yield better results for landuse changes and its prediction for the concerned watershed.

The landuse change prediction can be done by using **IDRISI's Markov Chain Analysis** in which the state of a system at time 2 can be predicted by the state of the system at time 1 and given a matrix of transition probabilities from each cover class to every other cover class. The Markov module can be used to create such a transition probability matrix. As input, it takes two land cover maps. It then produces a transition probability matrix which indicates the likelihood that a pixel of a given class will change to any other class (or remain the same) in the next time period. It also creates a transition area matrix which expresses the total area (in cells) expected to change in the next time period. The conditional probability images

express the probability that each pixel will belong to the designated class in the next time period. They are called conditional probability maps since this probability is conditional on their current state.

Cellular Automata is another method of analysing the changes which shows proximity areas will have a higher tendency to change to a class when they are near existing areas of the same class. However, a cellular automaton procedure is very specific to the context of predictive landcover change modeling is implemented with the CA-Marcov module.

In the present study satellite remote sensing data of LANDSAT-7+ETM imagery of 1977 and 1991, IRS ID LISS-III data of 1989, 1997 and 2002, IRS Cartosat data of 2007 and IRS P6 LISS-III data of 2010 have been used for temporal land use change detection. Out of the available seven bands in Landsat TM data, only four bands (band 2 to band 5) that are spectrally and radiometrically identical to band 1 to band 4 of IRS P6 LISS III image were chosen for classification purpose. To keep away from artificial alteration in LULC change analysis, preprocessing such as geometric correction, radiometric corrections and radiometric normalization for images of different dates were carried out with due care. In the present study, nine thematic classes have been considered from signatures as well as ground truth data collection.

The soil moisture, salinity and organic matter are important soil properties which determine soil spatial variation and integrate soil, land cover and atmosphere systems, influence the atmospheric precipitation and the redistribution of energy between the latent heat and the sensible heat, and finally govern the distribution of vegetation cover and the land productivity level. It has got immense importance in analyzing and simulating the fluid movement and the material migration process of dissolved matters, simulating hydrological processes and optimizing agricultural activities. For the study area soil data is extracted from NBSS & LUP soil map of 2000 in 1: 1 million scales. There are three major soil groups identified over the study area i.e., sand, silty loam and sandy loam. The organic matter content over the study area varies from 1.0 to 4.0 %. As here is no other published data available for spatial variation

of organic matter content it is assumed that the areas which are having greater vegetation cover have more organic matter content in soil and vice versa.

The daily rainfall information is obtained from Asian Precipitation - Highly-Resolved Observational Data Integration towards Evaluation "APHRODITE" (V1003R1 dataset having spatial resolution of 0.25°) website. Daily rainfall data of 2002-2013 (April) of Tadong station of Indian Council of Agricultural Research Complex for NEH region have been used for validation of the "APHRODITE" website data.

3. Prediction of Future Landuse Scenario

Markov model, which is based on probability that a given piece of mutually exclusive state of land will change from one to another, was applied to compute the current rate of change or transition probability. For generating transition probability, first a transition matrix of pixels in each class during the periods 1977 to 2010 was generated. In next step generation of probabilities of change between classes has been done. This was accomplished by dividing each cell value by its row total. The result is the probability that a given class in year 1977 will convert to another class in year 2010 in all possible ways. Although the transition probability may be accurate on a per category basis, there is no sense of geography i.e. knowledge of the spatial distribution of occurrences within each land use category. Therefore, a *Markov Chain Cellular Automata* model called *CA_Markov* implemented in IDRISI 15 raster GIS was used the output from the Markov model particularly for transition area file. Besides the transition area file the model requires a series of standardized (0 - 255) suitability image file for each of the LULC classes. In the present study, land use transition suitability image for a given LULC class was empirically derived from the current land cover images (2010), slope, distance from stream and major road network. The CA loops time was selected as 15 years to run the model at yearly increment because the transition probability matrix was obtained over a span of 15 years. A contiguity filter of size 5×5 was applied to "grow out" land use from the baseline time (2010) to predict a future land use scenarios (2025-2040).

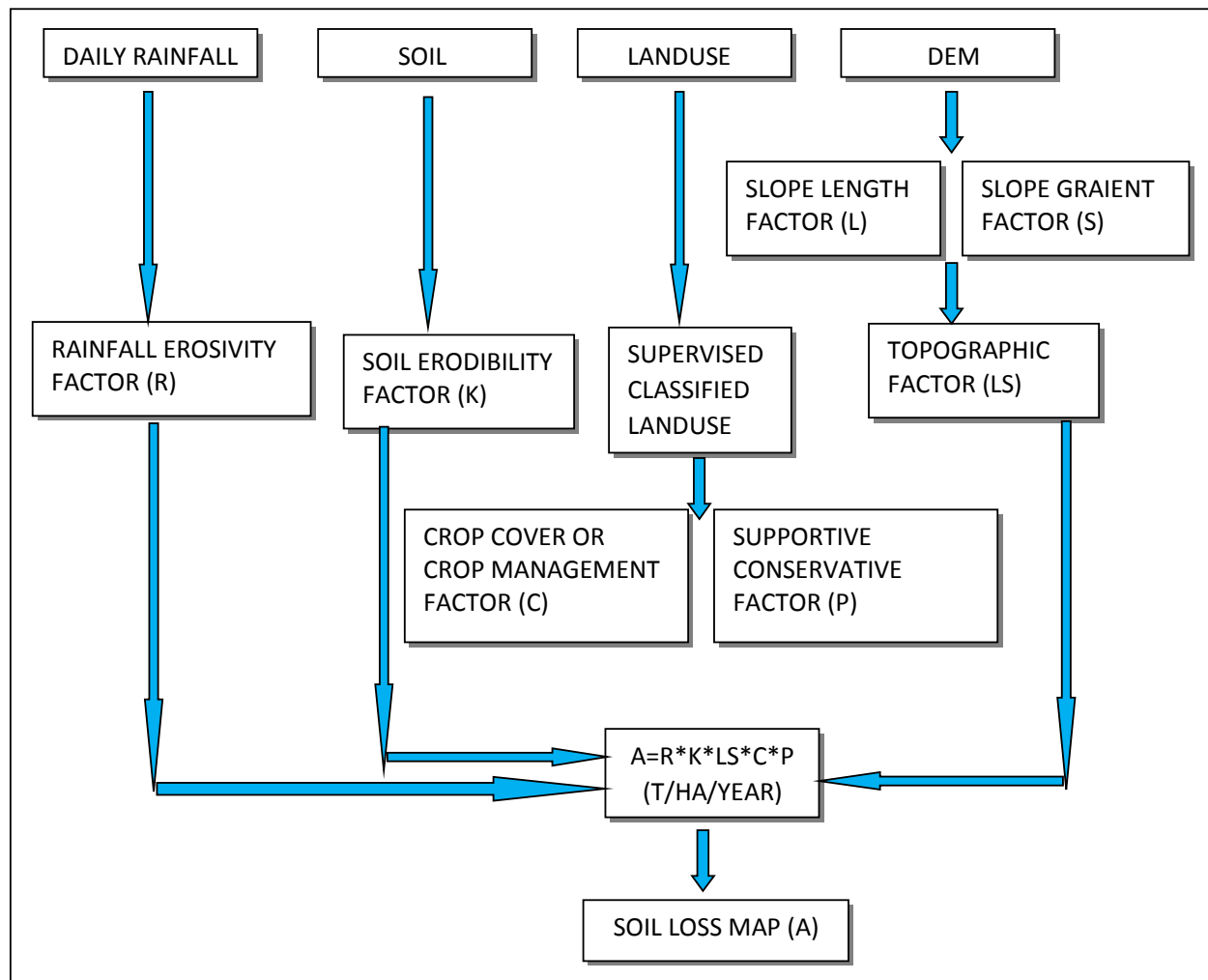


Fig. 2 Universal Soil Loss Equation Model

4. Hydrological Modeling

Soil loss estimation by universal soil loss equation (usle) model

The methodology used in the study was the implementation of the Universal Soil loss Equation (USLE; Wischmeier and Smith 1978), which is one of the most widely used model for erosion hazardous, prioritization and soil conservation planning on watershed scale. The model (Fig. 2) estimates average annual soil loss rate using a factor based approach with rainfall intensity, soil erodibility, topography, crop cover and management practices as inputs to derive annual soil loss estimation per unit area per year. Limitation of this model is that it does not correctly estimate deposition, sediment yield, channel erosion or gully erosion by the following formula and confined to rill and inter rill erosion only. The

USLE is expressed as: $A = R K LS C P$, Where A is average annual gross soil erosion or soil loss rate ($t\ ha^{-1}yr^{-1}$), R is rainfall erosivity factor ($MJ\text{-}mm\ ha^{-1}\ hr^{-1}\ yr^{-1}$), K is the soil erodibility factor ($t\text{-}ha\text{-}hr\ ha^{-1}MJ^{-1}\ mm^{-1}$), L is the slope length factor, S is the slope gradient factor, C is the crop cover or crop management factor and P is the supportive conservation practice factor. Soil loss from sub-basins ranges from 0.5 to 21 tonnes/ ha/ year.

Study area can be assumed. Stream network were delineated using a threshold of 2000

Pixels which after editing generate 137 microwatersheds. The hydrologic response

Units (HRUs) were created by overlaying the LULC map of the year 2004, soil map

With user defined soil database and slope maps of the entire catchment. For the slope

input, three slope classes of 0-2%, 2-5% and >5% were chosen. Multiple HRUs were

METHODOLOGY OF USLE

5. Decision Support System and Multi Criteria Analysis

Spatially distributed models are powerful tools that can support decision making processes in environmental policies and are able to predict the effects of changes in a distributed way and to relate the typical upstream-downstream relationships that are fundamental in order to reach a well balanced watershed management system. *Soil and Water Assessment Tool (SWAT)* is a hydrological model possessing the ability to assess the impact of land management practices on water, sediment and agricultural chemical yield in complex watersheds. To assess the soil erosion and the runoff the sensitivity analysis of the model is applied specially to assess different scenario generation and data base creation for MCA for sustainable development and management of the studied sub watershed. The results of this research work would link optimizing technique and environmental model to realize model output and to improve optimum proportional

solution for decision support system (DSS) for sustainable watershed management planning.

Summary and Conclusion

Geospatial technology has significantly changed watershed management in recent time. Advancement in GIS, remote sensing, GPS, internet and web mapping have improved in such a manner that stake holders of any watershed can communicate and exchange information much easily than before. Procedures that took a year or more when conducted manually, such as hydrologic model parameterization, can now be conducted in a much lesser time. As management decisions move toward a bottom-up approach, Geospatial technology can provide communication and education for people's participation. The information technology offers an efficient medium for transferring and sharing information among decision makers and planners. The information emerged from the micro watershed study may be used by the decision makers and planners to restrict the cumulative progressive degradation of land and may be utilised as a reference watershed unit for other similar type watershed also.

Assessment of Economic, Social and Environmental Impacts of Land Use Changes in Arid Western Rajasthan using Cartographic, Remote Sensing and GIS Technologies

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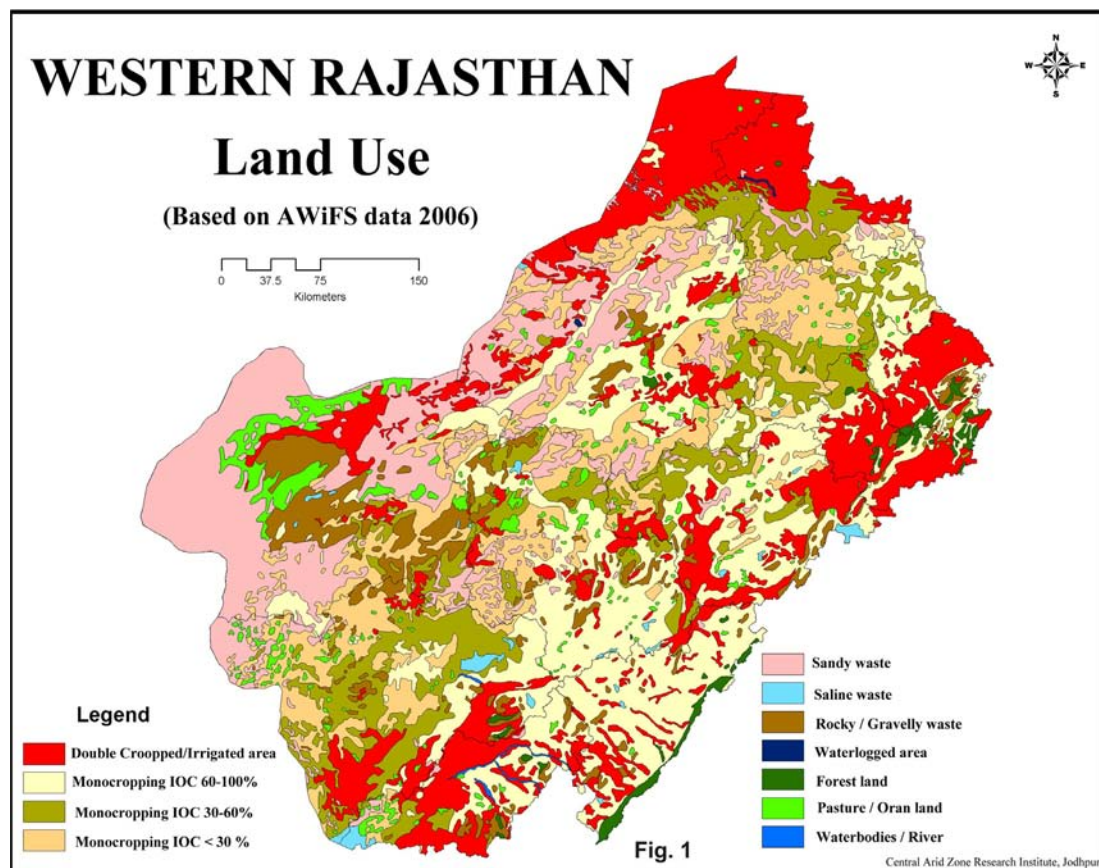
Keywords: Land Use Changes, Arid Rajasthan, Cropping Pattern, Crop Production, Economic and social impact, Environmental impact

Abstract: Land use is a dynamic and complex system which keeps changing with time through human intervention and natural forces. Natural resources in environmentally sensitive hot arid zone of India are more prone to degradation. The present study attempts to assess environmental, economic, social and impacts of land use changes in hot arid region of western Rajasthan through multi-dimensional approach of cartography, remote sensing, GIS and long term dataset. Through digital interpretation of LISS-III data from 2004-05 to 2007-08 supported with field check, land use maps of 12 districts of arid western Rajasthan are prepared on 1:2,50,000 scale. These were compared with old district level land use maps prepared through field survey at CAZRI from 1974 onwards and land use changes were identified and documented. Statistical data on land use, cropping pattern, crop production and other relational aspects from 1957-58 to 2009-10 are analyzed to assess the changes. Impact of such changes on natural resources and economic and social conditions of rural households are brought out. During this period the net sown area has increased by 33.64%, total cropped area by 60.44% and double cropped area by 20 times. On the other hand culturable waste lands are declined by 21.81%, other fallow lands by 36.13% and current fallow by 17.15% respectively. The net irrigated area has increased from 0.61 to 2.85 mha. Gross irrigated area has increased by 494.54 %. This gave way to introduction of new irrigated crops viz. cumin, isabgol, methi, fennel and castor. Total crop production increased from 1.65 to 6.1 million tonnes. Large scale infrastructures developed. Secondary salinization, development of sodicity, waterlogging, shrinkage and degradation of grazing lands, loss of biodiversity and biomass cover and creation of mine spoiled and industrial effluents affected are some adverse land use impacts.

Introduction

Land use and land management practices have a major impact on natural resources including water, soil, air, nutrients, plants, and animals. Land use is a dynamic and complex system which keeps changing with time through human intervention and natural forces. Such land use changes are necessary for economic development and social progress of a country (Jun Jie, 2008). Rapid and large scale land use changes have not only brought out environmental instability but also decreased the productivity of the rural ecosystem (Tiwari, 2008). In environmentally sensitive hot arid western Rajasthan natural resources are prone to degradation. Further, western India is getting warmer by 0.13° C per decade and land use/

land cover is contributing towards overall warming by 0.06° C (Nayal and Mandal, 2012). Increased societal demands for land based products caused expansion and intensification of agriculture and mining. Net sown area has increased from 118.75 mha to 142.2 mha, gross cropped area from 131.89 to 190.76 mha, net irrigated area from 20.85 to 54.57 mha and gross irrigated area from 22.56 to 72.78 mha respectively. Exploitation of natural resources far beyond their regeneration capability and inappropriate land uses caused degradation of ground water; development of salinity/sodicity/waterlogging and mine spoil area; and degradation of CPR. In order to save precious and finite land and water resources from further degradation and putting them into sustainable use, the impacts of land use



change on environment, economic and social conditions of rural communities are to be properly assessed. The present study aims to fulfil the above objectives using recent RS&GIS technologies, district wise land use maps and long term multi-facet data. Measures are also suggested for rehabilitation of degraded lands and sustainable use of land and water resources.

Study area

Hot arid zone in India occupy 31.7 mha of which 61.9% is concentrated in north-western India. About 61% of the total area of Indian arid zone is concentrated in 12 western districts of Rajasthan with a total geographical area of 208,751 km². The region extends from 24° 37' 00" to 30° 10' 48" north latitudes and between 69° 29' 00" and 76° 05' 33" east longitudes (Fig. 1). This hot arid region is characterized by low and high erratic rainfall, high evaporation loss and extremes of diurnal and seasonal temperatures. The average annual rainfall varies from 456 mm in north east to less than 100 mm in western most part of Jaisalmer district. The coefficient

of variability of annual rainfall varies from 40% to 70%. Temperature during long hot summer days goes as high as 50° C while in cold winter it falls below - 6° C. Mean aridity index is 78%. Probability of occurrence of drought varies from 50-60%. Mean moisture index varies from -59.5 in Sikar to -88.9 in Jaisalmer. The length of crop growing period varies from 8 to 15 weeks. The mean maximum expected wind velocity is about 30-40 km/ph, but can reach as high as 100 km/ph during severe dust storms. Mean relative humidity during July and August ranges between 75-80% and during winter from 46-56% (Narain et.al, 2006). The region is covered by three agro-ecological regions viz. western sandy plain, central alluvial plain and northern canal irrigated plain, 7 zones and 19 sub zones (Faroda et.al.1999).

Dominant landforms are the sandy plains with varying degree of hummocks and sand dunes. These are encountered with hills and outcrops (of mainly granite, rhyolite, sandstone and limestone), saline depressions and buried channels. Light textured sandy soils cover major part of this region. Desert soils are

lower in fertility status, water holding capacity, very low in organic matter and high in pH values. The soils have high infiltration rate. Deep sandy soils within dunes and interdunes occupy 28.36%, soils of sandy plains 40.05%, shallow soils with hard pan 3.87%, fine sandy loam 7.06%, medium sandy loam to loam 5.99%, clay loam 6.87%, saline soils 1.25% and shallow gravelly soils 3.88% area. Vegetation is quite sparse with limited number of xerophytic plants and thorny bushes. Drainage, except ephemeral *Luni* river system, is mostly internal. There are 550 reservoirs/tanks with storage capacity of 1169.28 mcm. Luni basin has 858 mcm capacities of which 700 mcm is utilizable potential (Khan, 1997). Total inflow of water is 57910 mcm (50124 from rainfall and 7786 from canal). Ground water is deep, scares and over exploited. In 45% area ground water is saline to very saline and in 40% moderately brackish. Total replenishable groundwater resources of the region comes to 3753.23 mcm, net groundwater availability 3427.27 mcm and annual groundwater draft 4355.61 mcm (CGWB, 2011). As per 2011 census the region has 27.12 million human populations. Density of population varies from 17 in Jaisalmer to 361 in Jhunjhunun district. Working force is 45.13%. Out of this 67.1% are cultivators, 11.67% agrl. labourer, 2.25% household industries and 18.98% other workers. BPL households are 23.09% (Anon. 2011b). The region has 14,374 villages and 86 towns. Livestock population is 29.11 million as per livestock census 2007. Of the total livestock cattle constitute 17.36 %, buffalo 11.85%, sheep 28.96%, goat 40.2% and camel 1.2% respectively.

Materials and Method

Land use maps of all the twelve districts of western Rajasthan prepared at CAZRI from time to time on 1:2,50,000 scale were updated through digital interpretation of IRS P6 LISS-III data from 2004-05 to 2007-08, using Arc GIS 9.2 version software and district wise statistics were generated. The results were compared with the statistics of old maps and land use changes were worked out. These maps were compiled and final land use map of western Rajasthan was generated through GIS on 1 million scale (Balak Ram and Chauhan, 2009). The socio-economic impacts are assessed at district level through analysis of multi-facet dataset from 1957-58 to 2009-10.

Results and Discussion

Land Use:

The statistics based on the land use map of western Rajasthan on 1 million scale (Balak Ram and Chauhan, 2009) reveal 13.91% area under irrigated cropland, 54.71% under rainfed cropland, 1.3% forest land, 4.14% permanent pasture, 24.21% wastelands and 1.78% under water bodies and built-up area respectively. Dominant land uses are shown in fig.1. Irrigated area through canals occurs mainly in Gang, Bhakhra and IGNP canal commands in Ganganagar, Hanumangarh and Bikaner districts. Ground water irrigated area occurs in younger alluvial plains, interdunal depressions and valley fill regions. The intensity of cultivation decreases from south east to north-west with the declining rainfall. Among wasteland sandy waste is most dominant occupying about 17.6% area. As per land records data of 2009-10 agricultural lands constitute 66.97% of the total reporting area. This includes net sown area 51.87%, current fallow 8.08% and other fallow lands 7.02%. The total cropped area comes to 61.41% and double cropped area 9.54%. Permanent pastures, forest, land put to non-agricultural uses and barren & uncultivable land constitute 3.8, 2.36, 5.5 and 4.02 percent respectively (Anon. 2011a). Churu district occupies highest (88.4%) rainfed agricultural area while Jaisalmer has least one (21.1%). Net irrigated area constitutes 13.69% (2.85 mha) and gross irrigated area 20.1% (4.18 mha). The irrigation intensity varies from 106% in Pali to 182% in Hanumangarh district. Cropping intensity varies from 106% in Barmer to 153% in Jhunjhunun district.

Cropping Pattern:

Western Rajasthan occupies 74.5% of the total cropped area under bajra crop in Rajasthan state, guar 45.8%, moth 99.75%, moong 77.19%, sesame 44.41%, groundnut 75.53%, mustard 33.04%, cumin 97.61%, isabgol 98.52% and methi 61.98% as per agricultural statistics 2009-10. Bajra, guar, moth, moong and sesame are most important rainfed kharif season crops produced throughout the region covering 28.31%, 17.74%, 9.31%, 5.22% and 1.62% of the total cropped area in western Rajasthan. Jowar and cowpea are lesser significant crops. Jowar (1.87%) is mainly produced in Pali, Nagaur and Jodhpur districts and cowpea (0.80%) in Sikar,

Jhunjhunun and Nagaur districts (Anon. 2011a). Wheat, mustard, gram, groundnut and cotton are important irrigated crops constituting 7.19%, 5.36%, 4.89%, 1.51% and 2.78% of total cropped area. Others are barley (0.83%), cumin (1.45%) isabgol (1.65%) and paddy (0.25%). Cumin and isabgol are mainly cultivated in Barmer, Jalor, Nagaur and Jaisalmer region; barley in Sikar, Ganganagar and Hanumangarh districts and paddy absolutely in Ganganagar and Hanumangarh districts. Castor (0.64%) and Tatamira (0.13%) are mainly grown under conserved moisture. Castor is mainly produced in Jalor, Jodhpur and Barmer districts. Similarly gram is grown both under irrigation and conserved moisture.

Crop production

Out of the total crop production in the region i.e. 6.1 million tons, 55.37% is contributed by cereals, 6.75% by pulses, 21.33% by oilseeds, fibre crops 2.27%, sugarcane 2.66%, condiments & spices 2.15%, isabgol 2.10%, guar 2.6%, and fruits and vegetables 4.67% respectively as per agricultural statistics 2009-10. Bikaner, Churu and Nagaur have highest production of pulse crops while Ganaganagar, Jodhpur, Hanumangarh, Bikaner and Nagaur have dominancy over oilseed production. Jaisalmer district contribute only 1.1% of the total crop production in arid Rajasthan. The production of rice during the year was 107864 tons, bajra 531950 tons, jowar 5460 tons, moong 35015, moth 40129, cowpea 9363, sesame 7596, groundnut 223130, castor 93812, cotton 138153, guar 161155, red chillies 2510, wheat 2405846, barley 305903, gram 322376, mustard 962147, taramira 6103, cumin 78591, methi 39680, isabgol 127936 and mehandi 2978 tons respectively (Anon. 2011a). The production of rainfed crops is entirely depends on amount, distribution pattern and intensity of rainfall.

Changes in Land Use, Cropping Pattern and Crop Production

The human population in the region has increased from 7.64 million in 1961 to 27.12 million in 2011 and that of livestock population from 13.72 million in 1961 to 29.11 million in 2007. This burgeoning pressure and societal demands on one hand and division of holdings on the other led to expansion and intensification of agriculture through reduction in fallowing practices, conversion of culturable waste land

category into agriculture. Development of ground water, construction of water storage/harvesting structures, introduction of canal irrigation, tractorization, use of high yielding varieties, fertilizers, disease pest management, improved farming practices, credit facilities together have improved the agricultural situation to a great extent. Expansion of cultivated area has mainly taken place in Bikaner, Jaisalmer, Churu and Barmer districts where as intensification of agriculture taken place in Sikar, Jhunjhunun, Ganganagar and Hanumangarh districts. During the period from 1960-61 to 2007-08 (Malhotra *et. al.*, 1983 and Anon. 2011a), the net sown area has increased by 33.64%, total cropped area by 60.44% and double cropped area by 20 times. On the other hand culturable waste lands are declined by 21.81%, other fallow lands by 36.13% and current fallow by 17.15% respectively. Net irrigated area has increased by 366.92% (from 0.61 to 2.85 mha). Increase in net and gross irrigated areas in the region has been 350.0 and 494.54 % respectively. Area under canal irrigation increased from 2,79,000 ha to 10,23,784 ha and that from wells from 2,54,000 ha to 13,20,868 ha between 1956-57 and 2007-08. During this period 165 minor and 18 medium irrigation projects were completed to enhance the area under tank irrigation from 31,000 to 55,656 ha. Such expansion in irrigated system has led to increase in the net sown area by 70.75%, double cropped area by 935.98% and total cropped area by 70.75%, respectively. The trend in different land use categories from 1957-58 to 2009-10 are shown in Table 1 and fig. 2.

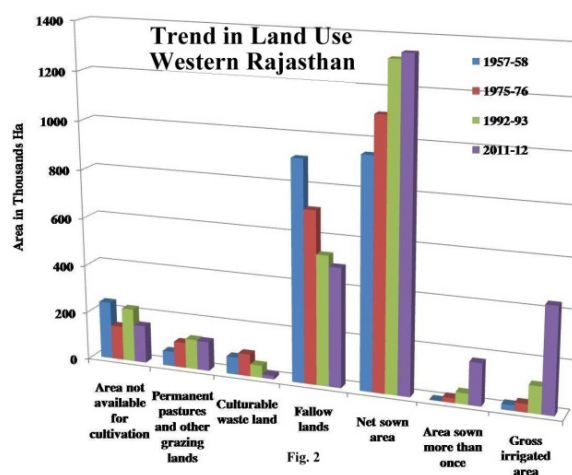


Table 1: Land Use Changes (%) in Arid Western Rajasthan (1957-58 to 2009-10)

Year	Forest	Area under non- agr. uses	Barren and uncultivable land	Permanent pasture and other grazing land	Culturable waste	Fallow land other than current fallow	Current fallow	Net area sown	Area sown more than once	Total cropped area
1957-58	0.69	2.85	11.15	2.30	24.18	14.24	9.07	35.51	0.70	36.21
1962-63	0.59	3.09	11.63	3.51	21.56	10.72	7.50	41.40	0.75	42.15
1967-68	0.72	3.11	11.37	3.71	21.70	7.70	6.53	45.15	2.30	47.45
1972-73	0.81	3.21	11.21	3.74	21.38	7.66	7.16	44.82	1.52	46.34
1977-78	1.23	3.31	4.87	3.96	25.55	7.92	6.87	46.29	2.70	48.99
1982-83	1.45	3.47	4.95	4.12	23.88	6.95	7.48	47.53	3.97	51.50
1987-88	1.73	4.19	5.02	4.10	23.07	11.28	20.60	29.91	2.06	31.97
1992-93	1.90	3.30	4.90	4.05	20.73	6.49	5.43	52.18	5.68	57.86
1997-98	2.00	4.42	4.86	3.97	19.32	7.08	5.99	52.34	12.19	64.53
2002-03	2.13	4.60	4.81	3.91	18.55	11.76	26.68	27.48	5.35	32.53
2007-08	2.35	4.90	4.58	3.90	17.69	7.50	6.29	52.67	11.47	64.14
2008-09	2.35	5.47	4.03	3.89	16.54	7.32	5.72	54.65	11.68	66.33
2009-10	2.36	5.50	4.02	3.89	17.23	7.02	8.08	51.87	9.54	61.41

Source: Statistical Abstract, Rajasthan, 1958 to 2011.

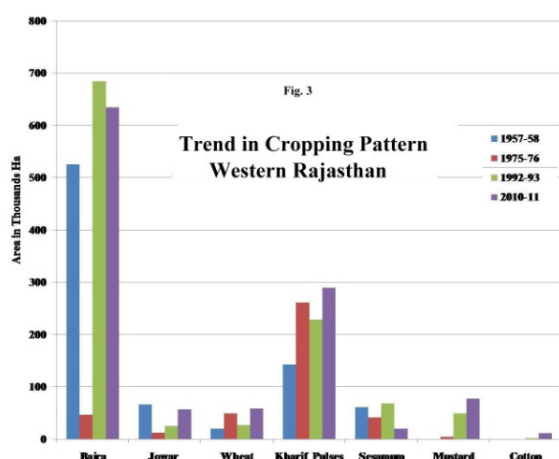
Development of irrigation and introduction of sprinkler system brought significant change in cropping pattern particularly in canal irrigated area. Cumin, isabgol, methi, fennel and castor were introduced as new crops after eighties. Similarly large scale cultivation of gram and taramira on the conserved moisture was taken up. Mixed cropping practice like bajra+moth+guar or bajra+moong+guar is almost withdrawn. Acreage of rice, wheat, groundnut, mustard and cotton increased by 153.5%, 117.3%, 935%, 1988.6% and 289.7% respectively. Jowar, barley and gram registered marginal increase. The acreage of sesame has declined by 5.3%. Trend in cropping pattern is shown in fig. 3. Production of wheat, barley, groundnut, mustard and cotton has increased

manifolds while the production of sesame, jowar and rice declined.

Another significant change in non-agricultural uses is the expansion of mining activities particularly of gypsum, limestone, sandstone, marble and lignite. The production of minerals thus increased from 3.89 to 4.15 million tones. Simultaneously, the expansion of settlements, built-up area and infrastructure facilities also increased in a big way. Area put to non-agricultural uses increased by 58.07 % during the period from 1957-58 to 2009-10. Length of roads increased from 914 km to 6180 km. Similarly the area under forest (mainly unclassified forest) has increased to 106.64 % and protected forest by 230%. In infrastructure development 75.37% villages are connected with roads (57957 km), safe drinking water facilities are available in 85.18% villages and 81.55% villages are electrified.

Impact of land use change:

Increased human and livestock population led to demand of more food and fodder and consequently the intensification of agriculture taken place. Natural resources were utilized to greater extent. Infrastructures were developed and public amenities were created. Impacts of these developments on food availability (IHD, 2009), food insecurity (WFP) and level



of development (Verghese and Mordia, 2006) at district level are shown in table 2.

Environmental Impact: Major positive impacts of land use change are: increase in net sown area, total cropped area, gross irrigated area (both from canal and ground water) and double cropped area; increase in irrigation intensity and cropping intensity, electricity operated tube wells and sprinkler system; acreage of almost all the crops (most particularly irrigated crops); crop production and crop productivity; increase in number of irrigated crops including vegetable and fruit and fodder crops; introduction of new irrigated crops like cumin, isabgol, groundnut, castor and methi; and stability of terrain, stabilization of sand dunes, increase in biomass, afforestation, canal and road side plantation and pasture development in IGNP Command area.

Adverse impacts are lowering of ground water level up to 16.95 meters during 1995-2009; secondary salinization/waterlogging and development of sodicity; conversion of irrigated double cropped lands into rainfed and decline in cropping intensity and crop productivity; conversion of prime agricultural lands into urban use; shrinkage and degradation of common property resources; creation of new wastelands, solid waste and waste water

generation through mining activities; discharge of untreated industrial effluents; abandonment of village ponds (*nadi*) and disruption of natural drainage; decrease in wild food availability, loss of emblematic species; dust pollution, landscape and forest degradation, suppression /extinction of native flora and invasion of new weeds in IGNP Command area; increasing intensity of desertification, drought, flood and other natural hazards; and air and water pollution in urban areas.

Economic Impact: Positive economic impacts are increased agricultural production (particularly of cash crops), production of non-metallic minerals, increased per-capita income and improvement of economic condition of peasants. Purchasing power of farmers has increased and use of tractors and transport vehicles raised many folds. Increase of market, transport, communication, banking and credit facilities in rural area as well as increase in industrial production taken place. Adverse impacts are: increase of land holdings and reduction of average size of land holdings; abandonment of rainfed cropland at several places by small and marginal farmers since it become unsupportive of livelihood; low crop yield, depletion of soil fertility, conversion to degraded and non-productive land and reduction of (ha/cattle) grazing area.

Table 2: Development Indicators in Arid Western Rajasthan (2009-10)

District	Change in human population 1970-2011	Change in livestock population 1971-2007	Change in average size of land holding*	Index of level of development	Food availability index	Food insecurity situation**
Barmer	236.14	126.54	13.77 - 10.13	24.65	Very Low	Mod. Insecure
Bikaner	313.11	186.52	12.05 - 9.41	35.28	Very Low	Secure
Churu	133.43	32.54	10.86 - 6.80	33.62	Very Low	Secure
Ganganagar	168.95	95.74	6.70 - 6.30	46.88	Moderate	Mod. Secure
Hanumangarh				33.61	Low	Mod. Secure
Jaisalmer	302.97	360.75	15.44 - 10.47	28.60	Extremely Low	Mod. Insecure
Jalor	174.0	53.90	6.24 - 5.33	33.78	Extremely Low	Ext. Insecure
Jhunjhunun	130.26	43.51	3.07 - 2.12	35.67	Low	Secure
Jodhpur	219.74	75.72	9.25 - 7.56	39.71	Extremely Low	Mod. Secure
Nagaur	162.19	35.28	6.21- 4.96	31.54	Extremely Low	Mod. Secure
Pali	110.16	22.33	3.97 - 3.70	40.61	Very Low	Mod. insecure
Sikar	156.82	48.01	3.37 - 2.36	32.58	Low	Secure
Total	176.47	78.75	8.26 - 6.28	34.71		

Source: Agricultural Statistics of Rajasthan for 2009-10,

*Change from 1990-91 to 2005-06

** Food Insecurity in Rajasthan, World Food Programme, New Delhi

Social Impact: Important positive social impacts are the increase in literacy percent, employment opportunities, improved housing condition, availability of safe drinking water, electricity and medical facilities; increase of per capita food consumption and availability of more variety of food material; increase in number of school and colleges, public transport system; and better connectivity of roads as well as television and mobile communication system. Adverse impacts are: deteriorating health condition of workers of mining sector, lowering of social status of grazing of livestock; decline in cattle population; reduction of opportunities and access to local community resources for rural poor households; and adverse affect of inflation and increased living cost on the livelihood of poor households.

Issues and Challenges

Major challenges of the region are sustainable livelihood and poverty elevation; enhancing production from rainfed or drylands; increase water productivity and water use efficiency; harvesting, conservation and efficient utilization of surface and ground water; management of grazing lands and livestock; rehabilitation and development of degraded lands; sustainable land management and soil health; combating drought, desertification and addressing climate change issues; and formulation of rational land use policy.

Development Strategies

Important development strategies are integrated management of resources by animal-tree-crop farming system; reversing land degradation and improving soil health; agri-business, prevention of post harvest losses and value addition of agricultural products; development of alternative land use systems; judicious use and management of ground water; sustainable irrigation development for enhanced productivity in IGNP command; development of sustainable rainfed agriculture system; improvement and value addition of biomass productivity; modernization of animal husbandry, dairying and livestock production; rehabilitation and development of degraded lands; reseedling and development of degraded pasture/grazing land; monitoring and management of forest and other treated areas; control and management of waterlogging, salinization and industrial effluents; drought

proofing; scientific mining and rehabilitation and development of mine spoil areas.

Conclusion

Agriculture is the most dominant land use occupying 2/3 area of the region. Of this about 52 % is regularly cropped. Net irrigated area is about 13% of the total area and 24% of net sown area. Rainfed cropland occupies 54% area. Annual cropped area varies from year to year depending on rainfall. The intensity of cultivation decreases from south east to northwest with decreasing rainfall. Nearly 30% area of the region is under different category of wasteland of which sandy waste are dominant. During the last four decades irrigated area has substantially increased while fallow lands and culturable wastelands have declined. Over exploitation of ground water caused lowering of water level and reduction of irrigated area. Irrigation with saline/ sodic water degraded soil structure and fertility. Sprinkler system of irrigation and gram cultivation on the conserved moisture came up in big way. Environmental problems have emerged due inappropriate land use and over exploitation of natural resources and hence should be timely and properly dealt with. The region has enough scope for enhancing production form rainfed cropland, development of animal husbandry and development of culturable wasteland. There is need for increasing water use efficiency & water productivity; harvesting, conservation and utilization of rain water; and drought mitigation.

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Agricultural Development, Status and Prospects for Rural Development in Andaman & Nicobar Islands

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Key words: Agrarians, Agriculture, Campbell Bay, Cropping Pattern, Intercropped, Operational land holding, Nicobaries, Settlers, Tribal Region, Tsunami

Abstract: Andaman & Nicobar Islands are situated in the Bay of Bengal between 6°45' to 13°41' north latitude and 92°12' to 93°53' east longitude. There are three districts. The North & Middle Andaman, South Andaman and Nicobar. Agriculture is the main occupation of these Islands in rural area. Most of people reside in rural area. There are 555 villages in these Islands as per census report 2011 and near about 70 percent population is engaged in agricultural activities while Islands having 6 percent agricultural land and production is maintain year per year by farmers, it has been noted through field visit and analysis of information gathered from farmers and agriculture department and other sources. Here the farmers are facing many problems. Besides, the practice itself presents many social and economic problems. The present primary as well as secondary information, collected through field visits to the farmers and Andaman Nicobar Administration officials in districts the North & Middle Andaman, South Andaman and Nicobar and other government offices.

Introduction

The Andaman & Nicobar Islands located in the Bay of Bengal of the eastern coast of India, consisting of 306 islands and 206 rocks and rocky outcrops. This islands chain is situated latitudinally between 6°45' North to 13° 41' North and longitudinally between 92°12' East to 93°57' East. There are three districts – North and Middle Andaman, South Andaman & Nicobar District, which are divided into nine tehsils as Diglipur, Mayabunder, Rangat, Ferrargunj, Port Blair, Little Andaman, Car Nicobar, Nancowry, Campbell Bay with 555 villages. The total area of Andaman & Nicobar Islands is 8249 square kilometers, out of which 8232.6 square kilometers comes in rural area and 16.64 square kilometers in urban area. As per 2011 census 64.33 percent population live in rural area 35.67 percent live urban area. Only 6 percent land or 50000 hectares land area come under agriculture pre-tsunami and 86.93 percent area in square kilometer area occupied by forest, remaining 7.07 percent area comes for residential and other settlement. Most of rural people of Andaman & Nicobar Islands are agriculturist or primary workers.

Study area

The study includes Agriculture land and Production of different crops and pattern of agriculture whole part of Andaman & Nicobar Islands. The people are engaged in different occupation, but the development of agriculture is carefully studied. The physical factors like relief, climate, soil are not favourable for the agriculture.

Aims & Objectives

The present study is an attempt to analyze the development of agricultural productivity and different types of crops spatial references to the change in cultivated area, cropping pattern and crops yields.

Database and Methodology

The present study is based on mainly primary and secondary data collected from different sources. The primary information has been collected through the field visiting different parts of islands and the secondary data are collected from the Directorate of agriculture Port Blair and Andaman & Nicobar

Administration Port Blair, Census Department and Statistics department of Andaman & Nicobar Administration etc.

Factors affecting Agriculture

The factors affecting agriculture may be grouped under three categories as shown below:

Physical	Economic	Others
1. Climate & technological	1. Market	1. Level of scientific development
2. Soil	2. Transportation	2. System of land tenure
3. Topography	3. Labour	3. Method of land utilization
	4. Capital	
	5. Government policy	

Climate

The overall climate of these Islands is humid, tropical coastal climate, Proximity the equator and the sea ensures a hot, humid uniform climate. These Islands receive rainfall from both the South-West and North-East Monsoons. Maximum precipitation is between May to December. The man annual rainfall is about 3000 Millimeters. The dry season remain warm and dry over these islands from January to April. The climate conditions effects production of crops variety of crops. In dry season few crops, vegetables and fruits are grown with the help some irrigation facilities. The temperature of these Islands is minimum 21 centigrade to maximum 35 centigrade and relative humidity record from 78 96%.

Soils

The agriculture productivity is also depends on the type of soil of region. Generally the felite soil is used for cultivation of crops, soil influence the particular type of food, fibre, horticulture crops and that can be raised on them. The soils of Andaman & Nicobar Islands are mostly sandy, clay loam and loam which are acidic medium texture on the surface of medium to heavy in the hills. The organic carbon and nitrogen of the soil vary from medium to low. The regular increase in iron and aluminum in the profile are seen. The soil of coastal region is sandy alluvium. Important agricultural aspects of the study area are given in table 1.

Table 1. Agricultural Aspect in Andaman & Nicobar Islands

Number of farmers	27461 (as per 2011 census)
Number of Land Holdings	11349 (Agriculture census 2011)
Physiography	Hilly & flat land
Natural of soil (Heterogeneous)	Sandy to heavy clay
PH Factor-Soil	3.75 to 7.5
Agro climatic Zone	1
Area under Agriculture pre-tsunami	50,000 Hectares i.e. 6% of the Total area
Area Permanently submerged in Tsunami	4,206 Hectares
Agriculture Zonal Offices	8
Sub-depots	48
Farms & Plantations	29
Agriculture Godowns	09
Rural Primary Markets	28
Seeds Dealers	14
Soil Testing Laboratory	02
Seed Testing Laboratory	01
Central Store	01
Rural knowledge centre	10

Pattern of Land Holding

The nature of the land holding has an immense importance in the agrarian economy of the area. Very peculiar condition of land ownership in Andaman & Nicobar Islands is that the operational holdings are very small with the size of less than one hectare. The land holding means that size of agricultural land which provides full employment to the farmer's family and allow him to enjoy a reasonable standard of living.

The size of holding has a close bearing on agricultural land use, patterns and yields per unit area. In the rural populated area of Diglipur, Mayabunder, Rangat, Neil, Havelock, South Andaman, Little Andaman and Great Nicobar area, the size of land holding is very small. Some people have 5 hectares of land holding and some others of this area having small holding. All of people are residing in rural area known as settlers. These people have come from different part of country and Bengali Settlers have come from East Pakistan or today is known as Bangladesh under the Govt. of India settlement scheme. Most of Part of Southern group of Islands known as

tribal region. Nicobaries mostly reside in Car Nicobar, Chowra, Teressa, Bompoka, Katchal, Nancowry, Trinket, Little Nicobar, Kondul, Pilomilo, Tillongchang, Ex-servicemen settle from the whole part of the country in Great Nicobar. They grow mostly plantation crop specially coconut crop and other crops as arecanut, some fruits crops and vegetables in very little quantity.

In our union territory, number and area of operational land holding is very small about this, the marginal size group below 5 hectares, small group 1.0-2.0 hectares. Some medium size group and also found large size of land holding of this Islands, on the basis of survey record of year 2012-2013, the 44.98% area was come under the marginal size of group, and the 17.30% of land area is comes under small size of land holding between 1.0 to 2.0 hectares of the area.

Cropping Pattern

Out of the total cultivable area of 50,000 Hectares plantation crops accounts for more than 50% of the available are intercropped with spices, root crops, few fruits & vegetables. Paddy is the main crop during Kharif season covering an area of 9000 hectares. Besides paddy, common tropical vegetables are also cultivated throughout the year both in Kharif & Rabi season. During Rabi season Pulses and oilseeds are also grown in the rice fallows.

Rice based cropping system

The geographical situation and Agro climatic condition of Andaman and Nicobar Islands are quite conducive for rice based farming system. Generally cropping of rice during kharif season is in practice followed by pulses /oilseeds and vegetables during Rabi season.

Coconut based cropping systems

Coconut occupies more than 50% of the total cultivable area. It occupies prime position in the social & economic lives of the people as it is the main source of income and livelihood support of the farming community. Coconut is intercropped with spices like Blackpepper, Clove, Cinnamon, Nutmeg & Ginger, fruits such as Pineapple, Papaya, Banana, Jack Fruit, Mango and Sapota are also intercropped followed by roots crops like Tapioca, Colocasia, Sweet Potato etc.

Arecanut based cropping system

Arecanut is also one of the main plantation crops of A & N Islands. Arecanut is intercropped with spices like blackpepper, clove, cinnamon, nutmeg & ginger. Fruits such as Pineapple, Papaya, Banana, Jackfruit, Mango and Sapota are also intercropped followed by roots crops like Tapioca, Colocasia, Sweet Potato etc. Apart from these betel vines are also grown along with arecanut.

Land utilization

Agriculture & allied activities is the major source of livelihood for about 50% of the Union Territory's Population. The Total land being used for agriculture is relatively small due to paucity of non- forested land and numerous competing infrastructural demands. Thus, only about 6% of the total non-forested land i.e. about 50,000 hectares area being used for agricultural purposes, of which 10500 ha approximately are under field crops and 30000 hectares approximately is under plantation crops. Out of the total agricultural land about 60% is under coconut and other plantation crops and 20% is for paddy cultivation. Land use pattern for the year 2012-13 is given in table 2. The soils of Andaman & Nicobar Islands have been developed under the dominant influence of vegetation and climate over diversified parent materials. These soils show considerable variation in profile and characteristic. There is extreme variability of soils from place to place which itself rules out uniform crops either for field or for plantation. Area and production of major crops from 2001-02 to 2011-12 is given in table 3, area and production of fruit crops

Table 2. Land Utilization pattern during 2012-13

Crop	Area (Hectares)
Paddy and other field crop	10242
Coconut	21875
Arecanut	4225
Cashew	1200
Red oil palm	1593
Rubber	1500
Fruits	3256
Spices	1666
Fallow land	461
Total	46018
Permanently submerged land	4206
Total area under agriculture	50224

Table 3. Area & production of major crops in the Andaman & Nicobar Islands

Crops	2001-02		2002-03		2003-04		2004-05		2005-06		2006-07	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Coconut	25205.0	89.7	25360.0	94.32	25394.74	95.2	25561.40	87.13	20927.0	78.46	21416.0	88.96
Arecanut	4354.0	7300.0	4363.0	7350.00	4379.00	6707.0	4425.37	4781.05	4046.44	3058.46	4056.0	5839.30
Paddy	9801.0	27333.0	10885.1	32111.66	10527.03	30850.0	10734.92	29192.23	7685.47	17255.36	7776.2	21535.26
Pulses	420.0	200.0	1282.5	641.23	696.15	360.6	710.40	368.55	430.05	279.85	726.2	400.04
Oilseeds	46.0	25.0	85.1	40.31	486.29	35.8	90.30	46.61	53.55	34.20	59.9	36.38
Vegetables	4250.0	21250.0	4572.7	31226.41	4730.70	23760.0	5738.24	22768.22	3668.90	25682.30	3803.6	30000.00
Fruits	4136.0	22350.0	4169.0	22141.00	4527.00	26062.0	4083.37	23436.23	2925.20	19528.36	2950.0	22511.00

Crops	2007-08		2008 -09		2009-10		2010 -11		2011 -12	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Coconut	21636.00	80.64	21689.00	81.90	21760.22	84.97	21768.00	95.00	21800.00	105.00
Arecanut	4066.00	5692.40	4147.50	5720.50	4152.50	5200.00	4152.00	5800.00	4220.00	5950.00
Paddy	7333.75	21864.00	7900.00	22100.10	8139.85	24907.01	8390.00	23916.00	8100.00	23976.50
Pulses	2093.34	1369.34	2119.47	1153.57	2971.09	1744.56	2610.00	1154.50	1805.30	980.15
Oilseeds	87.93	72.26	102.59	65.00	110.80	69.80	94.30	51.90	91.50	46.50
Vegetables	3951.60	30823.26	4598.66	30199.70	5200.00	41500.00	5150.00	31300.00	5175.00	34500.00
Fruits	2955.00	22456.60	3005.00	24941.51	3118.51	26767.67	3160.00	28772.00	3250.00	30600.00

Area (in hectares); Production (in Metric tons); Production of coconut (in million nuts)

from 2006-07 to 2012-13 in table 4 and area and production of spices from 2006-07 to 2011-12 in table 5.

Conclusion and Suggestions

The Andaman and Nicobar Islands are having different topographical features which are found, the hilly area is covered by natural vegetation. The plain area is having agricultural land, because the region exhibits equatorial belt

and have a warm tropical and moist climate. The annual rainfall is range between 2500 millimeters to 3000 millimeters. The overall development of the region is highly contained by socio-economic factors like population and land, pattern of land holding and the occupational structure of the people of the area. Agriculture is main source of economic development. Near about 70 percent of the population have engaged in agriculture. These

Table 4. Area & production of fruits in Andaman & Nicobar Islands (from 2006 to 2012-13)

Fruits		Mango	Banana	Citrus Fruits	Papaya	Pineapple	Sapota	Miscellaneous	Total
2006 -07	Area	242.7	1635.57	299.05	369	125.5	99.5	178.48	2950
	Prod.	1088.25	13708	1144.75	2775.5	1175	949.5	1670	22511
2007-08	Area	255.7	1523.54	248.95	370.8	165.8	123.8	266.41	2955
	Prod.	1847	13546.9	1344.46	2182.78	1077.5	895.85	1562.11	22456.6
2008 -09	Area	240.4	1589.64	252.42	375.45	150.18	126.2	270.71	3005
	Prod.	1899.16	15419.47	1489.27	2386.55	1063.29	995.73	1688.04	24941.51
2009 -10	Area	288.64	1596.3	279.61	311.55	224.71	156.4	261.3	3118.51
	Prod.	2558.2	14872.95	1334.36	2104.29	608.42	2914.6	2374.85	26767.97
2010-11	Area	290	1610	281	315	230	160	274	3160
	Prod.	2175	16910	1340	2200	680	2950	2517	28772
2011-12	Area	292	1681	280	320	148	162	367	3250
	Prod.	2750	18535	1350	2350	700	3100	1815	30600
2012-13	Area	295	1675	280.5	325	230	163	287.5	3256
	Prod.	2800	18350	1305	2380	685	3120	2183	30823

Area in hectares; Production (in Metric tons)

Table 5. Area & production of spices in the Andaman & Nicobar islands from 2006-07 to 2011-12

Spices		Black pepper	Clove	Cinnamon	Nutmeg	Chili	Ginger	Turmeric	Total
2006- 07	Area	610.26	165.7	152.59	78.7	363.32	205.56	80.5	1656.63
	Prodn.	37	7.5	18	8.55	868	1850	469.03	3258.08
2007-08	Area	610.26	165.7	152.59	78.7	363.32	204.93	80.5	1656
	Prodn.	35	6.2	17	8.47	683.84	1844.33	474.15	3068.99
2008 -09	Area	613.83	165.9	149.31	66.36	382.02	199.08	82.5	1659
	Prodn.	35.57	4.38	30.49	5.81	559	1524.55	381.41	2541.21
2009- 10	Area	600.4	155.9	150	69.4	392.8	210	83.5	1662
	Prodn.	58.31	4.82	30.6	5.23	573.5	1575	384.1	2631.56
2010 -11	Area	600	156	150	70	394	211	80	1661
	Prodn.	120	5	30	5.25	575	1850	482	3067.25
2011 -12	Area	600	156	150	70	385	210	80	1651
	Prodn.	31.71	1.1	28	3.51	580	1855	485	2984.32

Note : Area in hectares; Prod in Metric tons

Islands are having only 6% of the total area, but crops production is increasing year per year as shown different tables of area production of crops. The cropping pattern is also different in these Islands. The Rabi, Kharif, plantation, spices, crops, vegetables and pulses are grown in the whole rural area.

The present study area is not more developed area because there are various problems which are faced by the people of these Islands. So some suggestions are given for agricultural development. There is an urgent need to development of roads, because the farmers are living far away from the market area. To set up small market centres in different places which would help the people to get the required goods, services, to develop small industries where the farmers can get good returns. To improve the agricultural implements which can be helpful for the farmers get more production from their lands such as tractor, power tiller, pump sets, fertilizers, pesticides and other things which are useful for agriculture. The agriculture production depends on the rainfall. Therefore in dry season there is no any source of irrigation. It is essential to construct the dams,

ponds, tanks for the irrigation of agricultural land. There should be frequent boat and ship services for the southern groups of islands so villagers can come and go back their Islands with agriculture production and essential things those are required for primary work and daily needs.

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The Change in Agricultural Land Use in Ujjain Division of Madhya Pradesh, India

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Introduction

Agriculture is the main occupation of the people of Madhya Pradesh. In Ujjain Division 75 % of working population are engaged in agricultural occupation. Without land resource agricultural work is impossible. There are many use of land, but in different use of land, the agricultural land use is the most important sector. This is the reason that in this research paper the change in agricultural land use of thirty years of Ujjain Division district wise has been studied.

The study area Ujjain Division is situated in western side of Madhya Pradesh. Its area is 33958 Sq Km. The changes are negative or positive in respect of the study area. The study is based on secondary data which are collected from District Hand Bood, Directorate, Bhopal. Average data have been used so that the authenticity of research is maintained. It has Six districts namely Nimach, Mandsaur, Ratlam, Ujjain, Shajapur and Dewas. In 1971

the total population of the study area was 3723267 and in 2001 it became 7435077. To study the change in agricultural land use of the period of 30 years, (1971-74 to 2001-04 average data). Due to increase of population or any other reasons and also to know the changes are negative or positive in respect of the study area.

The Study area

The study area of the Ujjain Division is situated in western side of Madhya Pradesh (Fig. 1) It's area is 26938 Sq. Km. It has five districts namely Nimach, Mandsaur, Ratlam, Ujjain and Shajapur. Ujjain Division lies between $22^{\circ} 16'$ to $24^{\circ} 28'$ North Latitude and $74^{\circ} 44'$ to $77^{\circ} 20'$ East Longitudes'. In 1971 Nimach was a tehsil of Mandsaur district. So the data of Nimach district was included in Mandsaur district. Nimach tehsil became district in 1998. In 1971 the total population of the study area was 31289331 and in 2001 it became 6126854 Table 1.

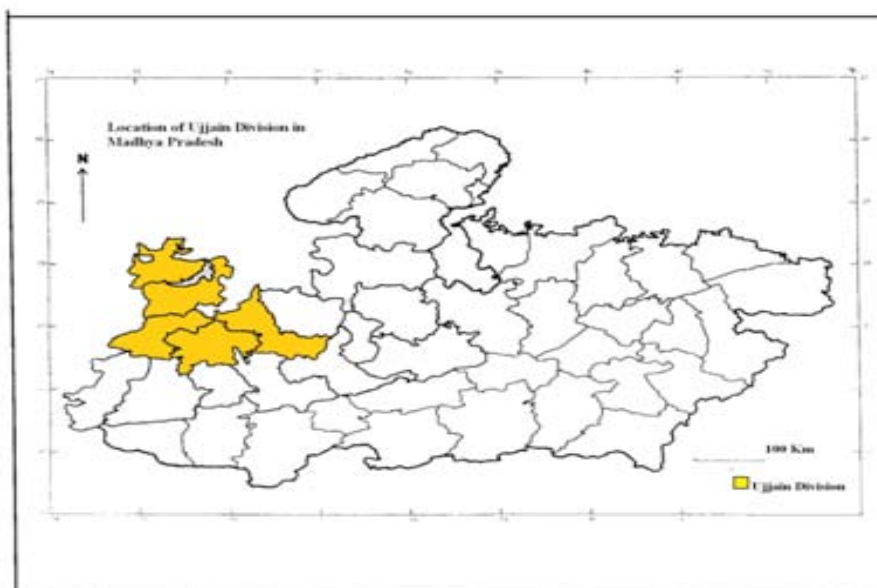


Fig. 1 Study area

Table 1. Ujjain Division: District wise total area and population

S. No.	District	Area (In Km ²) 2001	Population	
			1971	2001
1	Nimach	4256	Included in Mandsaur	726070
2	Mandsaur	5535	961522	1183724
3	Ratlam	4861	626534	1215393
4	Ujjain	6091	862534	1710982
5	Shajapur	6195	678369	1290685
Total	Ujjain Division	26938	3128931	6126854

Objectives

To study the change in agricultural land use of the period of 30 years, due to increase of population or any other reasons and also to know the changes whether negative or positive in respect of the study area.

Methodology

The study is based on secondary data which are collected from district Hand Book Directorate Bhopal. I have analyzed the average data of three years of 1971-74 and 2001-2004. I have used these data, so that the authenticity of research is maintained. Simple techniques are used to analyze the data.

Agricultural Land Use in Ujjain Division:

The study of agricultural land utilization has been conducted in the form of following land use category at district level (Table 2) and fig. 2 and 3.

- (i) Net area sown
- (ii) Area Cropped more than once
- (iii) Total Cropped area

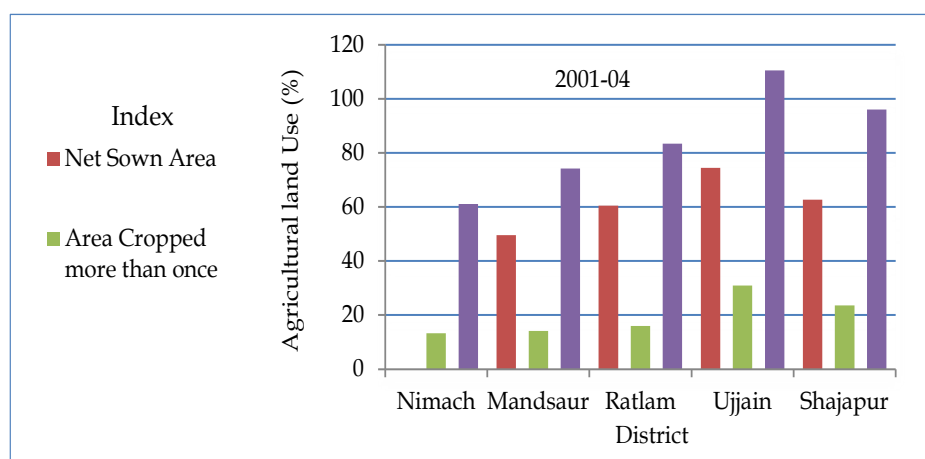


Fig. 2 Ujjain Division: District Wise Changes in Agricultural Land Use (2001-2004)

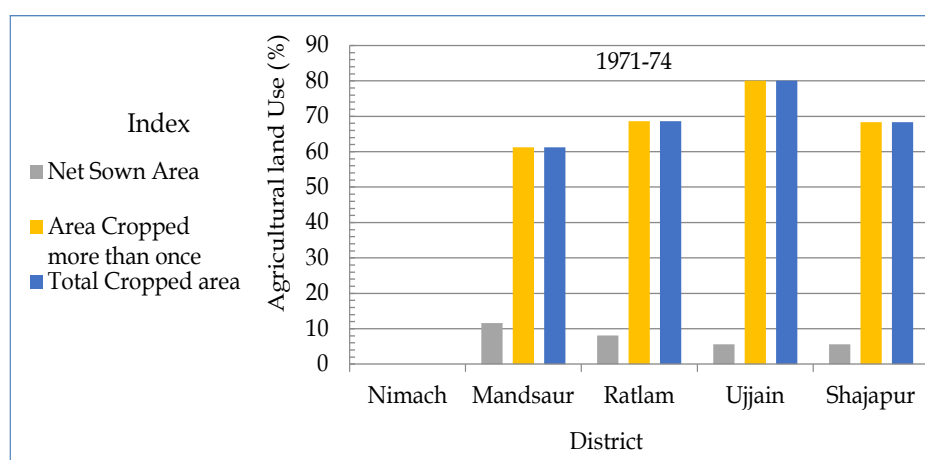


Fig. 3 Ujjain Division: District Wise Changes in Agricultural Land Use (1971-1974)

Table 2. Ujjain Division: District wise Changes in Agricultural Land Use (1971-74 and 2001-04 Average)

District	Geographical area		Net Sown Area		Area Cropped more than once		Area in 000 hect. (%)	
	1971-74	2001-04	1971-74	2001-04	1971-74	2001-04	1971-74	2001-04
Nimach	Included in Mandsaur	393.56	-	188.3 (47.85)	-	52.3 (13.28)	-	240.6 (61.13)
Mandsaur	1013.00	551.80	502.33 (49.58)	354.96 (64.33)	118.33 (11.68)	84.07 (14.20)	620.66 (61.26)	439.03 (74.18)
Ratlam	486.66	486.00	294.66 (60.54)	328.16 (67.52)	39.66 (8.15)	77.51 (15.95)	334.32 (68.69)	405.7 (83.47)
Ujjain	608.6	609.9	453.66 (74.53)	485.53 (79.61)	34.33 (5.64)	188.83 (30.96)	488.00 (80.17)	674.36 (110.56)
Shajapur	618.00	618.43	387.66 (62.72)	448.06 (72.45)	35.33 (5.71)	145.89 (23.59)	423.00 (68.44)	593.9 (96.03)

Source : Directorate Agricultural Statistics Dept. Bhopal

The cultivated land, specifically the total cropped area, excluding the double cropped area is defined for the purpose of land classification as the net sown area. It is the most significant use of land. During the past three decades net sown area of Ujjain Division has increased in all districts 5 to 15 percent. So we can say that such type of change is positive in the study area. Growth in net sown area depends on development of irrigation facilities, population growth and urbanization, favourable climatic conditions, improvement of transport and reclamation of fellow lands in Ujjain division.

Area Cropped More Than Once

Double cropped area is affected by development of irrigation facilities, suitable rainfall, nature of crops, interests of farmers and infrastructure facilities. Table 1.2 shows that in every district this area increased by 3 to 25 percent in a particular average year. It is possible due to irrigation facilities and agricultural innovation. In Ujjain district, the double cropped area was only 5 percent in 1971-74 but in 2001-04 it became 30.96 percent of the geographical area due to increase of irrigation facilities, fertile black soil and development of transport system. In Shajapur district very high increase in percentage in double cropped area has been made possible by the irrigation facilities.

Total cropped Area

It includes Net area sown and area sown more than once where the area more than one crop can be taken in a year. The table 1.2 shows that the change of total cropped area in between last three decades is increasing in a positive way. The reasons are flat land, fertile soil, population growth, craze of cash crop of farmers and small irrigation planning and agricultural techniques.

Conclusion

Very high changes in agricultural land use occurred in Ujjain Division. Net area sown increased in a positive manner. In Ujjain division rapid change in agricultural land use is possible due to infrastructure such as irrigation, transport, mechanization, use of fertilizers and market facility. Thus we can say that the growth in population only is not responsible for the change of agricultural land use. Other factors are also important for change in the land use.

Population is rapidly increasing in the study area. Therefore the pressure is increasing on land. The problems are rising in agriculture day by day. Therefore, it is necessary that an optimum use of the source must be taken care of them otherwise human existence will be danger in Ujjain Division.

Geospatial Thinking Initiative in Sericulture: Assessment of Real Time Photothermal Impact on Growth and Yield of Mulberry

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Abstract: Commercial exploitation and overseas trading of silk- the Queen of Textiles have been thriving in India since 15th century AD. About 7.56 million Indians are engaged along the value chain of sericulture - a labour intensive, low input but high output income generating agro-industry. It earned, Rs. 2353.33 crores during 2011-12 through export of direct and diversified silk goods. 60% of the work force is women in the down stream activities of mulberry sericulture. Sericultural R & D activities at the institutional level influence the livelihoods of the entire workforce by incorporating their work needs and economic aspirations while contriving, designing, conducting, and refining research programs. Agro-meteorological information plays a very crucial role in the decision support system for sustainable sericulture with a view to preserving natural resources and improving the quality of life of the stake holders. Often mulberry foliage abundance does not complement silkworm rearing environment and congenial rearing environments are not met with instar-specific adequate harvestable foliage. Thus resources and efforts are wasted at different scales. As remedial measures, strategy and policy intervention come through forecasting and forewarning models catering the need of mostly resource-poor sericultural farmers, who are exposed to nature's vagaries due to erratic weather under changing climate. Periodical foliage harvest is a heavy stress on mulberry. Quick regeneration, vigorous growth and yield for longer duration are culmination of many temporal plant processes and affected by photo-thermal responses which needs to be dealt with aids of geospatial thinking. Mulberry, like any other plants require a certain amount of antecedent and prevalent heat and light to carry forward the life-cycle processes. Because of yearly variations in weather, calendar dates are not a good basis for making management decisions. Measuring the amount of heat and light accumulated over the time provided a physiological time scale that was biologically more accurate than calendar days. In the present paper, growth and development of three improved mulberry varieties were studied in an irrigated geo-referenced location (24°06' North Latitude and 88°15' East Longitude) which is regarded as traditional sericulture-practicing and silk-growing area. The time pattern related to the development of different phenophases of these varieties under the influence of the specific quantities of accumulated heat and light were estimated with the help of temporal data sets along with growth and yield. The resultant model deciphered that lower accumulation of heat in terms of degree days having the base threshold temperature as 13°C coupled with longer photoperiod in terms of bright sun shine hours, greater foliage yield was expected. The strength of Multiple Correlation (R) being 0.96 and Coefficient of Determination (R²) being 0.92 confirmed the fitness of the regression model. This study opened the vista for using geo-spatial thinking aids for wider applications in space -time -mulberry yield level for better crop management and facilitating the sericulture farmers reaping higher benefits out of it.

Introduction

Mulberry (*Morus* sp.: Moraceae) flourishes extensively from 38°57'19" N 12°19'45" W to 18°55'52" N 126°32'32" E covering Spain to

Korea including China, India, Central Asia and the Near East; from 33°38'25" N 14°20'58" W to 3°55'22" N 48°19'01" E spanning across North and East Africa and again from 54°33'51" N 164°35'39" W to 54°58'41" S 65°09'57" W

spreading over the United States to Argentina, including Mexico, Central America, Colombia and Brazil. The most cultivated mulberry varieties are believed to have originated in the China/Japan area and in the Himalayan foothills. It is a very important horticultural crop worldwide and sericulturally important cash crop in at least nine countries. The domesticated silkworm (*Bombyx mori* L.) feeds exclusively on mulberry leaves and derive required nutrition to produce silk- a proteinaceous fibroin filament coated with gummy sericin. Mulberry is perennial in nature and its leaves are harvested during various phenophases or the vegetative growth stages in commensuration with the age of silkworm larvae.

Ontogeny of mulberry in the context of sericulture can be defined as the study of the time pattern of the phenophases related to the development of biological events of emergence of axillary buds and leaf tip. Unfurling and maturity of leaf and leaf yield in the plant life cycle as affected by the plant environment. The study of phenophases and correlating it with weather extracted from temporal data sets are the most essential component of any crop-weather relationship which could be used to quantify the most appropriate rate and time of the specific developmental phases for the maximization of the crop yield during the life cycle (Kumar *et al.*, 2008).

The metabolism of any plant is governed by a set of genetically pre-determined chemical reactions which include physiological life cycle processes and phenotypic expressions of all genetic traits. The speed at which the metabolism occurs is photo-thermally controlled because the enzymes that drive the reactions are mostly photo-thermo-sensitive. Leaf harvest is a heavy stress on mulberry and Fukui (2000, 2001, 2005, 2007 and 2008) felt the necessity of estimating the state of the growth in order to obtain a stable yield and design silk worm rearing encompassing the effect of temperature and light on phenophases of mulberry.

Unless stressed by other environmental factors like moisture, the ontogeny of leaf right from emergence to maturity of mulberry like any other plants depended upon the daily air temperature (Sugazawa, 1968; Suzuki and Kanaya; 1981) which in turn is universally

affected by light. Plant development phases are very much dependent on antecedent and prevalent temperature and the daily accumulation of heat (Klepper, 1991). The amount of heat required to move a plant to the next phase of development remains constant from year to year owing to genetic pre-disposition. Nevertheless, the actual amount of time in terms of calendar days can vary considerably from year to year because of weather conditions. Tracking growth and yield using photo- thermal units has taken momentum since 1990's in agricultural field crops and insects (Altman *et al.* 1995; Tripathy *et al.* 2004; Dubey *et al.* 2006). Growth and yield can be estimated by accumulating degree days between the high and low temperature thresholds throughout the life. Since many developmental events of plants depend on the accumulation of specific quantities of heat sensitized by light duration, it is possible to predict when these events should occur during a growing season regardless of differences in temperatures and photoperiods from year to year. Each developmental stage of an organism has its own total heat and light requirement (Miller *et al.* 2001).

The basic concept of growing degree days is that plant development occurs when temperatures exceed a base temperature. In mulberry the base temperature was experimentally determined as 13°C (Rangaswami *et al.*, 1976, Dutta, 2002; Sarkar *et al.*, 2005; Ganga and Chetty, 2008). Sarkar *et al.* (2005) deciphered the relationship of growing degree days (GDD) with shoot elongation and leaf yield of mulberry and emphasized the necessity of a mulberry crop calendar basing on GDD replacing the currently prevalent crop schedule based on calendar-day .

The time pattern related to the development of different phenophases in the plant as affected by the environmental factors was reported by a number of authors while taking the accumulated degree day and photoperiod into consideration for estimation of phenophase duration, growth and yield of various fields crops (Sinclair, 1984; Rickman and Klepper, 1991; Tripathy *et al.*, 2004; Bazgeer *et al.*, 2008).

Therefore, the present study was conducted to estimate the accumulation of GDD and Photoperiod numerically triggering sequential

growth of silkworm instar-specific mulberry and their impact on realized leaf yield.

Study area

A field experiment was set up at the irrigated farm of Central Sericultural Research & Training Institute, Berhampore having 24°06' North Latitude and 88°15' East Longitude. The soil of the experimental site was Gangetic Alluvial with a pH of 7.5.

Materials for the study

Three high yielding varieties on an established and irrigated mulberry plantation having a spacing of (150+90) cm x 60 cm. of were chosen for the study. These mulberry varieties namely, S1, S1635, C2038 were developed gradually in the Institute in different years with a yield potential of 28-29, 44-45 and 54-55 MT per hectare per year respectively (Bajpeyi *et al.*, 2007).

Methodology

The study was conducted with the help of temporal agro-meteorological observations during monsoon (July-August), 2012. After pruning the mulberry varieties at the ground level on July 2, 2012, the record of maximum and minimum temperature and bright sunshine hours (Automatic Weather Station, CSR&TI, Berhampore: courtesy Indian Meteorological Dept., Govt. of India) along with phenological

observations on days required for events namely sprouting of axillary buds, leaf tip emergence, unfurling and maturity of leaves were initiated immediately (Fig. 1). Recording of leaf yield data was initiated from 30 days after pruning and continued till 60 days at an interval of five days as per methodology propounded by Sarkar *et al.*, (2005). The increase in leaf yield of selected 15 plants was estimated by using the mean fresh weight of leaves per unit shoot length of another 15 sample plants of similar size in placebo sacrificed at each harvest. The growth and leaf yield of the experimental plants of each variety at each harvest of 5 days interval was continuously scrutinized from 15 plants of similar type, identified as placebo, pruned at particular harvest. Thus at each harvest 15 sample plants were pruned at schedule harvest days of 30, 35, 40, 45, 50, 55 and 60 days after initial pruning. Then total lengths of effective shoots per plant were measured. Shoots were stripped off of leaves and average weight of leaves per unit length of shoot was calculated from the sample placebo plants by the formula as here under:

On the same day of harvesting, the total length of shoots of the experimental plants from each variety was measured. The leaf yield at a particular harvest for individual varieties was calculated from the sample (Placebo) plants. The sample plants in placebo were used for

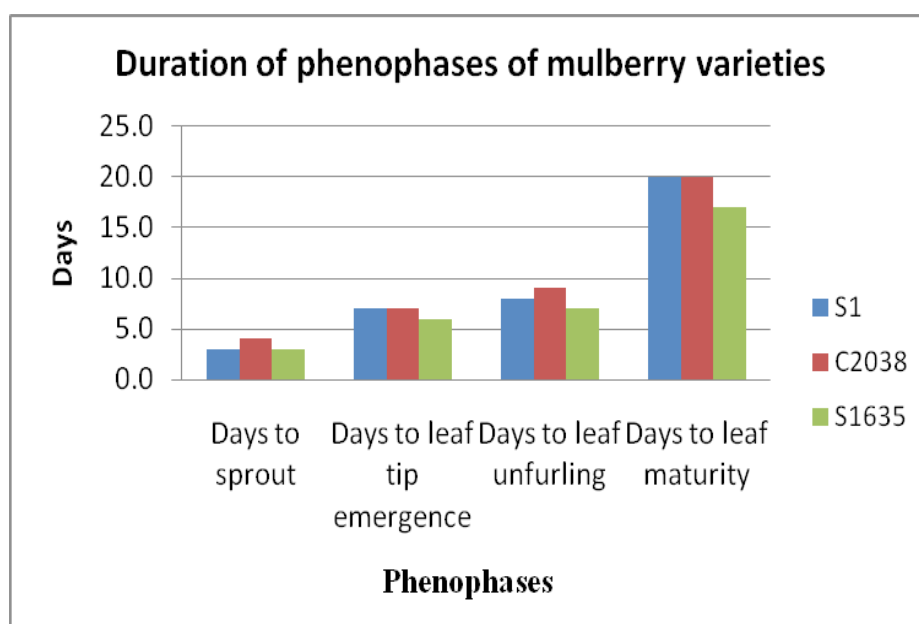


Fig. 1

estimating the leaf yield of the experimental plants at different harvests.

The thermal requirement in terms of growing degree days (GDD) for each day was calculated considering the base threshold temperature for mulberry as 13°C. The accumulated GDD (AGDD) was calculated using the following formula:

$$\sum GDD = \sum \{ [T_{\max} + T_{\min}] / 2 - T_b \}$$

Where,

$T_{\max}$ = Maximum daily temperature in

$T_{\min}$ = Minimum temperature in °C

T_b = Base temperature for mulberry.

The accumulated Photoperiod (APP) was calculated by summing up daily bright sun shine hours during each phase.

Growth phases were scored followed by leaf yield by weight were recorded at the completion of each five days periods between 30 and 35 days, 35 and 40 days, 40 and 45 days, 45 and 50 days, 50 and 55 days and 55 and 60 days after pruning respectively.

Results

Fig.2 depicted the leaf growth rate in terms of leaf yield/m of shoot of all three mulberry varieties through phenophases sequentially. It is evident that till phase up to 45th day after

pruning yield/m shoot increased steadily irrespective of varietal differences. But var. S1 and C2038 showed longer duration and higher quantity of realized leaf yield till 50th day which plummeted till 55th day. The reduction of growth might be ascribed to leaf senescence. After 40th day of pruning var. S1 excelled over C2038 and s1635 in terms of leaf yield/m shoot length. S1 scored the highest leaf yield on the 50th day after pruning.

The study on the requisite of growing degree days and photoperiod on phenology and yield of mulberry started with the ground pruning of the three different varieties viz., C-2038, S-1 and S-1635 on the 2nd of July 2012. Average of five replicated observations tabulated (Table 1) revealed that var. S1 and S1635 took 3 days to put forth the axillary buds triggered by an accumulation of 49.35°C day and 20.94 hours of growing degree days (GDD) and accumulated photoperiod (APP) respectively. It required 4 calendar days and an antecedent GDD and APP of 65.60°C day and 27.11 hours respectively. But differential responses to GDD and APP were observed in case of each subsequent phenophase which too were at slight variance among the three varieties in respect of leaf tip emergence, unfurling of leaves. While S1 and C2038 responded in the same manner in the phenological events of leaf tip emergence and attaining leaf maturity taking seven and 20

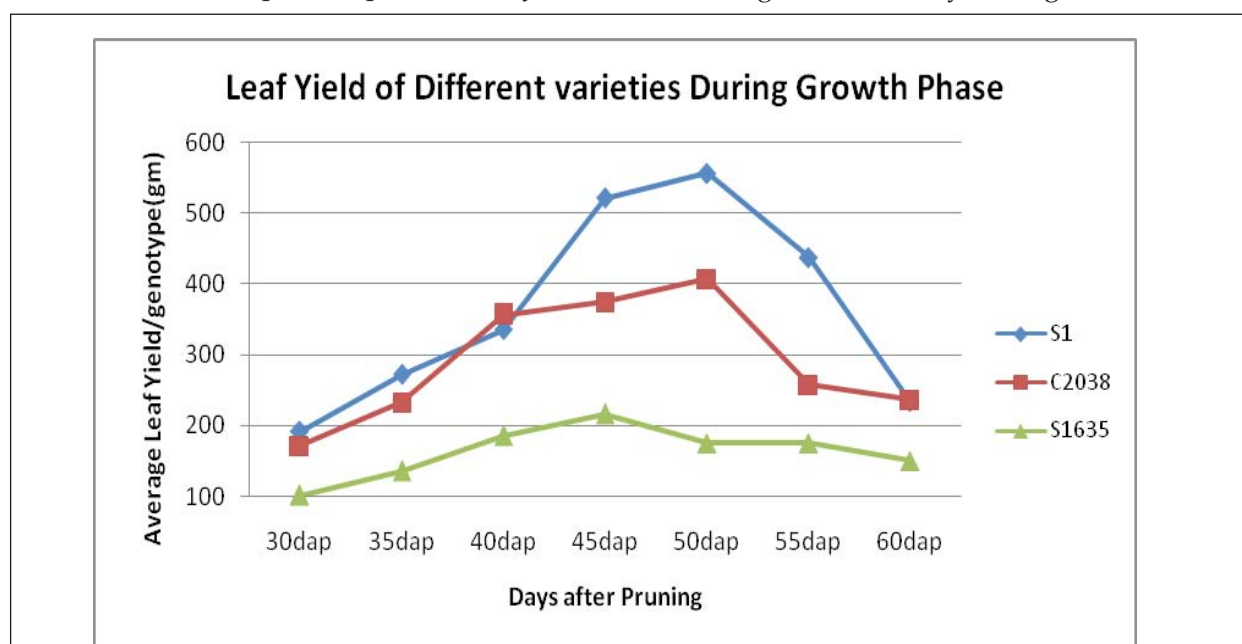


Fig. 2

Table 1. Phenophases and photo-thermal requirement of mulberry varieties

Days after pruning to events	Days after pruning to events	S1	C -2038	S-1635
Sprouting	Calendar day	3.00	4.00	3.00
	AGDD(0d)	49.35	65.60	49.35
	APP(hr)	20.94	27.11	20.94
Leaf emergence	Calendar day	7.00	7.00	6.00
	AGDD(0d)	115.20	115.20	98.75
	APP(hr)	52.60	52.60	44.10
Leaf unfurling	Calendar day	8.00	9.00	7.00
	AGDD(0d)	131.95	148.30	115.20
	APP(hr)	62.11	69.59	52.60
Leaf maturity	Calendar day	20.00	20.00	17.00
	AGDD(0d)	325.95	325.95	276.00
	APP(hr)	162.41	162.41	134.00

days respectively activated by 115.20°C day of GDD and 52.60 hours of APP followed by 20 calendar days, 325.950°C day of GDD coupled with 162.41 hours of APP respectively, var. S1635 struck early maturity amounting to six and 17 calendar days set off by 98.75°C day of GDD and 44.10 hours of APP followed by 276°C day GDD and 134 hours of APP. This very trait of S1635 might reduce its degree of acceptability by some farmers. It took eight, nine and seven calendar days coupled with 131.95°C day GDD and 62.11 hours APP with respect to var. S1, 48.30°C day GDD with 69.49 hours of APP in case of var.C2038 while the same for var.S1635 was recorded as 115.20°C day GDD 52.60 hours of APP for leaf unfurling. Fig. 1 elucidated the calendar days

required for setting of different phenophases starting from leaf-bud emergence till maturity of leaves.

To quantify the effect of growing degree days and photoperiod on leaf yield multiple regression analysis was carried out using SPSS 20 software (Table 2). Leaf yield was regressed over accumulated growing degree days (AGDD) and cumulative photoperiod (APP). The resultant regression equation (Foliage yield = $-715.42 - 2.99.14 \times \text{AGDD} + 8.73 \times \text{APP}$) deciphers that the less accumulated growing degree days coupled with higher photoperiod, better foliage yield was expected. The strength of Multiple Correlation (R) being 0.96 and Coefficient of Determination (R²) being 0.92 confirmed the

Table 2. Multiple Regression analysis of growing degree and days

Multiple Correlation (R) = 0.96					
Coefficient of Determination (R ²)= 0.92					
Regression equation:					
Foliage yield = $-715.42 - 2.99.14 \times \text{AGDD} + 8.73 \times \text{APP}$					
	Regression ANOVA				
	df	SS	MS	F	Significance F
Regression	2	5784.041	2892.02	22.37779	0.006731
Residual	4	516.9447	129.2362		
Total	6	6300.985			

fitness of the regression model. Further, highly significant Regression ANOVA and very low residual output added to the confirmation of the regression. The finding was in partial agreement with the experimental observations of Sarkar *et al.* (2005). Nevertheless, similar experiments at spatio-temporal level may be helpful for even more precision results.

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Micro Level Planning - RS & GIS Approach

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Abstract: The North Eastern Space Applications Centre (NESAC) has been providing support to developmental activities in the North Eastern Region (NER) through establishing an operational remote sensing based natural resources information generation facility, an operational satellite communications application segment to assist education, health, social welfare and other developmental activities since its inception during 2000. During past thirteen years of service in the region, it has been realised that the problems in NE Region are many and unique by itself. Keeping the strengths and weaknesses of the region, an attempt has been made to generate the database at micro watershed level on 1:5K (using enhanced CARTO-1 and IRS-P6 LISS IV with suitable merged techniques) for natural resources information (base details including marking assets, LULC, slope, water potential, land forms, geology, soil and drainage) along with land and water plan of action maps to address the issues of sustainable development of the region. This type of approach of planning at the lowest spatial unit can be called as Micro Level Planning and it is a continuous process of implementation, monitoring and evaluation of plans prepared. Generally micro level planning focuses more on the involvement of local people with less of technical skills and more of social skill of interacting with the community for a common cause, bringing them together on a common platform. The attempt to keep the Headman of the village in development planning right from the mapping exercise proved successful in preparing the action plan maps for land and water resources. It also encourages in implementing the decisions unanimously helping in improving the livelihood to the villagers at grass root level.

Remote Sensing (RS) in its role as the data or information collection system has the advantage of providing synoptic view and helps in understanding the interrelationships among various components in the village or micro watershed a smallest unit for study. Geographical Information System (GIS) provides answers to the questions such as resources needs, availability, adequacy and accessibility and it enables to select an option from a set of alternatives making decision easy, accurate and cost effective. In the present paper, we discussed RS & GIS technology approach in planning at micro level taking micro watershed as unit of development in West Garo District, Meghalaya.

1. Introduction

Planning at the lowest spatial unit can be termed as micro level planning. In the Indian context micro level planning can mean planning carried out at the village level or at the watershed level. The objectives of the

micro level planning are to mobilize local community to prepare action plans to develop resources and to use them in an efficient manner. Micro planning should not be seen as a one shot exercise; it is a continuous process implementation, monitoring and evaluation of plans prepared. Micro planning focuses more on the involvement of local people. In fact the object and subject of micro planning is local people. Micro planning exercise involves less of technical skills and more of social skills of interacting with the community for a common cause, bringing them together on a common platform and understanding the existing social hierarchy in a given locality. These are the issues which make a micro planning exercise successful or failure. Micro planning exercises can not be based on a single model. Each area may have some characteristics which may make micro planning exercise different across localities.

Remote Sensing (RS) in its role as the data/information collection system has the

advantages of providing synoptic view which helps in understanding the interrelationships among various components in the village or a watershed and the ecosystem they belong to. Satellites which orbit around the earth, provides a vantage point to observe, measure, map and monitor the change in resource use and availability. RS offer a rich source of information about conditions on the surface that change over time. Sensors on board RS satellites measure the amount of reflected energy from different land features. These data are translated into information either by visual interpretation or computer-aided image analysis techniques. The data then can be integrated with the other data such as physical parameters, socio-economic profiles and other related inputs using a Geographic Information System (GIS). It provides answers to a set of questions on resource needs, availability, adequacy and accessibility. It enables to select an option from a set of alternatives. Decision making is made easy, accurate and cost-effective.

In the present paper, we discuss the use of remote sensing (RS) and GIS in planning at micro level taking village and watershed as units of development. Few case studies are given to illustrate the use of these technologies.

2. Data needs for planning at micro-level

For effective planning and development exercise at micro-level variety of data on physical resources, human and economic aspects, etc. are required. These may broadly be grouped into following data sets:

- Natural resource data in terms of land use/land cover that shows forest area, cropping area, water, soil and mineral resources.
- Demographic data – relating to population, sex, ratio, age structure, urban and rural population, scheduled caste and schedule tribe population, occupational structure, migration etc.
- Agro-economic data – comprising information about cropped and irrigated area, agricultural productions, land holdings, live stock population, etc.
- Socio-economic activities relating to industrial, fishing activities, tourism development as

well as beneficiary of various schemes and programmes of development.

- Infrastructure data relating to availability and level of various facilities, utilities and services such as education, health, power, transport network, water supply, drainage, etc.

The above information needs for each sector may be categorised into three types: i) information related to the present state of development of resources in each sector (basically the availability aspects), ii) information related to 'projected needs' of the plan period (one, five and ten year period) and iii) Information related to the 'gaps' in each sector (availability vs needs). Based on these three aspects, the plan for further development can be decided.

3. Planning at the village level

The following steps are involved in planning at the village level. Understanding the Village may be a first step to identify the problems faced by the village so that basic intervention strategies can be clearly understood.

Preparation of a Village Map: A village may be having many resources (natural and man made) and infrastructure facilities. These resources and facilities have to be plotted on a map so that people of the locality will be able to visually observe their village and location and allocation of the facilities in their village. A discussion based on such a map may be a meaningful exercise.

Village Needs Register: Identification of local needs and assessment of resource supply becomes a part of micro planning exercise. Household survey provides details about the socioeconomic needs. This will be very useful information to initiate corrective measures.

Preparation of a Village Development Plan: Once the community needs are identified then it is possible to prepare a village development plan focussing on the specific problems faced at the household or community level. Preparation of such plans and monitoring of implementation activities thus identified in a village plan make planning exercise an effective tool. Drafting of such a plan requires the co-operation from the elected representatives, functionaries and common people. Such cooperation need to evolve locally, rather than super-imposed

from outside the village. A common pattern found in areas where micro planning exercises are well appreciated is to form a core group consisting of different segments of population of the village, orient them to the idea and help them in the initial stages to organize some of the activities under the micro planning exercises.

Assessment of Village Development: A Village Development Index (VDI) can be worked out using the following development indicators:

- Population density, (higher density is an indicator of a higher level of development).
- Percentage of literacy (higher number of literates gives impetus to development).
- Percentage of participation ratio (ratio of total workers to the total population; higher the number of workers in a village the higher is the involvement in economic activities and thus indicates a higher level of development).
- Percentage of non-agricultural workers (an indicator of the urbanisation activity and development).
- Road length ratio (accessibility of a village by roads is considered as an impetus to development).
- Percentage of irrigated area in each village (less risky agriculture and assured drinking water).
- Percentage of forest area (larger the forest area, the lesser would be the land available for cultivation and the development would be based on forest resource utilisation).

Indices for each of the above parameters can be derived by relating each village data with the district average for the parameter. The accumulation of weightings for these parameters provides the overall index of the village development. Villages are then categorised based on these indices to indicate the level of development of the villages in a watershed, block or a district.

Base map and Cadastral level inventory of natural resources in the NE Region:

Topographic maps form dependable database for administration managing natural resources and initiating developmental activities. However, in the NE Region 33 percent of the

topographic maps on 1:50,000 and larger scales are not available or inaccessible to the users. And the available ones are mostly of 1970s vintage. As a result, planning and implementation of developmental schemes are hampered. Hence, a remote sensing based approach was developed by North Eastern Space Applications Centre (Nongkynrih and Murlimohan, 2003). A base map is the one that shows the administrative boundaries (village, block/taluk, district), road and rail network, drainage (major streams upto second order); water bodies (larger than 0.1 ha), latitude and longitude grid, location and names of villages and other settlements and boundaries of reserved and protected forests. 5-metre resolution 'black & white' imagery from IRS 1C PAN sensor was used to prepare the base map. A participatory method of village territory determination with the help of village head (*Rangbah shnong*) was adopted.

The cadastre is used as an important input for agricultural and urban planning. However, these cadastres are not updated frequently, which may affect the planning process. The cadastres are stored on a low quality paper or cloth, which is subjected to various distortions. Problems are encountered in edge matching of one cadastre with the other. Therefore, area measurements from these maps may sometimes be erroneous. RS data from Indian Remote Sensing Satellites (IRS) and foreign satellites like IKONOS having high resolution are being used. On these base maps thematic information such as land use, agricultural (Irrigated/Non-irrigated), forest cover, fallow land, wasteland, population (socio-economic), water (surface and under ground for drinking and irrigation), infrastructural, health and education facilities could be plotted. GPS could be an additional tool for land survey, apart from excellent navigational aid. Possible applications of such maps are natural resource management, precision agriculture, facility management, public safety, insurance sector, detection of encroachments into public land, assessment of properties, real estate evaluation, legal document in case of disputes, etc.

Saini et al (2002) have evaluated high resolution IKONOS data for updation, rectification and mosaicing of cadastral maps. The study was carried out for five villages (i.e. Lathia, Bisokher, Amera Khera, Abeleshpur and Surwahi) near Varanasi city, U.P. The

study shows that old cadastres, which were distorted due to poor maintenance, could be updated; field boundaries and curvatures of the physical features could be mapped accurately and without much mismatch during mosaicing of the five village cadastres.

Participatory land-use planning

As increasing population has put more pressure on land, fallow periods have been shortened and continuous cultivation is becoming more normal. Extensive deforestation and the use of animal dung for fuel and crop residues for fodder have drastically reduced the nutrient cycle. Severe soil erosion is evident, as over-cropping and grazing on steep and unprotected slopes continue. In many areas, rainfall is becoming scarcer and less reliable. Traditional farming systems are no longer able to meet farmers' subsistence needs. This means that families have less reliable sources of food. Local people can begin to reverse this decline by planning their land-use as a community. Once the cadastral maps are prepared as discussed above, the land use planning can be done through community participation.

4. Planning at the Watershed level

Planning watershed management at micro level needs delineation of watershed boundary at micro level. The delineation is based on stream hierarchy and codification from upstream downward that allows to get a micro-watershed of 500 to 1000 ha size viable enough for implementation of soil and water conservation programmes. The beauty of such delineation and codification is that it could be recognised with a national code with seven digits and symbolized as 2C3G5p1 where "p" stands for sub-watershed and "1" denotes the micro-watershed. Thus 2C3G5p1 stands for a national code of a micro-watershed belongs to river resource region "2", basin "2", catchment "2C3", sub-catchment "2C3G", watershed "2C3G5" and sub-watershed "2C3G5p".

Watershed Prioritization: Watershed prioritization is a prerequisite to operationalise any major scheme as it allows the planners and policy makers to adopt a selective approach considering the vastness of the catchment area, severity of the problems, constraints of funds and man power, demands of the local and political system. The prioritization of watershed

varies with the objectives of different schemes but the basic framework of watershed remains the same. The priority approach is based on Sediment Yield Index (SYI) and Runoff Potential Index. In all these endeavours, the basic framework of watershed will remain the same but priority will vary and it will be in accordance with the objective of the various schemes.

SYI model for watershed prioritization in the catchments of River Valley Project is a predictive model based on the soil and land characteristics of reconnaissance level. The model consists of two aspects, viz., delineation and codification of the catchment area into micro watershed level based on drainage map generated from 1:50,000 scale Survey of India topographic map and generation of Erosion Intensity Map based on rapid traversing of the catchment. The generation of erosion intensity map comprises following steps:

- Study of the satellite imagery and Survey of India topographical map on 1:50,000 scale to have an idea of the catchment area and identification of the major landscape and land use.
- Rapid reconnaissance of the catchment area to familiarize with the terrain characteristics as per preliminary study of map for formulation of mapping legend.
- Formulation of Erosion Intensity Mapping Unit (EIMU) legend comprising soil and land characteristics for mapping. The mapping legend is updated based on field information and a progressive legend is developed and finalized. EIMU is an assemblage of land and soil characteristics, viz., physiography, slope land use and land cover with density, surface condition, soil depth, texture and structure of surface and sub-soils, colour, drainage condition, salinity and alkalinity, stoniness and rockiness, erosion condition and existing management practices.
- Mapping of the catchment area using EIMU legend.
- Finalization of the map using slope map generated from SOI map and random field checking.
- Assignment of weightage and delivery ratio to each and every EIMU.

- Computation of area of each and every polygon and micro watershed using planimeter.
- Computation of SYI using the empirical formula
- Statistical analysis of SYI values of all the micro watersheds for categorization of very high, high, medium, low and very low priority watersheds.

An improved method is to use the Runoff Potential Index (RPI) model, a modified model of SYI where delivery component has been excluded and weightage value to each mapping unit is assigned based on runoff generation potential of each and every mapping unit. This model is used for prioritization of watersheds in the flood prone catchment. The delineation and codification as well as the mapping procedures including watershed categorization are alike to that of SYI model.

Integrated Development plan: As per the WARSA – Jan Sahbhagita guidelines, issued by Government of India, two types of development plans have to be prepared viz., strategic plan and annual action plan. Satellite remote sensing and GIS have been effectively utilized to generate these plans by integrating the resource demand with supply. The resource maps are generated on 1:50,000 scale. The methodology adopted involves generation of natural resources inventory maps showing current land use/landcover, types of wastelands, forest cover/types, surface water resources, drainage system/pattern, potential areas for ground water prospecting, land forms (geomorphology), geology (rock types, structural features, mineral occurrence), soil resources maps (soil type, irrigability, land capability, crop suitability maps) etc., using RS data. In addition, maps like slope, village location, boundary and transport network maps are generated using collateral information. Socio-cultural, socio-economic, demographic and meteorological data are collected from available existing databases.

By integrating all these information in a GIS environment, derivative maps called composite mapping units showing resource availability of individual land parcels, land characteristics, status of land erosion/limitations etc., are prepared. These maps are validated through

adequate field checks and by using authentic existing information. Strategic developmental plans in the form of schemes for conservation of soil and water and land resource development alternatives are generated on watershed basis. This is done in consultation and close coordination between scientists, officers of the concern department/watershed, agricultural universities/research centers and local people who are the real beneficiaries so as to ensure the technical feasibility and acceptability of the schemes.

We have three case studies that illustrate how the methodology described about has been adopted in the Watershed Development Programme. The first case study is from Hassan district in the Karnataka state, the second from Nilgiris district in Tamil Nadu and the third from East Khasi Hills district, Meghalaya state. In each of the case studies, unique resource management problem has been addressed. For example, in Hassan district, the issues are more related to efficient use of water resources to meet the food, fodder and fuel needs of the people. In Nilgiris district, the issues related to ecological and environmental concerns due to land use in conflict with the terrain have been addressed. In the East Khasi Hills district, issues related to preserving the forest ecosystems and sustainable agriculture are addressed. In each of the above, the use of the modern tools of data collection through RS, synthesis and planning decisions using GIS have been demonstrated.

One of the examples discussed here on the use of Rs and GIS for micro level planning is the Mynali micro watershed in the Nilgiris district, Tamil Nadu (Kandasamy and Venugopal, 2002). Base maps of 1:5000 scale were generated from Orthophotos & Toposheets. Aerial Photos taken during 1995 was used for generation of Orthophotos. GPS was used for Ground Control Survey. Orthophoto, DEM & 5m interval contour maps were generated using Photogrammetric Techniques. The orthophotos and IRS 1C LISS III +PAN merged satellite data were used for the generation of thematic maps such as Landuse/landcover, Soil, Drainage etc. Slope map was derived from 5-m interval contour using Arcview 3D analyst. Action plan for resource management on a sustainable basis was derived using GIS. Cadastral map showing parcel boundaries on

1:7920 obtained from Survey and land Records department was brought into 1:5000 scale and superimposed on thematic maps and action plan maps. And also other socioeconomic data pertaining to the watershed were collected and cadastral level resources information database was generated. Cadastral level database is customized in the GIS environment, which is interactive, and user-friendly. Monitoring and further updating will be easier for the field officers. Thus RS, GIS and GPS have been found to be very effective and economical tool for generating action plans for the micro watersheds.

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Impact of Watershed Development Programme in the Ugain Watershed of Rajasthan through Geospatial Technologies

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Keywords: Watershed Monitoring, Evaluation, Land Use/Cover and NDVI

Abstract: Watersheds are an important concept when considering the development of water resources. They are an important contributor towards sustainable development of the region. Many development programmes are applied generally on watershed basis. These plans have to be monitored and evaluated continuously to provide insight in to the impact of developmental activities in the watershed and also provide feedback for making necessary modifications, plans revisions and preparation of other watershed developmental projects. Thus, in lieu of this the National Watershed Development Program for Rainfed Areas was designed to develop and monitor specific watersheds in India with Remote Sensing and GIS techniques. The present study has been done for Ugain watershed falling in the Bundi district of Rajasthan state covering an area of 784 ha. Image processing and visual interpretation techniques were employed to carry out Land use/Land cover classification and NDVI maps using LISS-IV data (2007 and 2011) satellite images of same season. Images were rectified with the help of ETM data. Level-I classification approach was used for delineating LULC of the area for both. Similarly, NDVI was performed on the two date images with specific vegetation density classes for pretreatment and during treatment analysis to monitor the development and changes in the area. The analysis shows that the cropping area has increased by 29.58 % with a decrease in fallow land and wasteland. NDVI studies shows that there is a remarkable increase in Biomass in these years. Changes were validated and analyzed through ground checks. A major change in terms of land development is the construction of Water Harvesting Structures like farm ponds, Check dams, etc. Farm ponds have the capability to store rain water in the farm which was previously draining out. Watershed development programs in rainfed areas are presenting a better opportunity for the sustenance of individual's in the adverse situation (John Kerr et. al. 2002). Sustainable development of Panchayat is possible with the available natural resources which are not utilized to the optimum level at present. Hence Geomatics may act as effective tool in understanding and monitoring the target areas at desired intervals for suitable analysis.

Introduction

Under the centrally sponsored NWDPA scheme, Agricultural Department has accorded high priority to the sustainable integrated farming systems of rainfed areas on watershed basis through National Watershed Development Project for Rainfed Areas [NWDPA]. The project aims at in-situ moisture conservation primarily through vegetative measures to conserve rainwater control soil erosion and generate the green cover both on arable and non-arable lands (Sreedevi et. al., 2006). The scheme is implemented at the field level by an interdisciplinary team of members from

line departments of state government and the beneficiaries of the watersheds. Indicators like land value, employment opportunities, changes in groundwater level, agro-based and allied industries, migration of labor and cattle, etc., are collected from field survey (Table 1).

In Rajasthan among 286 watersheds, 36 watersheds from 21 districts are taken up during XI five year plan period for monitoring and evaluation. Treatment period for this phase of NWDPA monitoring was from 2007-2012. This paper describes Ugain watershed characterization, watershed activities during implementation, monitoring and impact

Table 1. NWDPPRA Project Data Collection parameters

Quantitative Parameters	Qualitative Parameters
Cropped Area	Ground Water Depth
Plantations	Well Density
Sustainability	Socio-Economic Indicators
Productivity	Migration of labor and cattle
Livestock	Employment Opportunities
Drainage Line Treatment	Land Value
Non-Arable Lands and Biomass	Agro-Based and Allied Industries

assessment and change detection with following objectives.

- Evaluation of the impact of watershed programmes treated micro watersheds.
- Assessment of implementation of NWDPPRA developmental activities and their impact on arable and non-arable land.

- Agro-climatic zone wise analysis of the performance of developmental activities in the watershed.

Methodology

The digital analysis involved geometric correction, image registration, extraction of study area and classification of land use/land cover types. Comparison of two dates classified outputs and Normalized Difference Vegetation Index (NDVI) images were performed to study the changes in land use/land cover and vegetation vigor transformation. Integrated remote sensing and Geographic Information System (GIS) techniques were used for the analysis of watershed characteristics. Satellite remote sensing data of the Ugain watershed pertaining to pre and post treatment periods (2007 and 2011) were analyzed (Fig. 1). Slope and drainage network were prepared for characterization of watershed.

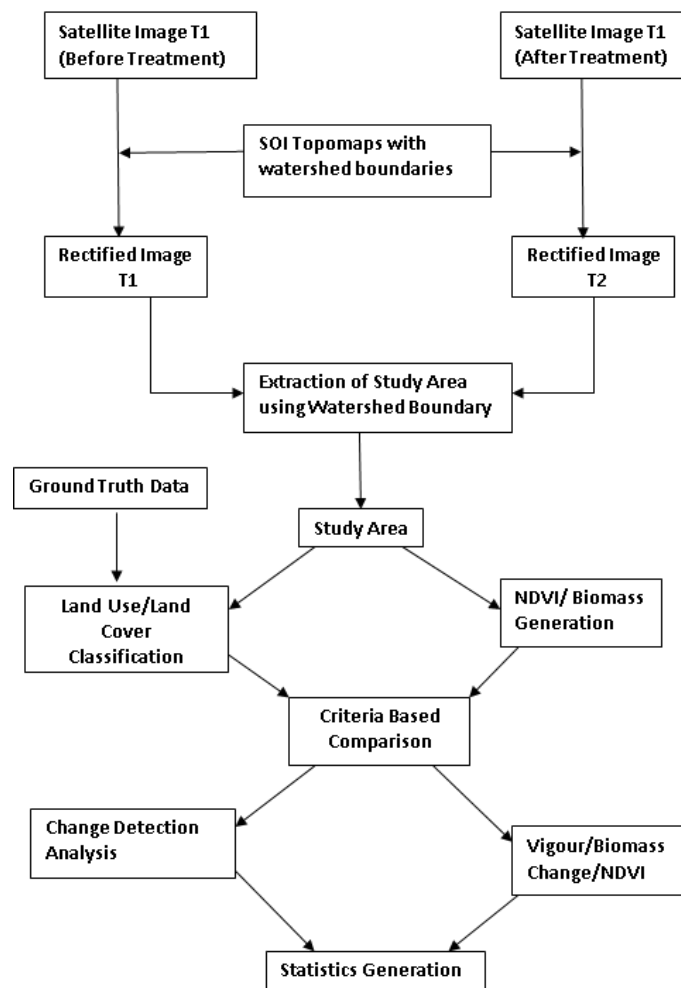


Fig.1. Flow Chart for Methodology

Major Problems and constraints

Prior to rainwater harvesting, acute water scarcity was the major constraint for agriculture. Moderate rainfall and soil erosion cause frequently to crop failure. Poor soils with low-water holding capacity, inherent low fertility and Non-adoption of improved methods of agricultural Practices are resulted in low crop yields. Poor Socio-economic condition leads to migration of people to nearby cities in search of livelihood, is common feature in this watershed.

Data Used

Resourcesat-1 LISS-IV (MX) and Resourcesat-2 LISS-IV (FMx) data are used for this study along with other ancillary data and Survey of India topographical maps on 1:50,000 scale. Slope and drainage maps were prepared using SRTM data. The ground information on different land use / land cover categories and activities under watershed development program were collected by visiting the study area in the watershed along with satellite imagery. The field work was carried out along with concerned line department officials during Kharif/Rabi season of 2012. Satellite Imageries, topographical maps and Global Positioning System (GPS) were utilized during ground truth collection. The field details were collected discussing with farmers as well as officers concerned in the watershed.

Land Use / land cover classification were made into five different categories namely, crop

land, fallow land, wasteland, water body and settlement. On screen digitization at 1: 50000 scale is done to carry out LULC categories for both pre and post treatment period. NDVI classifications were done for extracting biomass index for the particular area. The NDVI is highly correlated with vegetation parameters such as green leaf biomass, leaf area and is an indicator of photosynthesis activity and hence is of considerable value for vegetation discrimination and seasonal monitoring. The magnitude of the NDVI obtained from the satellite imagery is a function of the level of photosynthesis in the green vegetation and the percent of the land surface covered by the leaves. The NDVI of the images for both the dates were generated to derive information on changes with reference to vigor/biomass. The resultant difference images were suitably color-coded highlighting the changes under significant, moderate and marginal categories. NDVI has been computed using the infrared and red bands of the satellite data. The ratioing is done to remove temporally or spatially varying gain and bias factors, suppressing radiance variations arising from topographic slope and aspect and enhances radiance differences between soils and vegetation.

Results and Discussion

Topographical conditions play a vital role in watershed management and characterizing the nature of the terrain and landforms (Govinda Gowda V et. al 2011). The watershed boundary



BEFORE TREATMENT (Jan-2007)



DURING TREATMENT (Dec-2011)

Fig. 2. False Color Composite Image of Ugain Watershed.

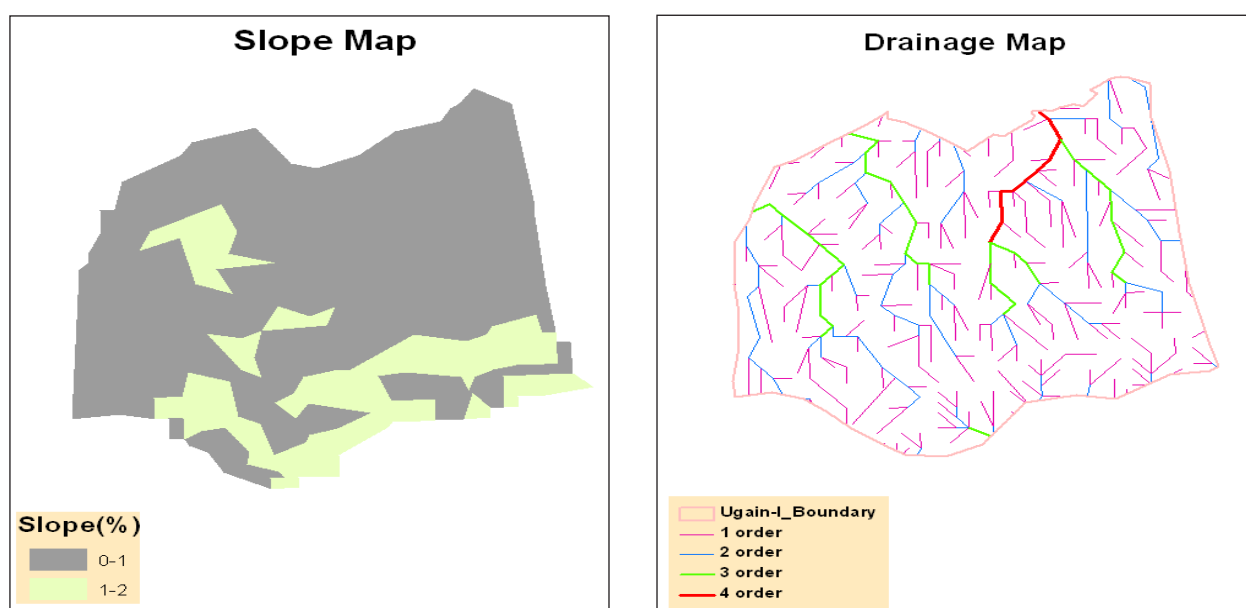


Fig.3. Slope and Drainage map of Ugain Watershed

depicted in the false colour composite of image was shown in (Fig. 2). The slope is very gentle to nearly flat (0 - 2%). Drainage order analysis reveals that streams up to fourth order exist in the study area (Fig. 3).

Ugain watershed has an area of 784 ha. Out of which 95.2 ha has been treated under the project. The classified images having different LULC categories pertaining to pre and after treatment period have been compared to derive information on changes. The land

cover transformation in terms of increase in vegetation cover, area under crops, water bodies, etc. has been derived and the spatial extent of wastelands have been obtained in order to quantify the extent of changes in the watershed (Fig. 4). The statistics with respect to areal extent of different LULC categories in the watershed and changes with respect to vigor/ biomass have been presented in (Table 2 & 3). Around 97.40% area coming under crop and fallow land category in both periods followed by settlement and wasteland. NDVI studies

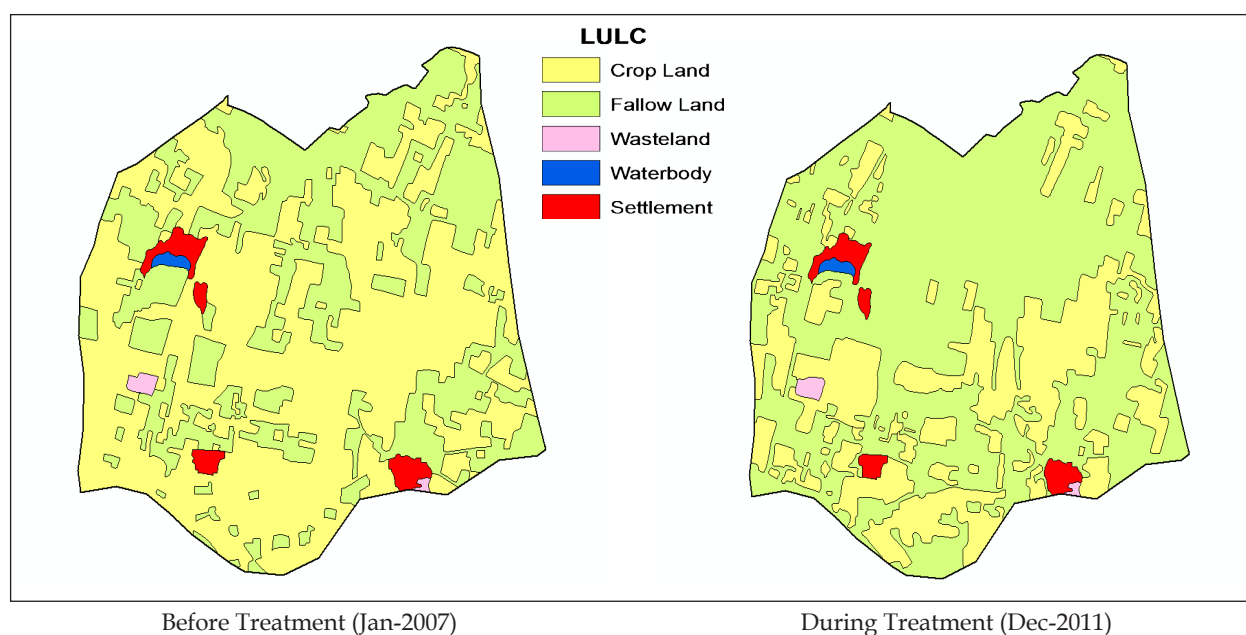


Fig.4. Land Use Land Cover Maps of Ugain-I Watershed.

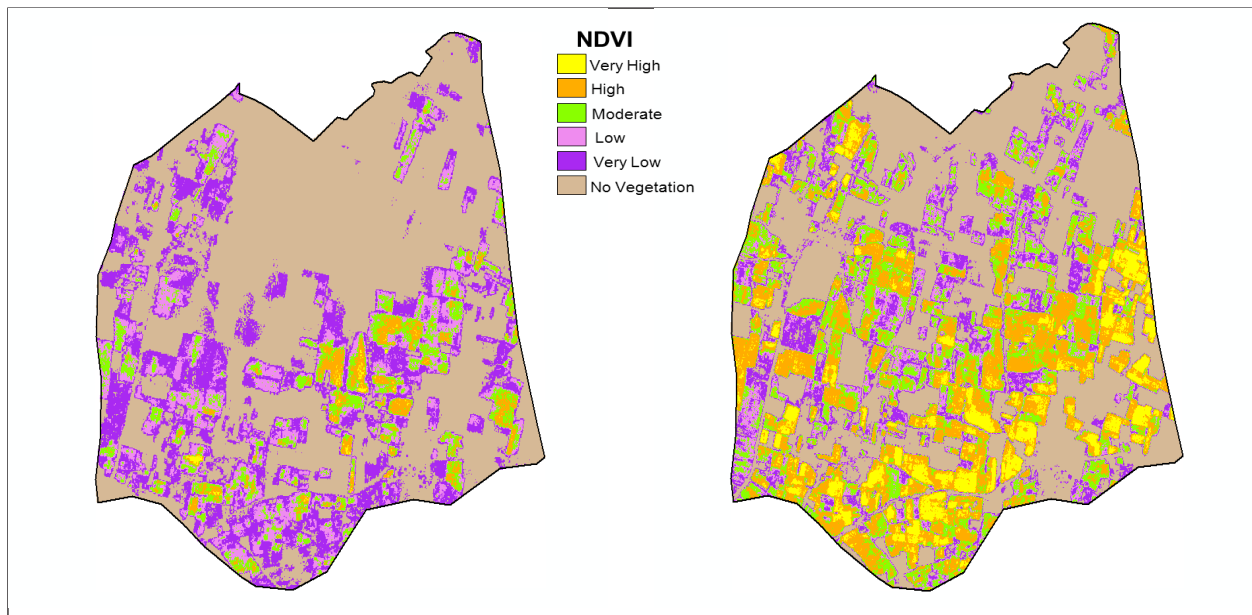


Fig.5. NDVI/Biomass Maps of Ugain-I Watershed

show that there is a good improvement in the overall vegetation category (Fig. 5). Area is dominated by the positive changes observed under high to very high 22.06% (174.2 ha) while 7.93 % (62.41 ha) under moderate and 9.77 % (77.09 ha) under low to very low. Major positive changes have been in the categories viz. crop land area which is increased by 231.91 ha (29.58%) at the cost of fallow land. Built

up has increased marginally by 0.42 ha and wasteland decreased by 0.27 ha (Fig.6).

Field Survey

The introduction of water harvesting structures like construction of farm ponds under NWDPPRA Project has an influence on availability of water for irrigation purpose. A significance increase in ground water level

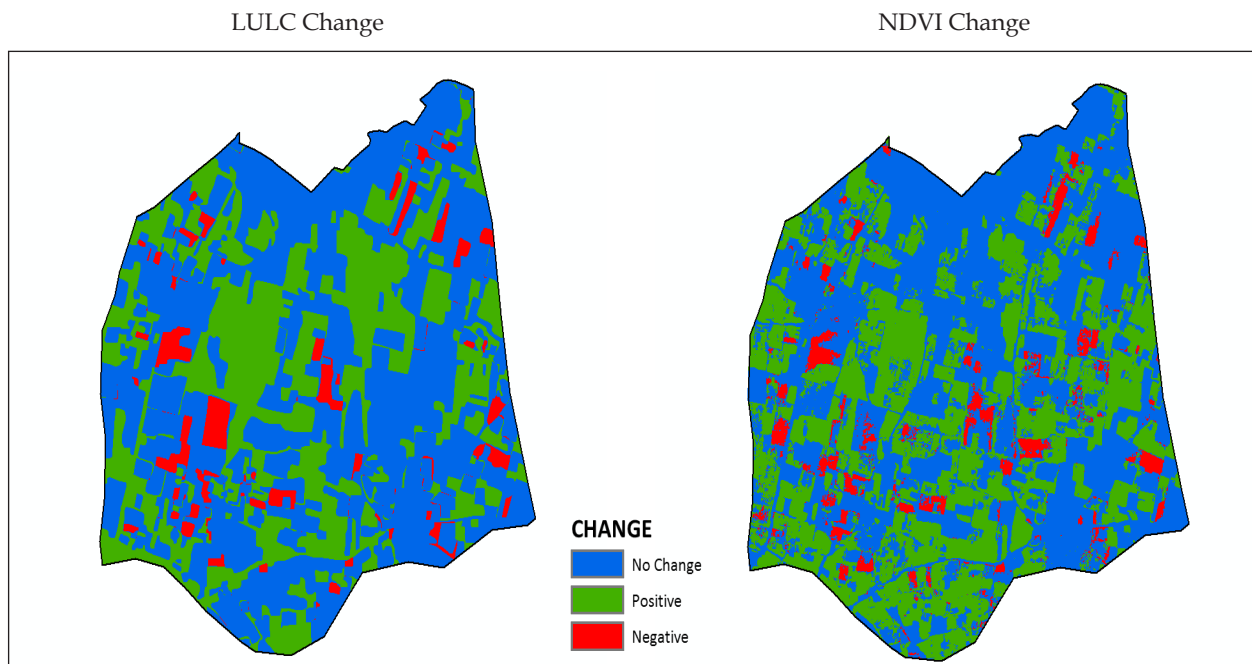


Fig.6. Change Detection Maps (LULC & NDVI) of Ugain-I Watershed

Table 2: Change Analysis Landuse / Landcover classes

Sl No.	Vegetation Vigour	Before Treatment (2007)		After Treatment (2011)		Changes ($\pm$)	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
1)	Very High	1.51	0.19	51.56	6.55	50.05	6.36
2)	High	22.21	2.82	146.36	18.59	124.15	15.7
3)	Medium	48.60	6.17	111.02	14.10	62.41	7.93
4)	Low	86.23	10.94	74.54	9.47	-11.69	-1.48
5)	Very Low	154.02	19.55	88.62	11.25	-65.40	-8.29
Area Under Vegetation		312.57	39.67	472.09	59.95	159.52	20.28
6)	No Vegetation	475.39	60.33	315.41	40.05	-159.98	-20.28
Total		787.96	100.00	787.50	100.00		

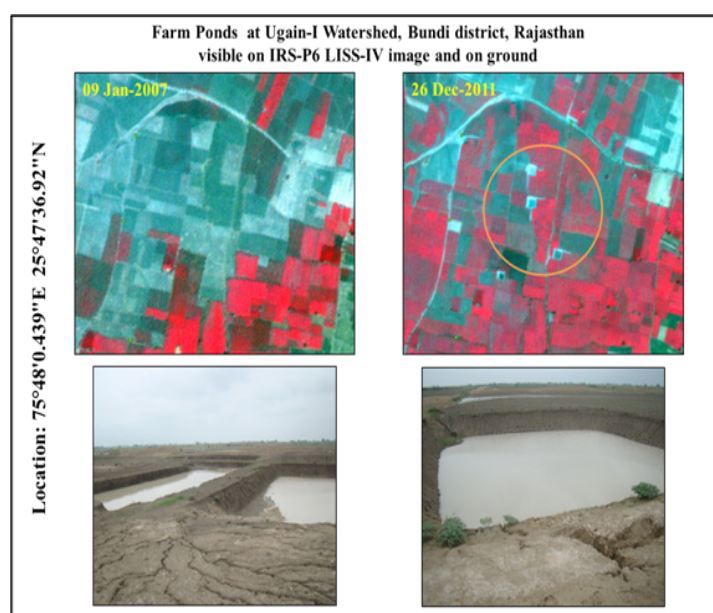


Fig.7. Ground achievement seen through LISS-IV Satellite Image

up to 7 m shows a remarkable success of the project. This may be a reason for increase in crop land during after treatment period. These achievements are shown in fig. 7.

Apart from this creating Mitra Kissan and formation of self-help groups (SHG) insures people's participation. Training cum orientation programmes was conducted to demonstrate

Table 3: NDVI change statistics

Sl.No.	LU/LC category	Before Treatment (2007)		After Treatment (2011)		Changes ($\pm$)	
		Area(ha)	%	Area(ha)	%	Area(ha)	%
1)	Settlement	14.78	1.88	15.20	1.94	0.42	0.05
A) CROPPED AREA							
2)	Cropland	242.81	30.97	474.72	60.55	231.91	29.58
3)	Fallow land	521.06	66.46	289.00	36.85	-232.07	-29.60
B) NON-ARABLE LAND							
4)	Wasteland	3.34	0.43	3.08	0.39	-0.27	-0.03
C) SURFACE WATERBODY							
5)	Water body	2.01	0.26	2.01	0.26	0.00	0.00
TOTAL		784.00	100.00	784.00	100.00		

dry land farming technology. Support was also provided to landless laborers, women and marginal farmers by creating employment opportunity under household activity in the watershed areas. The livestock developments by providing animal camps for the care of their animals are the other important activities taken up in watershed area.

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Demand Forecast of Electricity and Optimal Locationing of New Transformer Locations Using Geo-spatial Techniques: A Case Study

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Abstract: Rural electrification is one domain of the planning sector that needs continual observation and management so as to aid in timely development and distribution. The development of any rural area depends on a multitude of factors and for a rapidly progressing country like India, it becomes prerogative for every rural community to be provided with all basic requirements, in order to utilize its resources in maintaining itself and commit in the betterment of the entire economy. One of these rudimentary necessities of life is the access to Electrification. The use of Geographic Information Systems (GIS) in the planning and development sector is not a recent concept. There have been several instances where GIS and remotely sensed data have been brought together in order to identify pockets for intensifying electrification, delineating routes for placing transformer lines, grid network analysis and so forth. In the present study an attempt has been made to identify the demand of each household in the study area and divide the region into pockets of High, Moderate and Low Priority for electrification (by using "Priority Index"). This index takes into account four parameters – number of members in a household; number of school going children in a household; load of the household in terms of wattage; and area of the property in meter square. The data regarding the same was collected by an exhaustive questionnaire based field survey conducted in five village of Gaya district in the state of Bihar, followed by compilation of the data for attaining an approximate idea of the level of consumption. Along with this, other socio economic parameters (like family strength, number of school going children etc) were also considered in order to compute a bias free Priority Index which was not just dependant on the number of electrical points in the house. Using the Priority Index, the households were divided into high, moderate and low priority. This spatial division was helpful in proposing new transformer locations, providing higher spatial coverage with planned allocation of load among the transformers and minimizing transmission loss. In this manner a very holistic categorization was possible which truly identified the pockets with highest priority for providing electricity as well as promising optimum spatial coverage.

1. Introduction

Over the years, it has been seen that the people belonging to the rural sectors of India, have diversified so much in terms of their lifestyle that the need for a reasonable supply of electricity is a must so as to be able to cope with their daily activities. The era of oil lamps and incandescent lighting sources has been replaced with energy efficient bulbs for e.g. CFLs, mechanized tools for irrigation, television sets and dish antennas etc. showing the transition of rural lifestyle. This clearly indicates the upliftment of the marginal classes but at the same time, also lays more stress on the government to cater to these growing demands.

Several initiatives have been taken by the government from time to time aiming at the reduction of power distribution inequalities in the economy coupled with intensive electrification of rural sections. One such widespread programme of the Indian government is the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) which aims at the provision of electricity to the villages of India at subsidized rates for Above Poverty Line households and free of charge for Below Poverty Line households. Also, one of the main objectives of the scheme is a minimum daily supply of 6-8 hours of electricity in the RGGVY network with the assurance of meeting any deficit in this context by supplying electricity

at subsidized tariff as required under the Electricity Act, 2003.

Unfortunately, due to several shortcomings, these primary objectives are noticeably absent in the villages selected for the purpose of the study. The transformers installed are often unable to meet the total load of all households in a village even for the minimum duration of 6-8 hours only because the load on them is too great due to higher consumption causing premature breakdown of transformers. In this manner, such programmes are unable to fetch rightful sanctity but with slightly more refined planning and pre installation measures, such shortcomings can be greatly removed.

There are various reasons for this reduced supply of electricity and disproportionate demand that act as deterrents in the functioning of these distribution transformers. According to Bhalla (2000), haphazard growth of distribution systems with short sighted supply goals; large scale rural electrification through long 11 kV/ Low Tension Lines; high degree of theft/ pilferage activities by the unauthorized hooking or tapping of bare conductors of the LT feeders are only some of the factors that cause the imbalanced situation of power supply.

This study is a small effort aiming at the assessment of the programme in five blocks of Gaya and Nawada districts, Bihar, India. It follows a basic methodology of thoroughly surveying the villages to identify the reasons for poor performance of the installed transformers and also to acquire, as precise as possible, electricity demand per household. This way a forecast of the demand of the entire village has been done to calculate regions of priority which forms the base for the identification of potential locations of new transformers. The positions of the new transformers have been suggested in congruence with the load of the village in totality.

The use of geo-spatial techniques has been highlighted in the study resulting in better planning and reduction in total cost of implementation and maintenance. The major reason for poor performance of such programmes is the miscalculation of the demand of the area being served and this technique of applying geospatial tools is one of the ways to bridge this gap. If more and more similar methodologies can be developed and applied intelligently then

perhaps the issue of pre-installation planning can be catered for thereby increasing the life of the transformers and allowing the people to access an undisrupted flow of electricity.

2. Previous work:

There are ample studies that have been conducted to portray the advantages of applying geo-spatial techniques in rural electrification planning and network constructions but not many have applied their methods at the grass root level i.e. they have confined themselves to the district or state level. Nevertheless, such works have proved quite beneficial in constructing the methodology followed in this study.

Barnard (2010) utilized various factors for the identification of "the best path for an extension or new network", the important ones being -roads, land cover, household positions and slope. Thereafter the layers were overlaid and the values for corresponding pixels were added together to obtain a combined suitability raster with pixel values rating equal or near to zero. The conclusion of the study showed that the implementation of GIS and spatial analysis was highly appreciable in finding areas which were supply deficit, overloaded demand, spare capacity pockets, ideal spaces for new substations establishment and so forth.

Another such study by Kaijuka (2006) used a multitude of factors for formulating a plan for network development for intensifying electrification along the existing routes. Some of these variables included population distribution and population density, location of demand centers i.e. schools and village trading centers, road network, health centers, and finally the projection of high demand centers or regions as an assimilation of the above variables. The entire study has been performed on the GIS platform enabling data interoperability and the effect of one variable over the other.

3. Study Area:

The Study area is situated in the Indo Gangetic plains within the state of Bihar. The villages used in the study fall in the district of Gaya and Nawada. They are located between 24° 45' and 24° 56' North latitudes, and 84° 52' and 85° 22' East longitudes (Fig. 1). The names of the villages with their respective household

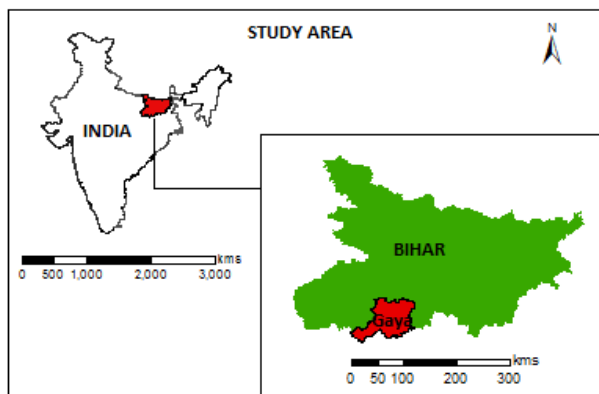


Fig 1: Map of Study Area

counts are Ganjas (54); Paharpur (104); Nepa (128); Risauhdh (159) and Repura (199), first four from Gaya district and the last from Nawada.

4. Research objectives:

The most important research question to be answered through this study was to see the degree up to which one could successfully employ geo-spatial techniques in the domain of rural electrification. This was a challenging task as in most Indian villages, unplanned routes; scattered settlements and unequal demand of the households make it difficult to develop an approach which could provide electricity in an equitable manner. The second objective was the computation of an index for dividing the households as per priority (considering load cum socio economic factors); and finally to propose new transformer locations catering to the newly defined priority centers.

5. Data and Methods:

5.1 Data used:

For the current study, high resolution images from Google Earth (DigitalGlobe and GeoEye imageries) were extracted and geo-referenced using ERDAS Imagine 9.1. These images provided the base for generation of digitized maps for the study area. Delineation of priority areas, location of transformers and street network was done using the base maps in ArcMap 9.3.

5.2 Methodology:

The methodology adopted in the study has been summarized in the flow chart (Fig. 2) shown below:

5.2.1 Data Collection:

A questionnaire was prepared using which data was collected from a sample of households in each village and a total of 195 households were questioned out of 644 approximating to 30% of the total number of households. Out of the 30% of the total sample, only 25% were used to ascertain the values for the remaining households. Properties of similar sizes (in terms of area) were allotted similar details of load and demographic structure in order to have a general overview of the pattern of demand and family structure of the entire village. Remaining 5% of the data collected was used to validate the values of the households that

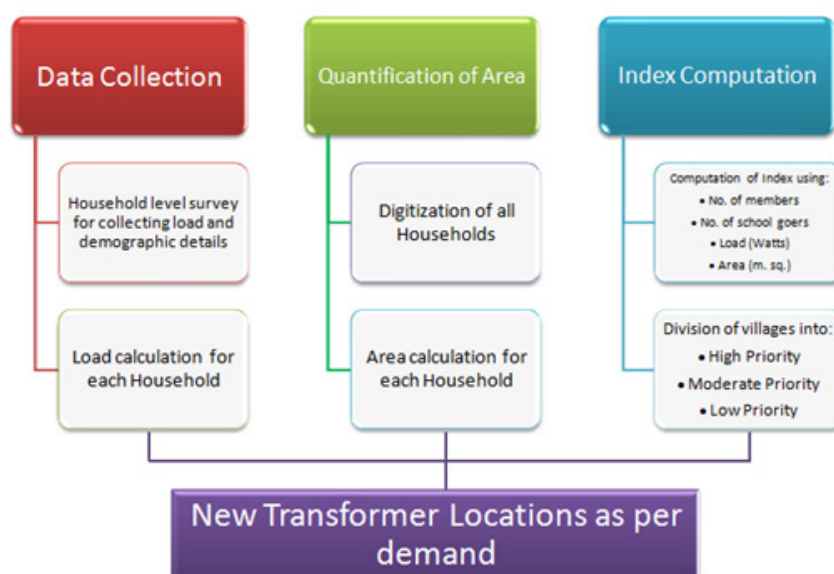


Fig 2: Methodology of the study

were not in the initial sample. The degree of reliability of this approach was checked using the correlation of the previous data's Priority Index values and the new data's Priority Index values (for Priority Index refer 5.2.3).

A sum of the total wattage of the electrical items installed in each household was taken to be the "load" of a household for instance if there are 3 bulbs of 100 watts and a fan of 60 watts, then the load of the household would be denoted as 360 watts. This way load calculation was done for every household in a village.

5.2.2 Quantification of Area:

The Google earth imageries previously cited were used (post geo-referencing) for digitizing the household boundaries, street network and positions of the already existing transformers (if any). This data was projected on UTM projection (Zone 45N) at WGS 1984 datum, and the areas for each property was calculated using "Calculate Areas" tool in ArcMap 9.3.

5.2.3 Computation of Priority Index:

The division of villages was required, so as to delineate which area of a village required more attention in terms of providing access to electricity compared to others. A simple division of the village in terms of load could also be done such that households with maximum demand for electricity could be given more priority when deciding the placement of transformers. But this technique was not adopted because transformers would then be placed close to the more affluent households (i.e. houses with TV, more number of electric appliances etc) leaving behind the marginal households with hardly one bulb or one fan. It was not considered appropriate for households with high demand getting greater weightage, as the low demand households would be marooned with no access to electricity.

Due to this shortcoming, the computation of a Priority Index was done by incorporating these four factors, namely - number of members in a household; number of school going children in a household; load of the household in terms of wattage; and area of the property in meter square.

The formula for the Priority Index designed by incorporating the above factors was:

$$HH(i) = \sum \left[\frac{M(i)}{M_{max}} + \frac{S(i)}{S_{max}} + \frac{L(i)}{L_{max}} + \frac{A(i)}{A_{max}} \right]$$

where, HH is household; M (i), S (i), L (i) and A (i) is number of members, number of school goers, load and area for every ith household respectively; M max, S max, L max and A max is the maximum value of M, S, L and A in the dataset respectively.

On the basis of these composite values, every village could be easily divided into classes of High, Moderate and Low values, because by using this index, a single value could be allotted to each household. Previously this could not be done because all the variables used for the study were in different units and could not be directly summed up.

6. Results and Discussion:

Once the Priority levels of the households were calculated using the aforementioned Priority Index, it was easy to predict the potential positions for suggesting new transformers. One such map is shown here (Fig 3) where the village is divided into three categories as per priority i.e. high, moderate and low shown by red, orange and yellow respectively. These



Fig 3: Village of Nepa in block Tikari showing the division of the village as per Priority Index

divisions have been arrived at by applying the method of Natural breaks (Jenks) in the dataset to find regions having similar values and applying class boundary where the values of the preceding group of items and a subsequent group is wide enough. This classification of the households helped greatly in deciding positions of the new transformers.

Subsequently, after working out various combinations, optimal positions of transformers were suggested resulting in maximum coverage and minimum overlap. Coverage was generated using buffer tools in the ArcMap environment which show the houses covered by each transformer, in such a way, that the total load of the houses falling under every transformer does not exceed the capacity of the transformer thereby catering to the issue of overloading. An example of the transformer positioning for one of the villages have been shown in Fig. 4.

The buffers generated around the transformers are not symbolic of the limit of the transformer in terms of providing electricity. Here a buffer of 50 m has been taken as a standard for all transformers but it is not so that houses beyond this distance would not have access to electricity. Certain points have been considered which are (a) greater the distance from the transformer, greater the transmission loss; (b) greater the length of the wires for connections, greater the threat of theft of electricity by illegal consumers en-route; (c) smaller capacity transformers in a greater number are better than small number of large capacity transformers for the provision of "intensive electrification"; (d) smaller capacity transformers (equal to less than 25 kVa) are considered safer and easier to maintain as opposed to bigger transformers; (e) smaller capacity transformers can be placed closer to households due to their safety and small size while bigger ones must be placed away from local regions of influence.

In Fig. 4, four 16kVa transformers have been suggested to meet the demand of the entire village but even with this kind of system, a few houses get left out as including them under any of the transformers may lead to overconsumption and thereby cause premature breakdown. In order to avoid such situations, it was considered better to leave a few households than to cause overload on any transformer.

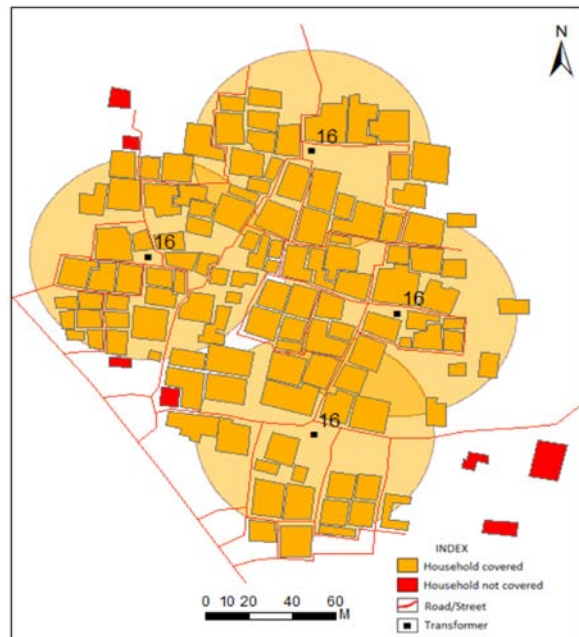


Fig 4: The village of Nepa with new transformer locations showing maximum coverage of households

7. Conclusion:

In all five villages, the ratio between the households not covered to the total number of households is less than 1.0% indicating a very high coverage. Also the transformers have been placed in such a way that they do not obstruct any movement i.e. they are not along any street or road and are positioned only in open spaces thereby causing no threat. It can be seen by the previously shown maps, that although the transformers are positioned in a manner by which they cover all high priority households, households with low priority have not entirely been neglected or avoided. They are also greatly covered showing that there is no bias in the positioning of the transformers.

The primary advantage of the study is that it highlights the ways in which GIS and remotely sensed data can be utilized for effective planning in the electricity domain. Sarr (2006) had performed a similar study in Senegal to come up with a sustainable electrification program for the rural communities. It was concluded that GIS played a critical role in estimating the true demand on the system and for the purpose of designing an optimal electrification model. Similarly, in the Indian context, such innovative methodologies need to be adopted at the earliest as there is huge scope for GIS implementation in the planning

arena which is yet to be discovered. Another advantage of the study is that it has been conducted at the household level. This implies that the “bottom up” approach has been applied truly. Extending a study at the grass root level is the most preliminary step that must be taken for performing socio economic research. The main objective of the study was to identify potential locations which can be used for placing transformers. This has been accomplished by identifying which portions of the village community needed to be given priority in terms of the “priority index”. Such other indices or parameters can be constructed for other electrification programmes as well. Overall, this project is sufficient to assess

the demand of a village for electricity and decipher ways to provide access. If such works can be usefully implemented by the planning organizations, new pathways for planning can be paved.

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Asset Mapping of Gram Panchayat and Web based Interface for Development

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Keywords: PRI, Asset register, e-panchayat, Web-based browsing system.

Abstract: Panchayat is an important institution through which decentralization and participation in local self-government is attained throughout India. Empowerment, enablement and accountability of Panchayat Raj Institutions (PRI) ensure inclusive development with social justice and efficient delivery of services. This system needs proper register, monitoring and awareness about the environment and development. In this paper authors have tried to develop web base browsing system where individual, community, institutional asset of a gram panchayat may be registered. The study area in this paper is Kotra gram panchayat, Barasat Block of North 24 Parganas, West Bengal. Various information regarding different types of assets were collected from different sources viz. landuse / landcover data by image processing, census data, and primary socio-economic data from field survey. A good data base of the study area was developed. Thematic maps based on different data base were also developed in GIS environment. Then the databases were linked with the maps. This e-panchayat is made web based where stakeholders may browse or search their necessary information through a search engine. PRI's may upload and update their different information regularly in this system and make available to the stakeholders for their good understanding. It is a good and forward looking step for PRI's for their data collection, storage and analysis.

Introduction

Panchayat is an important institution through which decentralization and participation in local self-government is attained throughout India. For increasing enablement and accountability E-Panchayat has usually been undertaken through which good governance has been deployed. One of the most important criteria for good governance for development with social justice is the preparation and updating of asset register. Asset mapping provides information about the resources of a community and promotes community empowerment. Identification and mapping assets in any community may be done through a proper planning. There are different types of assets. In this work, authors made a reconnaissance survey to make a list of available resources of the selected panchayat. Those resources are grouped into five categories. All of them are listed in table and make visualized by mapping. Last of all, web-based information is made available to stakeholders with interface facilities. Such program may help planner,

businessman on one hand and aware the local people about the resource availability or any upcoming hazard on the other.

Asset mapping process for E-Governance

E-panchayat has usually been undertaken to strengthen E-Governance in Panchayat Raj Institutions. At present e-panchayat has been deployed for asset mapping in GIS layer.

This paper attempts to record different assets of panchayat linking different sources through an integrated application of web design.

- (i) Application of remote sensing for land use land cover mapping and monitoring of each panchayat.
- (ii) Connecting the census population data at village or gram level.
- (iii) Digitalization of plot to plot cadastral map and its integration through widely used website i.e. Google earth to get location and detail information on physical and socio-economic condition.

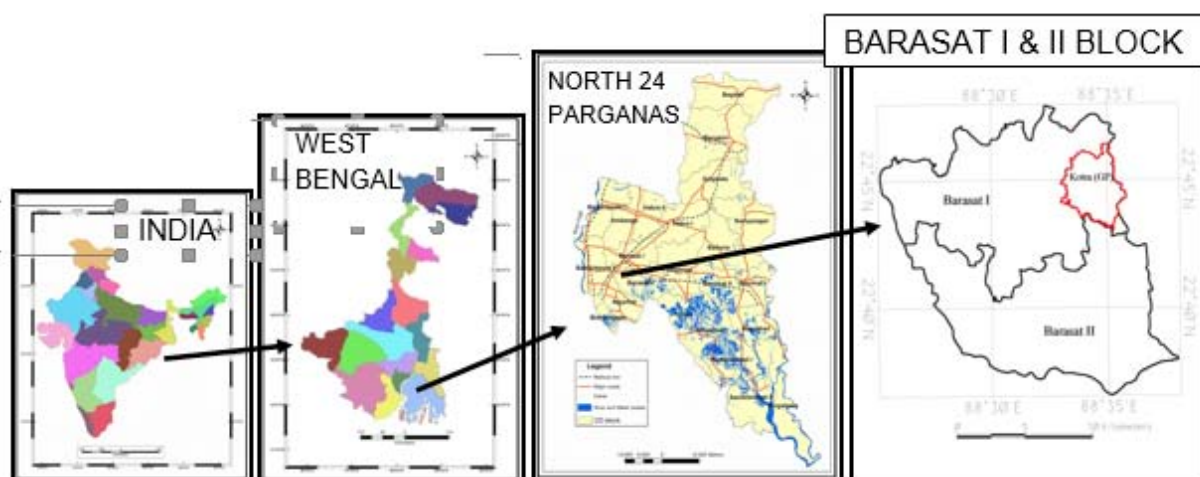


Figure 1: Location map of the study area

Study area

A case study of Kotra Gram Panchayat has been undertaken for asset mapping and web based technology is used to make the information available to the stake holders. This panchayat is located in Barasat block I, North 24 Parganas, West Bengal (Fig. 1). There are 15 villages in this panchayat. It covers an area of 1795.63 hectares Total number of population in this Panchayat is 23644 in 2001. Physiographically, this region is in Gangetic delta of West Bengal. It is underlain by tidal channels and alluvium soil is highly productive in agriculture. Most of the people (13.26%) are associated with agricultural activities.

Methodology

Phases of assets mapping of Panchayat in GIS environment

Phase I: Identification of potential resources from different sources.

- Land use / Land cover mapping using satellite images for information on different land use categories (Fig.2)
- Primary data collected from plot to plot survey using cadastral map.
- Identification of individual and community resources using G.P.S.
- Population data of the study area from census of North 24 Parganas, West Bengal

Phase II: Asset mapping for E-Panchayat and good governance.

Asset mapping create a comprehensive list of community resources that can provide programmes, services and a base of support and partnership for neighborhood network (Burns et. al. 2012). This type of guide may be used in conjunction with the website creation tool to create navigation of the assets and it may be updated and customized according to the need

Table 1: Different types of assets

Individual	Institutional	Governmental	Organizational	Physical
House	School	Gram Panchayat	No. of registered industry	Recreational facility (Play Ground, Picnic Spot)
	Religious	BL & LRO	No. of club	Crop Land
	HealthCare /center	Veterinary Institute	Community activity	Current fallow
	Market	Economic Development	Available no. of Home based organization	Settlement
			No. of family engaged with Home based organization	Water bodies Roads

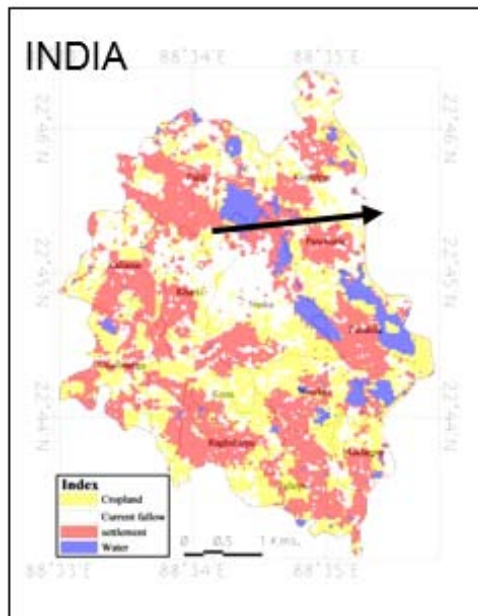


Figure 2: Land use/land cover map of Kotra Gram panchayat

or purpose. Listing and visualization of asset help the Panchayat administration in proper planning, monitoring, and development.

Phase III: Classification of assets:

The chart below (Table 1) further classifies the asset into five types. Within each type there is a list of resources available in this Panchayat.

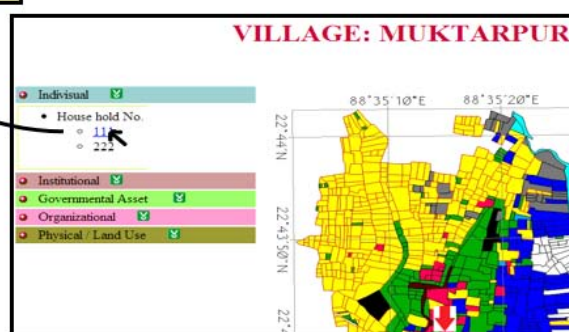
Phase IV: Asset mapping technique

- Geo-referencing of the selected area with referenced image.

Muktarpur ↔ Individual → Home address



Figure 3: Location of house in Muktarpur village



- Creation of Area of Interest (AOI) of that Gram Panchayat with village boundaries.
- Collection of GCP of different land use categories
- Identification of different land use from Google Earth.
- Supervised classification of land use from the image.
- Accuracy assessment of the land use classification.
- Extraction of different land use categories.
- Referencing of cadastral map of Muktarpur village or gram with the help of geo referenced gram panchayat map.
- Digitalization of the cadastral map (plot wise).
- Plot wise land use with G.P.S. survey and Google Earth and identification of socio economic Features.

Phase V: Web-based information

- Link of Gram Panchayat at village level with census population data.
- Visualization of land use categories (plot wise) of Gram and panchayat level as well.
- Visualization of assets (where and if necessary).

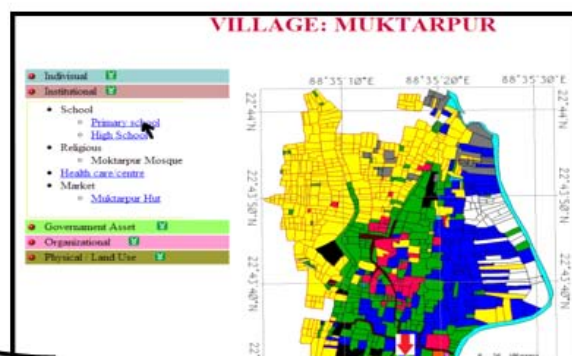
Results & Discussion:

Asset mapping is an ongoing process. It effectively helps the local people and organization, Businessman to discover the community asset and good relation among the people. Creation of webpage and its links to

↔ **Institutional** → School, Religious, HealthCare /center, Market



Figure 4: Location of primary school in Muktarpur village



other organizations can provide direct services such as job search; business opportunity etc. school, hospitals, and panchayat office are easily shown in the map. Fig. 3 to 6 show different assets of Muktarpur village and fig. 7 Google Earth Map. Also beneficiaries will get direct information about Govt. non-govt. programmes from the web-page. Its neighborhood connectivity helps different interrelated mission of development. Web-based E-Panchayat makes good governance. Gram Panchayat administration will be well governed through this process. Birth/death registration, marriage NREGS, SGSY, pension scheme, PDS scheme may be well managed and monitored through web page. It facilitates rendering educational services. Different information to the farmers, businessman is available through interface. Fisheries, animal husbandry may get good step for marketing. Small scale industries may organize or get connection to the larger market. The web page and its neighborhood connectivity will help the availability of knowledge and information at the same time.

↔ **Governmental** → Gram Panchayat, BL & LRO, Veterinary Institute etc.

↔ **Organizational** → No. of registered industry, No. of club, Community activity,

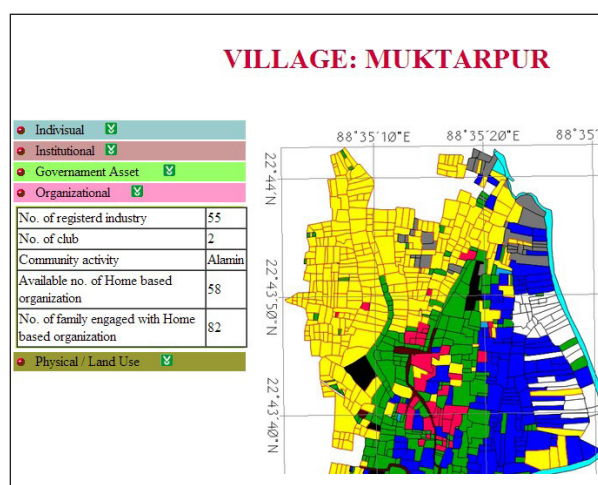


Figure 5: Organizational assets of Muktarpur village

Available no. of Home based organization, No. of family engaged with Home based organization etc.

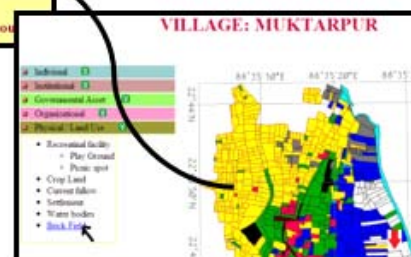


Figure 6: Brick kiln of Muktarpur village

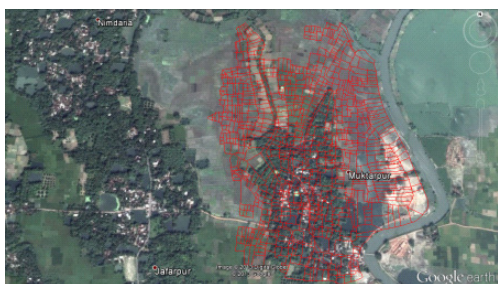


Figure 7: Muktarpur village on Google Earth Map

↔ **Physical/Land** → Recreational facility,
Crop Land, Current fallow, Settlement, Water
bodies, Brick Field

Acknowledgements

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Assessment of Social Infrastructure in Transforming Mills Areas of Mumbai: A Geographical Inquiry

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Keywords: *Geoinformatics, Typology, Decision-making, Valorization, Infrastructure, GIS environment.*

Abstract: The transformation of modern cartography from pure artistic schematic representation to present day modern scientific tool for analysis has given the geographer immense power to visualize and envisage the variety of data into either two or three dimensional surface. The concept of Geoinformatics has further supplemented and amplified the analytical capacity and measurement of data especially the spatial data. Techniques of map making and knowledge of Cartography is a crucial issue. The matrix of physical and social environment could be represented and exhibited through typologies of cartographic knowledge according to the level of decision-making.

The paper presents the attempts made to visualise the hurdles in amenity planning in the fast changing area of Mumbai and interpretation to understand the powerful players who make decisions for a socio-economic vulnerable space. The area selected for the study is the part of Mumbai City. F and G South ward which has experienced a drastic landscape transformation over a period of time. The area is targeted for valorization of space. Vertical and horizontal spatial extension is distinct. Traditionally known as mill area it is associated with cotton mills, their workforce establishment and infrastructure. This area lost its significance after the closure of these mills in early 90s. There is a clear cut contrast in the form of basic amenities, infrastructure and facilities in the old residential area and newly developed skyscrapers. This new development is gradually building the pressure on the existing infrastructure such as water supply, transport, medical and other civic amenities. An attempt has also been made to highlight the condition of existing infrastructure and its future composition by creating a spatial data base for the study area and develop a model in GIS environment to evaluate present and future problems the area is facing and the solution for the same, if any.

Introduction

Mumbai is one of the fastest growing cities of the world. It has changed its face from a purely industrial centre to the business hub over a period of time. The earlier expansion of the city was restricted to the Mumbai City limit which spread northwards to western and eastern suburbs along the rail corridors with the pace of time. The central part of Mumbai was dotted with number of cotton mills which was the boost to the economy of the city.

The cotton mill era and its decline

The textile mills, which played an important role in the industrialisation of Mumbai and evolved around the culture of the city's working class, are now giving way to development of

upscale neighbourhoods. The area was the crucible for the creation of a self-conscious Indian working-class and retained a strident trade union movement during the 1970s and 1980s. This was demonstrated by a prolonged and fractious textile strike during 1982 and 1983.

Gentrification has become a global phenomenon over the last fifteen years, and has been understood as an increasingly important strategy within neoliberal policy-making. The metamorphosis of the land is virtually complete. The mills of central Mumbai, once the engines of economic growth that employed lakhs of people, have long fallen silent. Smoke-stacks have been razed to make way for residential towers, malls, food courts, multiplexes and even a five-star hotel.

GIS and Socio-spatial Information

Conceptually, the Geo-environmental landuse mapping is the spatial representation of the human activities which is mainly dependent on socio-economic condition on the nature's own built system exemplifying the suitability of different terrain units in relation to the existing utilization or selective alternate uses, i.e. sustainable landuse planning. The holistic approach, using Geographical Information System (GIS) allow managers to observe, study and monitor, for instance, the effects and consequences of a particular decision on land use within a large geographical area concurrently and over appropriate periods of time. Spatial information fully and reasonably provides information services for urban planning management and decision-making for urban planning administration. This promotes the modernization for urban management. Application of GIS is appropriate and essential for scientific management and the decision making for socio-economic vulnerable space.

Study Area

The area selected for the study is the part of Mumbai City which comprises F and G South ward (Fig. 1) experiencing a drastic landscape transformation. The study however is confined to the mill areas of Parel. The area is targeted for valorization of space.

Vertical and horizontal spatial extension is distinct. Traditionally known as mill area it is associated with cotton mills, their workforce establishment and infrastructure. This area lost its significance after the closer of these mills in early 90s. There is a clear cut contrast in the form of basic amenities, infrastructure and facilities in the old residential area and newly developed skyscrapers..

Geoinformatic Inventory Analysis of F and G South Ward

To effectively manage all of the geospatial and non-geospatial information associated with urban infrastructure, cities today need 3D City Geospatial Information System. Efficient urban information system is a vital pre-requisite for planned development. The increasing demands in urban planning and management sectors call for co-ordinate application of remote sensing and Geographic Information System (GIS) for sustainable development of urban areas. There is an urgent need to adopt Remote Sensing and Geographic Information System approach in urban development and monitoring process for implementing pragmatic plan of Urban development. The plan must incorporate an integrated approach of spatial modelling using Remote Sensing Data, GIS database. This helps in evolving efficient and economical models for development and location of industries, education, housing, water supply, service



Fig. 1. Study Area (F and G South Wards of Mumbai City)

facility and disposal system etc. Geospatial Virtual Environments of the study area provides an effective way of presenting large amounts of complex information to a wide audience. 3D visual through geospatial analysis representation is fundamental to understanding and analysing variations in geospace. The endeavour for the study is as follows:

- Visualisation of the susceptible space of the mill land area and creation of database.
- Generating a landscape model with high degree of realism.
- Represent space and to understand space management

The study emphasised through GIS the planning for utilities like water supply, sewerage and storm water, hospital, drainage channels, educational institutes and housing facilities. Creation of geodatabase would augment the capacities in relation to the projected population and economic activities in different urban vulnerable space. This gives rise to design challenge that can be adequately addressed by GIS functions like 3D modelling.

Changing cityscape of Parel

With the gradual decline of the mills in the late twentieth century, this space is being recycled. Recently Parel has seen an influx of huge enterprises in the compounds of the long gone cotton mills. Five star hotel ITC Hotel, The Grand Central, Mumbai - The Luxury Collection is located in Parel. During the time cotton mills were operating in Parel area, many thousands of mill workers called Parel home. The large cotton mill real estate is being recycled into ultra-expensive gated communities. Parel has thus become an area where lower middle class and rich live side by side. Parel happens to one of the fastest developing neighbourhoods in the world. Parel has seen huge property price appreciation in excess of 8X over the last 10 years. Lodha World One, the world's tallest residential tower, which is to be located on former mill land in Lower Parel Urban planning and development is a continuous process and involves planners, administrators, developers, investors and of course, the residents. It is therefore high time to consolidate on the reported gains of the GIS application in urban planning. On

the other hand interfacing of urban planning models with GIS is important. Incorporation of land-use transportation models, water distribution network analysis, and simulation of urban activities to evaluate different urban development alternatives in the GIS framework needs to be explored for added advantage. Evaluation of urban policy by model-based GIS approach provides a useful insight to guide the development process and this is another area of application. The large variety and number of actors possibly involved in urban renewal, makes the design of urban gentrification plans a very specific and complex challenge. In this process design and communication tools play an important role. Visual information is believed to help to find out what the design problems are, to understand them and to choose sustainable solutions because this visual information is supposed to be a common language between the different actors in the process. In this paper we study in which ways visual information may support the design process or urban renewal and in how far 3D visualisation and GIS-technology is useful to achieve this task. 3D models provide the largest flexibility in interacting, exploring, editing and analysing. But in contrast to photo images, 3D models always lack the real-world realism, which often is seen as the greatest problem in communicating ideas.

Present Landuse

The map depicts the dynamicity of the landuse in the area (Fig. 2). It is observed that there is contrasting use of land here. Pockets of high-rise apartments are embedded in the original landscape of the mill land with workers quarters and mills. The process of gentrification is visualised by the geoinformation analysis. The targeted locales can be recognised and the related socio-spatial issues could be identified. This had helped to build a knowledge base of the study area for infrastructure planning. Recycling and generation of new landscapes are visualised. The analysis also highlighted FSI of the skyscrapers within the built environment. This clearly projects the intrusion of globalisation. There are 37 projects on the mill areas of which 9 major upcoming projects are given below. The transformation is mainly to the high class residential areas and corporate offices. The following table (Table 1) highlights the selected on-going projects on the mill areas.

Table 1: Selected on-going Projects in the Study Area

Sr. No	Name of the former mill	Name of the Project	Nature of change	Height in meters
1	Jupiter Mills (South)	Indiabulls Sky	Commercial / Finance	200
2	Matulya Mills	Sun Palazzo	High class residential	66
3	New Islam Mills	One Avighna Park	High class residential	256
4	Phoenix Mills	Futurex	Residential / Commercial	
5	Piramal Spinning & Weaving Mills	Marathon Nextgen by Marathon Group	High class residential	120
6	Shriniwas Mills	World One	High Class Residential	442
7	Shriniwas Mills	World Crest	Commercial	228
8	Shriram Mills	Palais Royale	High Class Residential	320

It is interesting to note the competition for the sky scrapers. A 3D modelling is also attempted to visualise the effect of such projects on the surrounding.

Status of various amenities of the Study Area:

A detailed survey was carried out regarding the basic amenities like open spaces, medical, educational, administrative, transport, banks, police station, fire brigade, post office etc., available in the changing cityscape (Fig.3 and table 2). It is very interesting to note that the most of the amenities are concentration on the eastern part of study area than the western. Before closing of the mills majority of the area was occupied by the mills and the mill workers working in these mills come from the adjoining areas of Parel. It is evident that the amenities

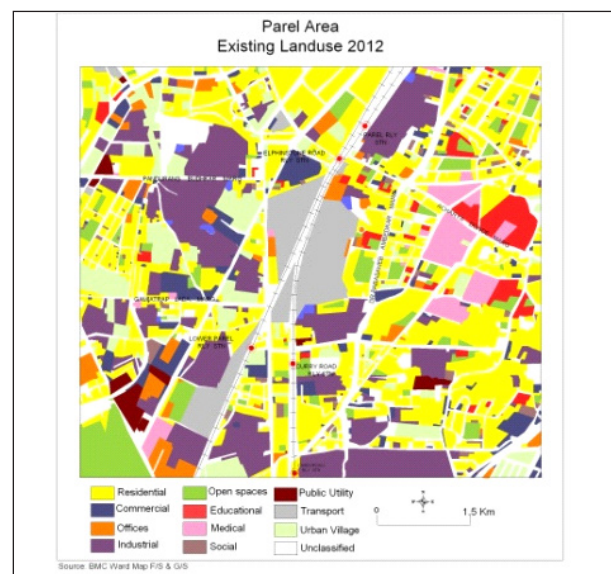


Fig. 2 Existing Land Use of Parel Area



Fig.3 Spatial distribution of these basic amenities of the study area

Table 2 Spatial distribution of these basic amenities of the study area

Sr. No	Type	No	Existing Amenities and its nature	Proposed Amenities and its nature
1	Medical	8	Mainly general hospitals for lower income groups	Super special hospital to cater high class residential
2	Educational	18	Majority of the schools are municipal except few having English medium	Schools with IB, ICSC and CBSC for elite class
3	Bus Depot	2	One Best and one ST depot	Bus depot in western part is essential
4	Ward office	2	Only one F/S and G/S ward office	More local administrative offices for filing complains
5	Banks	7	Banks concentrated in eastern region	More banking is inevitable due to emergence of corporate offices
6	Police Station	4	No major police station on western side	More police chowkies should be established from security point of view
7	Fire Brigade	-	Nearest fire station 2 km on northern and southern side	At least one fire station on western front is must
8	Post Office	5	Only one western side	Two more post office will be strictly necessary taking into account the vertical expansion

available in these are essentially meant for the lower strata of the society i.e. lower and middle income groups (Fig. 4). For example the majority of the schools in this area are municipal schools with few English medium. The hospital like KEM essentially deals with the patients from the surrounding area. As compared to other amenities the number is very less when compared to the vast areas to be served. It is very shocking to note that

there is no fire brigade station in the mill area. The nearest one is at Naigaon in the north and Sarrasta in the south. Though these are around 2 km away, congested and narrow roads with heavy traffic will make it still difficult to reach to such huge buildings in the adverse situation. The police stations are only 4 putting enormous pressure on the station to control crimes. After the closure of mill many of the unemployed youths of these areas have opted the criminal activity due to dearth of making money for survival. One of the permanent problems of this is the water logging during the monsoon. With increasing concretisation the more number of cars are expected to come on the road creating a complete chaos.

A survey of all related issues to Municipal Corporation was conducted by Praja - an NGO actively involved in bring out the real status of each ward every year. The survey of F/S and G/S brought out some shocking results. The results for 2011-12 are tabulated in the following table 3.

In both the cases diarrhoea with maximum occurrences is the most sensitive disease; where death by tuberculosis is an alarming situation. In G/S ward (western part) Water supply is the top civic issue for last three years and as per the perception survey corruption is the top issue. In F/S ward (eastern part) drainage is the top civic issues for last three years and as per the perception survey water logging during rainy season is the top issue.

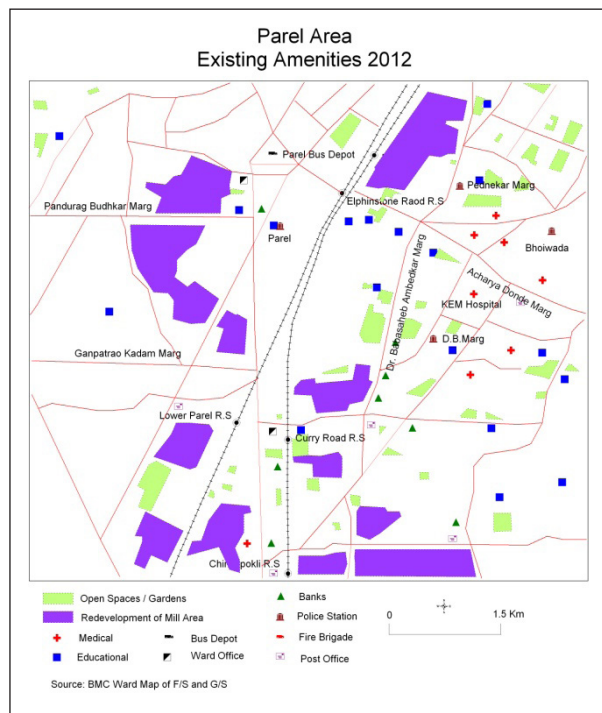


Fig. 4 Existing amenities in Parel Area (2012)

Table 3:

Nature or type of Complain	F/S Ward (eastern part of study area)	No	G/S Ward (western part of study area)	No
Major Issue	Drainage	506	Water Supply	509
	License	288	License	386
	Road	145	Pest Control	273
Health	Occurrence	Death	Occurrence	Death
Diarrhoea	7261	34	7252	25
Malaria	4499	126	3115	130
Hypertension	3586	242	2198	150
Tuberculosis	-	1053	-	286

Conclusion

From the above discussion it is very clear that there is going to be tremendous pressure on the existing amenities of the Parel area, e.g. the western part suffers from water shortage while the eastern part lacks proper drainage facility. The question of creating new will amenities remained unanswered as there is no horizontal space available in the mill areas due to fullest utilisation of the FSI. Though the upcoming projects always claim to fulfil all the essential amenities within the project area, how far they will be feasible, accessible, affordable, maintainable is the main issue. This is, therefore, debatable that what planning measures have been taken by the concerned authorities before sanctioning such

huge projects of vertical expansion. There is no doubt that the dream of making Mumbai like Shanghai (in other words fancy of few elite classes) will be fulfilled. However it is at whose cost? is it by making the already poor people more poorer thereby displacing them or construction of one more dam in adjoining rural areas for supply of water for swimming pools of these projects. Well the list will go on and on, and the life of the common people in this area will remain unchanged.

Acknowledgement

The authors would like to acknowledge the work done by 'Praja' Foundation, an NGO in Mumbai which helps us tremendously in the present study.

Geo-spatial Availability of Amenities and Planning of Service Centres: Case Study of Dharampuri Tehsil of Dhar district, M.P.

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Keywords: *Amenities planning, Hierarchy, Ordering of services, Spatial distribution, Flow of amenities*

Abstract: Service centres are those spatial units by which mostly services and amenities are provided to particular area and their population. These centres are located in central suitable position in an area where accessibility is more. Town's development is not a spontaneous process while cause of environment created by nearby places which lead to centre development. Each service centre may be metropolis or rural market does social, economic, cultural and political work for nearby areas. These functions or services have not equal importance on development of centres. In present era the differences between villages and cities is closer to end which leads to new aspects of development in rural areas thus a change is identified in services centres and providing amenities. Services and amenities are basic feature for this development. Planning of these amenities relating to the services and its better utilization can be improved as developed centres. For finding of possibilities of development services and amenities should be studied which we will try in this paper for better planning and status of centres in Dharampuri tehsil. The main objectives are Present status of services and amenities in Dharampuri tehsil and its hierarchical status, determination of service centres and ordering of services on hierarchical basis, flow of amenities through service centres and planning measures.

In study total 7 market centres of Dharampuri tehsil are universe. Based on avail services in these market centres Scalogram will be prepared and then determination of service centre will done with categorisation in to Low, Middle, and High services group and a directional flow of these group between service centres with diagram will be shown. In study primary and secondary data will be collected. For survey we include 5% of total household population at service centres. In analysis we will include data obtained from group discussion and observation table.

Introduction

In 20th century hierarchical concept is getting more important in regional studies. On the basis of hierarchy we determine the morphology, status, functional role of city and which amenities should be intensified in particular area. Which service is appropriate for region is decided through hierarchy. If settlement is large then the services will be compact and more important and opposite for smaller settlement.

Service centres are those spatial units by which mostly services and amenities are provided to particular area and their population. These centres are located in central suitable position in an area where accessibility is more. Town's development

is not a spontaneous process while cause of environment created by nearby places which lead to centre development. Each service centre may be metropolis or rural market does social, economic, cultural and political work for nearby areas. These functions or services have not equal importance on development of centres. In present era the differences between villages and cities is closer to end which leads to new aspects of development in rural areas thus a change is identified in services centres and providing amenities. Services and amenities are basic feature for this development. Planning of these amenities relating to the services and its better utilization can be improved as developed centres. For finding of possibilities of development services and amenities should be studied which we tried in this paper for better

planning and status of centres in Dharampuri tehsil.

Objective

The main objectives are –

- Present status of services and amenities in Dharampuri tehsil and its hierarchical status.
- Determination of service centres and ordering of services on hierarchical basis.
- Flow of amenities through service centres and planning measures.

Study area

Dharampuri tehsil in Dhar district is located at $22^{\circ}25' - 22^{\circ}50'$ N latitudes and $75^{\circ}15' - 75^{\circ}35'$ E longitudes & MSL + 368 m. towards south-east to Dhar district head quarter (Fig. 1). Area of tehsil is 446 sq. KM., population according to 2011 census is 183509 and population density 412 per sq. KM.

Research Methodology

In present study total 7 market centres of Dharampuri tehsil are universe since in area

market centres are less so all we included into our research. Based on available services in these market centres Scalogram has been prepared and then determination of service centre been done and categorised in Low, Middle, and High services group and a directional flow of these group between service centres with diagram is shown.

In study primary and secondary data are collected. For survey we include 5% of total household population at service centres. In analysis we include data obtained from group discussion and observation table.

Ordering of services

In geography the concept of hierarchy is most important in all. To understand the order of settlement the phenomena of hierarchy is always there in various form. In present day it is used in decide the order and level of any element. Hierarchy is based on centrality of settlement. By Centrality we conclude number of thrust functions of settlement and their characteristics. Thrust functions are those are found in specific settlement cause of their

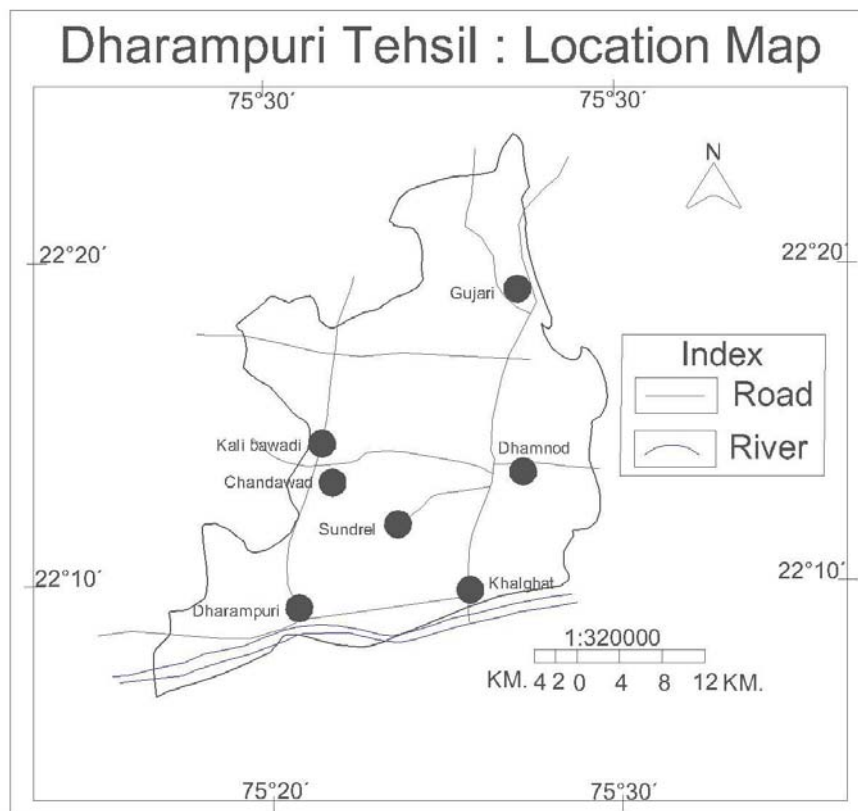


Fig. 1 (Source: Tehsil office)

Table 1.

Services	Functional Weight	Order Value
Primary School, Middle School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Seed & Fertilizer Distribution Centre	1	5.54
High School, Magazine, Co-operative Bank, Other Credit Society	1.17	13.50
Higher Secondary School, Telephone Bill Office, Electricity Bill Office, Commercial Bank, Village Panchayat	1.40	18.00
Lodge, Petrol Pump, ATM	2.33	22.00
Police Station, Two Wheeler Showroom, Nursing Home, Cyber Cafe, Gas Booking Office, Nagar Panchayat	3.5	26.50
Block Office, College, Krishi Mandi, Cinema, Tehsil office, Court, Godam, Jail	7	33.50

Source: Field Survey 2012

nature. These functions are non ubiquitous neither found uniformly and nor act similarly.

For hierarchy mainly two bases are considered-

- Total population
- Centrality

But in this paper we consider centrality as main factor; based on its avail services and their hierarchy because some service centres has been observed which population is less but the services present there are comparatively high so they got importance. In this research paper we included 37 services. By these services scalogram has been prepared and based on hierarchy of service centres and amenities order of services has been drawn which are given in table 1.

After calculating the functional weight of services we arranged them in ascending order and draw the order value for each service. As per order value we Classified services in three Groups (Table 2) and available amenities in table 3.

Table 2.

Sn.	Group	Value Range	Services
1.	Low Service Group	- 13.50	Primary School, Middle School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Seed & Fertilizer Distribution Centre, High School, Magazine, Co-operative Bank, Other Credit Society.
2.	Middle Service Group	13.51-26.50	Higher Secondary School, Telephone Bill Office, Electricity Bill Office, Commercial Bank, Village Panchayat, Lodge, Petrol Pump, ATM, Police Station, Two Wheeler Showroom, Nursing Home, Cyber Cafe, Gas Booking Office.
3.	High Service Group	26.51-33.50	Block Office, Nagar Panchayat, College, Krishi Mandi, Cinema, Tehsil office, Court, Godam, Jail.

Source: Field Survey 2012

In regional Planning the hierarchy is most important. If we want to arrange any new amenities or services in any particular area then hierarchy must be key factor and it is only possible by the help of hierarchy. According to Total Functional Weight we can classify service centres in five categories (Table 4).

Specific Nature of any services determine the linkage and distribution of itself and meanwhile it also a factor of dynamicity. If amenity is present in each service centre then effect and mobilization of service will defiantly low while if amenities presence is less then dynamicity and linkage will high. For the determination of connectivity and effect of service centre the empirical method is used which is shown through fig. 2, 3 and 4.

Through the maps we found that how is the linkage, connectivity and effect of any service group and its flow. Linkage of service centres are drawn by lines in different maps.

Conclusion and Planning:

We can provide new form and aspect to any service centre through planning and

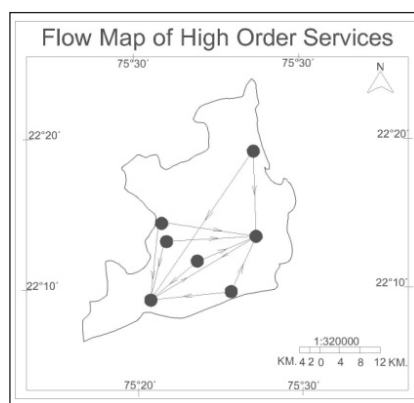


Fig. 2

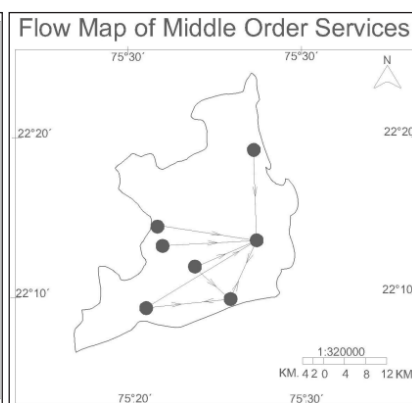


Fig. 3

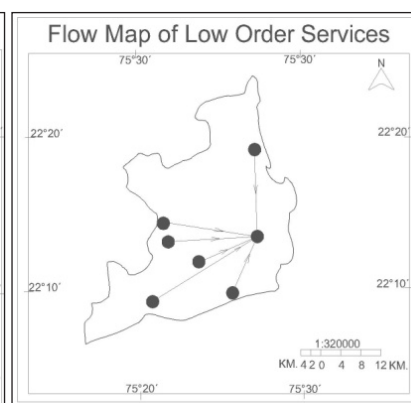


Fig. 4

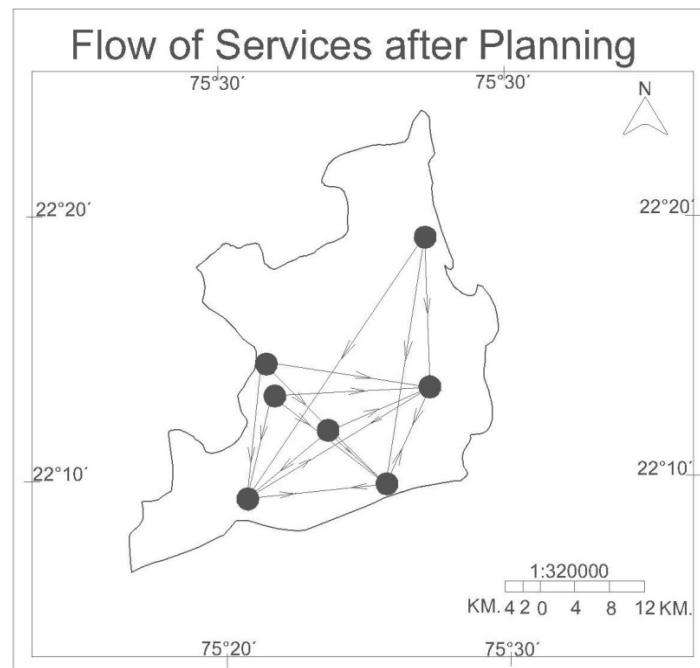
planned distribution. In Dharampuri all types of services are available from low to high but there are some services for them people are dependent to other centre as- higher education, super specialist hospitals, super markets, malls, four wheeler showroom, railways, air services, industries etc. Dharampuri is located at south-east to Dhar district headquarter and its boundary touches to Indore, Badwani, and Khargon District. NH3 and Narmada River

also passes here which most benefited situation finds in Khalghat service centre. While there is low population but cause of abundance in amenities it keeps specific position.

Dhamnod service centre is not a Tehsil point but keeps high order service groups so here is an opportunity to start super markets, and various company to generate employment and commercial benefits because its population and direct connectivity with Indore metropolis.

Table 3. Available amenities in Dharampuri Tehsil

Sn	Service centre	Amenities
1.	Dharampuri	Primary School, Middle School, High School, Higher Secondary School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Telephone Bill Office, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Electricity Bill Office, Commercial Bank, Lodge, Police Station, Petrol Pump, Two Wheeler Showroom, Block Office, Nursing Home, Cyber Cafe, ATM, Gas Booking Office, Nagar Panchayat, College, Tehsil office, Court, Jail.
2.	Dhamnod	Primary School, Middle School, High School, Higher Secondary School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Telephone Bill Office, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Electricity Bill Office, Commercial Bank, Lodge, Police Station, Petrol Pump, Two Wheeler Showroom, Nursing Home, Cyber Cafe, ATM, Godam, Gas Booking Office, Nagar Panchayat, College, Krishi Mandi, Cinema.
3.	Khalghat	Primary School, Middle School, High School, Higher Secondary School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Telephone Bill Office, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Electricity Bill Office, Commercial Bank, Village Panchayat, Lodge, Petrol Pump, ATM.
4.	Sundrel	Primary School, Middle School, High School, Higher Secondary School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Telephone Bill Office, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Electricity Bill Office, Commercial Bank, Village Panchayat.
5.	Gujari	Primary School, Middle School, High School, Higher Secondary School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Telephone Bill Office, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Electricity Bill Office, Commercial Bank, Village Panchayat.
6.	Kali Bawadi	Primary School, Middle School, High School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Village Panchayat
7.	Chandawad	Primary School, Middle School, Primary Health Centre, Clinic, Post Office, Telephone, Mobile, Metalled Road, Bus Service, News paper, Magazine, Seed & Fertilizer Distribution Centre, Co-operative Bank, Other Credit Society, Village Panchayat



Source: Field Survey 2012

Fig. 5

Sundrel service centre needs to maintain their accessibility through quality of roads because it is connected with many villages and it is also provide a corridor to reach nearby places. Here also famous weekly periodic animal market is confined with have influence area about to 200 KM. So if road services got intensified and maintained, it will directly benefit other services.

Table 4.

Sn.	Service Centre	Total Functional Weight	Present Status of Service centre
1.	Dharampuri	87.77	Developed Centre
2.	Dhamnod	70.27	Developing Point
3.	Khalghat	29.67	Market Centre
4.	Sundrel	24.67	Service centre
5.	Gujari	24.67	Service centre
6.	Kali Bawadi	19.04	Central Village
7.	Chandawad	17.87	Central Village

Source: Field Survey 2012

Apart from above mentioned ways Kali Bawadi and Chandawad needs to progress in primary level as in improved educational

facilities and other civil service centre to control the flow of population to other destination.

The facilities which are under developed due to migration of population towards Indore centre to get higher level facilities. If facilities grow here then we can stop migration.

If Planning be done as per our suggestions the flow of amenities will be in following manner (Fig.5)

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An Assessment of Community Development of Jhargram Municipality, Paschim Medinipur District, West Bengal using Remote Sensing and GIS

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Keywords: Community development, Fundamental, political infestation, physical resource, problems, social linkage, RS/GIS, decentralization, traditional habitats, development, land use/land cover.

Introduction:

Community development combines the idea of community with development. The World Bank research observes the situation of a community, not only just economically, but also as a strong functioning community itself. Thus community development relies on interaction between population and joint action rather than individual activity what some sociologist called collective agency (flora and flora 1993) Urbanization is one of the most important factors that changes land surface which are usually composed of natural covers and Jhargram municipality is not any different. Jhargram municipality is the newest municipality of the district of Paschim

Medinipur has set on 1982 .It consists under Jhargram Block and Jhargram sub-division. It extends from 22°24'00" North Latitude to 22°28'51.57" North Latitude and 86°58'26" East Longitude to 87°3'0" East Longitude respectively. Its total area is about 24.01^{sq}km (2013 after delineation). Now it is in newly formed Jhargram police district. It is situated in the forest fringe area of Jangalmahal which is the extended part of Chhotanagpur plateau. It is also situated in the water divided region of river Kansai and Subarnarekha. Average height is varies from 57 m to 113 m above the sea level. Rainfall is very low 800 mm/year. Highest temperature is 45° during summer and lowest temperature is 20° during winter Fig. 1.

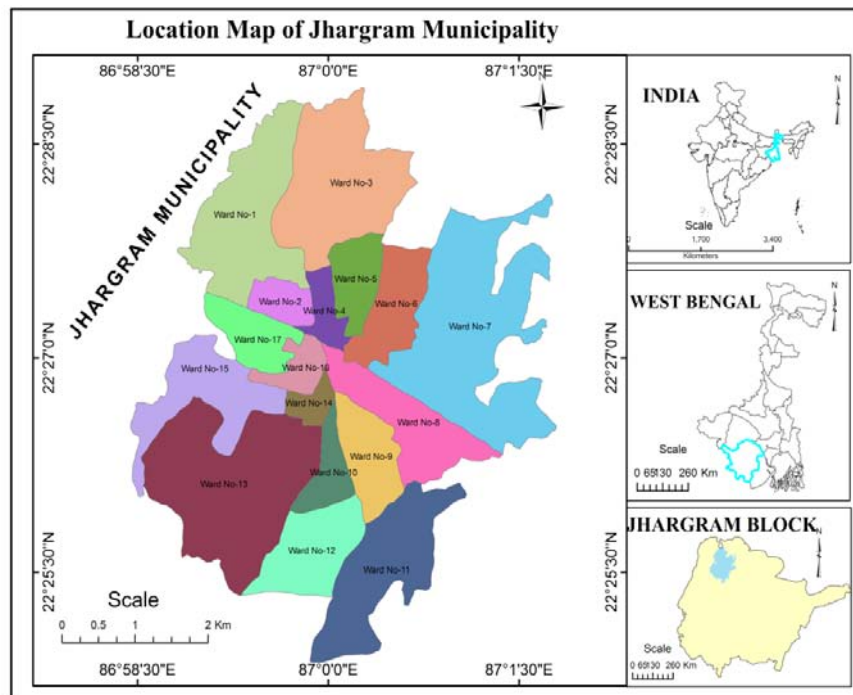


Fig. 1.

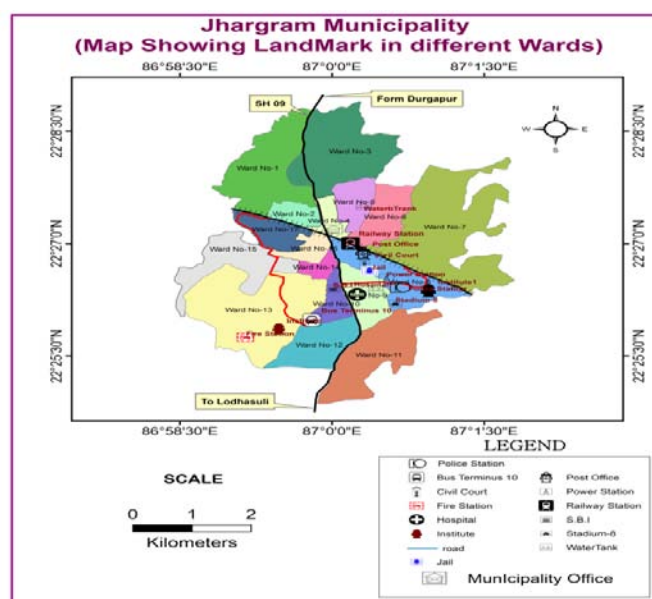


Fig. 2.

Groundwater table is very low, pre-monsoon water table is 20 to 25 m below the surface and the post-monsoon water table is increased 5 -6 m.

Total population of the study area is 61682 (2011). Male population 50.17 % and female population is 49.83%. Female population has been increasing around 1 % in last census decade. It is a good sign for demographic composition. Here male literacy is 43.24% and female literacy is 39.04%. Total literacy is 82.28%. Scheduled caste population is 9.93% of the total population and 10.67% belongs to Scheduled Tribe population. Main tribal communities are Lodha, Santal and kharia. Binswanger and Aiyer (2003) have provided examples of successful community driven development interventions. According to Shaffer (1989) community vitality is the capacity of the local socio economic system to survive and persist in generating employment, income and wealth and to maintain if not improves its relative's economic position.

Relevance of the study:

The main rationale of the present study is to find out the streams of development in different wards for improvement of the livelihood Patten in relation to community development of Jhargram Municipality .Forest provides the livelihood security for the people living in close proximity to the forest. More than one billion people in the world depend on forest

for their livelihood (World Bank 2001). There are 3 wards have tribal dominated with Lodha and Santal. Most of the tribal communities are living with traditional occupation based on forest .Here development is a social stigma for them .This is one of the backward municipality in West Bengal as well as India.

The main focus of the study will be to look in to the different government facilities and municipal programmes working in this area for improvement of livelihood pattern.

Aims and objectives:

1. To identify different problems of community development.
2. To identify change in the urban space of Jhargram town and to determine the trends of change over the period of 21 year for 1990 to 2011.
3. To understand the amenities available for the people.
4. To Harness the strategy for sustainable livelihood enhancement for community development

Data Base and Methodology:

The present study is based on the primary information collected through field and perception survey of the local communities with the help of questionnaire during 2012-2013. Jhargram municipality is divided in to

17 wards; from every ward 10 households were sampled. So the study is based on 120 household. The main purpose of the field survey was to know the present problems of the inhabitants and the reasons behind it. In the second phase field data have been collected for identifying sample site for classification and reference data for accuracy assessment of classified images. Secondary data and information gathered from different offices such as Municipality office, S D O office, Hospital, P H E office, Electric office etc.

Normalized different vegetation Index (NDVI) image generation and differentiation Image classification and post classification, change detection, analysis of results and identification of spatio-temporal change of urban settlement. Satellite data from ETM+ image were used. Image processing was done in Erdas Imagine (version 9.1) and spatial GIS data creation and analysis were done in Arc GIS (9.3 version) GIS. Different cartographic techniques are used to analyze different data.

Results and Discussions:

Land use Pattern: The Pattern of the land use reflects the characters of rapidly growing urbanization. The total area of municipality is 24.01 sq. km. The town expanding in such a way that it is very difficult to identify the Panchayet area and municipal area at the outskirts in three sides. The land use land cover map shows that the area is used in following purposes (fig 3).

Settlement roads etc- 71.45%

Forest-17.61%

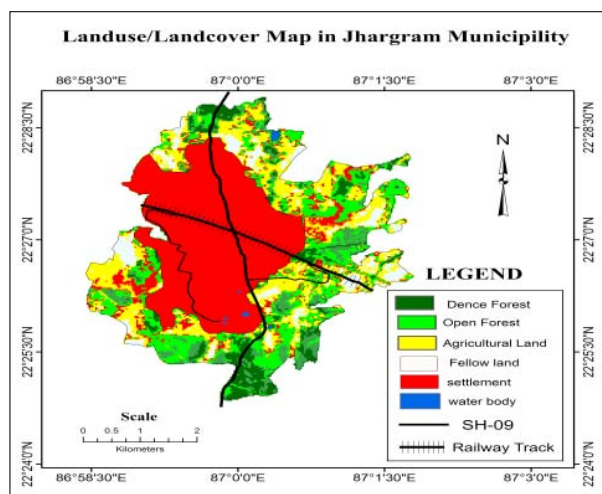


Fig. 3

Agricultural lands and water bodies-5.07%

Fallow land - 5.87%

Forest cover change map (fig 4 and 5) reveals that in 1990-36% land is covered by forest. But now (2011) only 17.61% land is covered by forest. Now dense forest is still noticed in the ward no. 11 (old Jhargram), 1 (Lodhabosti) and 7.

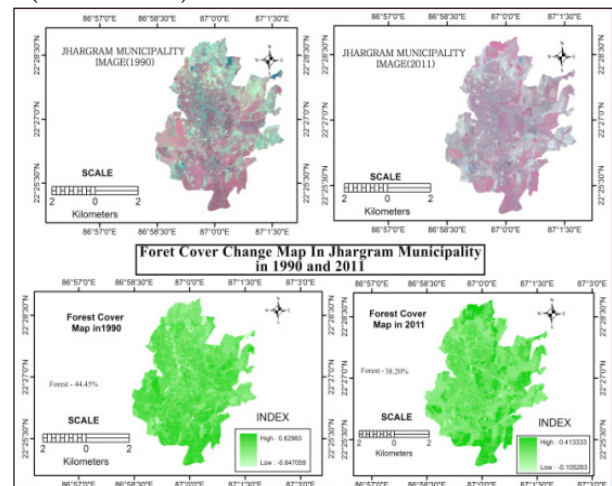


Fig. 4

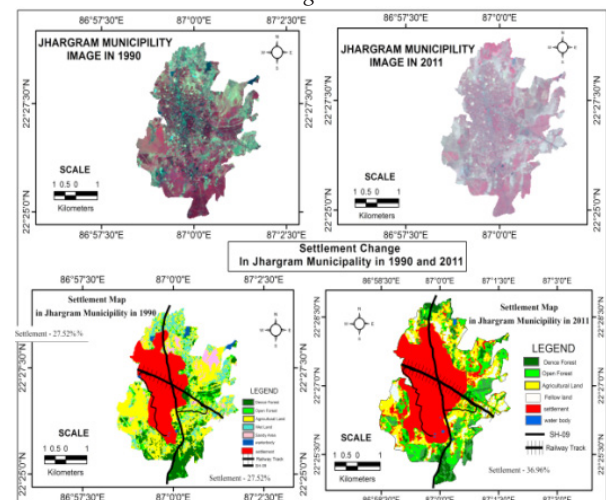


Fig. 5

The settlement change detection map reveals that with the increasing settlement the forest land and agricultural land is being decreases. The most of the settlement grown up area is noticed in the ward no. 13, 14, 15, 16 and 17 because of the central part of the town (fig-6). Different amenities and infrastructure is easily available here.

Drainage system: -The town has no underground drainage system, only the town is depend on insufficient surface drainage

system. The commercial place of the town faces water-logging during rainy season. The town dwellers are mainly depending on katcha drains which are silted and encroached for construction of houses and accumulation of wastages. Drainage systems fully depends upon the landscape of a place. The contour map and cross section of line reveals that the area is mostly undulating. The range of the height is 57m to 113m approximately above the sea level. The burning need of the town is to arrange proper and ideal drainage facilities according to contour plan.

Water supply:-Drinking water is supplied through pipe water from 12 deep tube wells ,8 nos. maintained by PHE Dept. and 4 nos. by Municipality ,and 2 overhead reservoir ; one is of 1 Lakh gallons& another is of 50 thousand gallons & 37 hand pump tube wells. 2.71 Lakh gallons of water supplied daily from the 12 deep tube wells against the daily total requirement of 16.28 Lakh gallons. Through 65% area of the town has been covered so far by providing insufficient drinking water from 850 standpoints through 70 km pipeline. People of rest portion depend on ring wells for drinking water which is unsafe .No holding is provided with house connection due to scarcity of drinking water. An adequate water is essential for households welfare and a pre requisite to good hygiene and sanitation .In adequate water supply facilities and poor sanitation condition can have a deleterious impact on household out comes. (Kumar et.al 2003)

Literacy:-Literacy is an important indicator of development. Literacy can eradicate poverty and control the rapid growth of population and help to secure food. The rate of literacy is 82.28% of which male literacy rate is 43. 24% and female literacy rate is 39.04%.

Communication:-Jhargram railway station is situated in the middle of the town on Howrah-Mumbai railway line. It is one of the busiest stations with unending movement of passengers. The main level-crossing of the town very often remains closed due to movement of passengers and goods train creating heavy traffic jam on the main road of the town. Jhargram town is connected with District Headquarter State-capital other district of the state and neighboring states by road. N.H.6 is passing 15 km away from the town. At present there are 47 km pucca

(bituminous) road, 65 km. morum road and 55 km katcha road which are very insufficient in comparison to increase of traffic load and habitations. The town is mainly dependent on a main road running through the town .But the state road was close from August 2011 because of construction of railway over bridge near the railway station. Now there is a confusion that the over bridge area is situated in the Rayti land instead of government land. So the construction is stopped now. Encroachment of road side and small passage of road create several problems of dwellers. Some times to cover 500 m road it takes about 3 km to reach the place by car or taxi, because of construction of over bridge. It is great problem, for the patient, student, old man and other persons. The situation revealed that rail way over bridge construction project has some serious negative impact on its surrounding environment especially during rainy season.

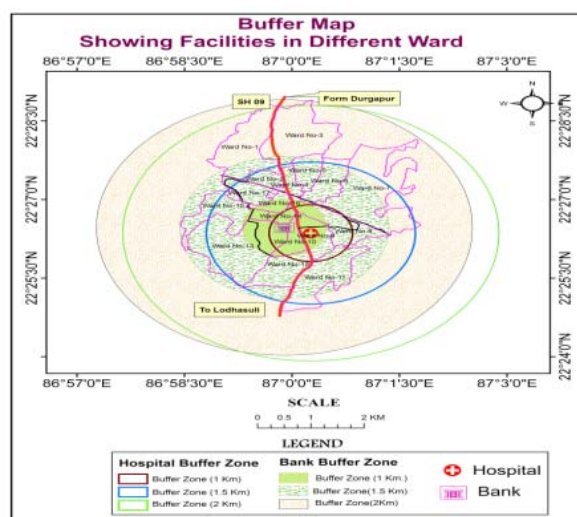


Fig. 6

Health Facilities: Health status of the residents also influences the community development. Jhargram Sub-Divisional Hospital situated in the heart of the town as well as Sub-Division as a whole. A number of private nursing homes and clinic are there in the central place of the town. Jhargram sub-division Hospital has 265 beds, 37 doctors, 68 nurses and one ambulance. Three ambulances of private ownership are also used by the hospital in case of necessity. Patients of serious diseases are not treated here due to non-availability of infrastructure and specialized personnel. The municipalities do not have any medical unit. Only an ambulance is going to be purchased for affording the health and immunization

programmes. The number of registered patient is 97025 in 2012-13.

Banking Facilities:- Three nationalized banks and three co-operative banks are located in central part of the town. The Buffer map is prepared in two layers using GIS data (fig 7). The first layer is showing the facility based on availability of the hospital. People living in distance area cannot easily access to the hospital facilities. Four banks are concentrated in the central portion of the town, get banking facility easily. Similarly people in distant area from the central place cannot easily get to the banking facilities.

Electricity Facilities:- The electric energy is controlled and maintained by WESEB in the town. The Municipality maintains the street light arrangement. Before 2011 the town suffers from low voltage and frequent load shedding but now it is removed. Street light is not provided properly throughout the town. Only central place is properly lighted.

Social Instability:- There is no proper numbering of the house hold. In Urban area it is a vital problem. Jhargram is well known for last 5 years for its political unrestness. Several times strikes, Bandh are the major causes for the lagging of development. Now the political situation is quite better. 997 person (436 male and 531 female) joined West Bengal police service from Jhargram in 2012. The ultimate developmental purpose there have been formed a special Jhargram police district. Different developmental programme is going on with the help of state government as well as central government.

Suggestion and Conclusion

Electricity, pucca drain and the safe drinking water should be providing for all the people of Municipal area.

Due to scanty rainfall underground water level is drawing down day by day. To provide with drinking water to the uncovered area of the town and to provide house connection a few deep tube wells & reservoirs are required to installed at this moment and surface water of the river Kangsabati, 7 km away from the town, may be utilized to meet the need of the town.

The inhabitant of out skirts wards that in ward no. 1, 7 and 11 are the main beneficiaries

of forest. So special emphasis should be given for eco-friendly forest resource management process for then this process is healthy for the tribal community as well as forest protection.

The micro level s integration resource planning through state government should be implemented.

There is sufficient potentiality of establishing of small and medium size industries within and adjacent areas of the town.

Dairy industry is to be developed commercially with special emphasis.

The environmental impact assessment has to be done before different developmental planning. Though Jhargram is situated in backward area of west Bengal the proper developmental programme should be initiated without the social and political biasness.

Acknowledgement

The author acknowledge the university grants commission for funding a minor research project entitled, problems and prospects of community development in Jhargram Municipality W.B This paper is the part of that project.

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Identification of Potential Site for Coastal Tourism with the Aid of Geospatial Tools for the Upliftment of Fishing Community Development: A Case study of Manavalakurichi Fishing Hamlet, Kanyakumari District, Tamil Nadu

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Keywords: *Geospatial Tools, Coastal Tourism, Chinnavalai, coastal resources, tourism and accessibility facilities*

Abstract: Coastal zone is the source for a number of resources that gives rise to characteristic activities, especially tourism. Sun, sea and sand form the basic components for coastal tourism, which is environmentally dependant. This research aims at using the Geoinformatics technology/geo-spatial tools for identification of the potential coastal tourism resources in Manavalakurichi for development and social upliftment of the resident fishing community. The study area has the fishing villages of Periyavalla and Chinnavalla, Manavalakurichi, Kanniyakumari district, Tamilnadu, is a less explored coastal tourism spot, with a great scope for development. The study aims to study the impact of Tourism to provide an additional means of income to the local fishing hamlet, which in turn will harvest satisfied host communities. Remote sensing data, GIS and GPS are the important geospatial tools for the interpretation of potential coastal tourism resources and its development. Remote sensing and GIS in the study of coastal tourism provides the permanent representation of objects, phenomena and other existing elements. The geospatial tools provide an excellent opportunity to repeatedly analyse the same data for various objectives and purposes.

Introduction

Coastal zone is the interface of land and ocean encompassing the fine shoreline either a sandy coast or a rocky coast. The components of the coastal zone comprise deltas, plains, wetlands, beaches, mangroves, lagoons and etc. Coastal zone plays a very crucial role for several coastal inhabitants since time immemorial. The coast line is approximately the 14,474 km length with the beautiful environment and view of the area. The beaches of both Periyavallai and Chinnavalai are very clean by looking anyone would like to visit the area. It has the environment of partly cloudy with calm wind.

Coastal Tourism Product

Coastal area has been the leading preference for choosing as a popular tourist destination. Coastal destination offers variety of activities for tourist. The world has been experiencing the booming tourism sector around the globe and ever increasing demand for an unexplored coastal destination. The inherent character of

every coastal area makes tourism unique. Coastal resources can be divided into natural and historical resources. Natural resources have to fulfil certain conditions such as physical suitability, scenic quality and accessibility facilities and etc. Hence the above qualities of the beaches will turn into a recreational spot and in turn will contribute to the revenue regeneration as well as employment opportunity to the local community.

Geospatial tools used in the Study of Coastal Tourism

In a quick span of time, with less man power large amount of data can be procured using geospatial tools. Besides using of geospatial tools are cost effective and identify even the minute details invisible to human eye. Integrated use of remote sensing and geographic information system has been proven useful in several fields. In such cases optimum use of geospatial tools will produce gainful information. The data obtained from remote sensing provides a good source of input in GIS; the same data can be

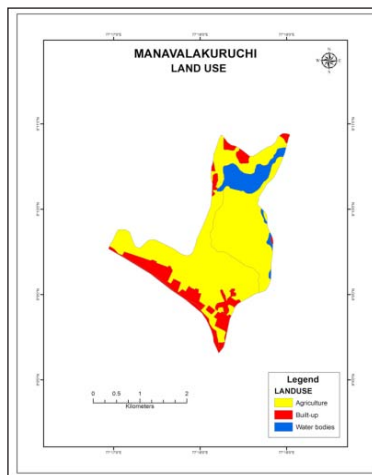


Fig. 1.

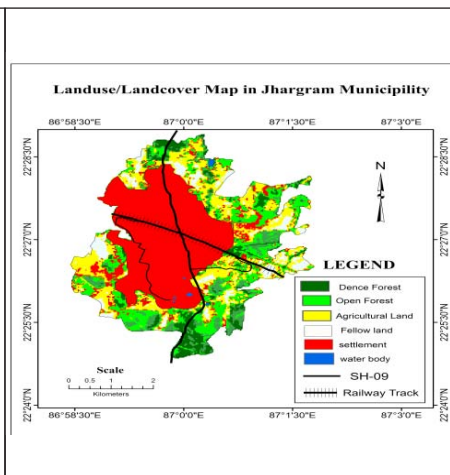


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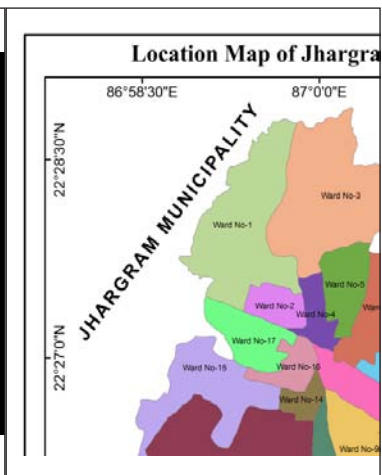


Fig. 3. Study area

used again and again to get various outputs and results. Uses of the google images are done for digitising the landuse and the landuse was prepared from LISS III images (Fig. 1&2). Both the images were compared and tourist spots are identified.

Area under study: Manavalakurichi fishing hamlets: periyavallai and chinnavalai

Manavalakuruchi is a panchayat town located in Kanyakumari district, Tamil Nadu, India. The case study areas are Periyavalla and Chinnavalla fishing hamlets of Manavalakurichi, Kanniyakumari district, Tamilnadu which are situated in the coastal stretch of the district. It includes the five villages such as Thingal santhai, Puthur, Kunnankadu, Periyavallai and Chinnavallai. It is around 25 km north of Kanyakumari. The nearest railway station to the point is Nagercoil junction railway station. It is situated at the location of 8.13°N latitude 77.3°E longitude (Fig. 3). It consists of 326 from 1820 fishing hamlets in Peryivallai and 399 from 1462 in Chinnavalai with total population of 3282.

The present study is on the use of the geospatial tools for sustainable development of the tourist spots in fishing hamlet area which in lead help to the coastal local communities in different way. This area which not known to anyone but has hide the very beautiful places in it crystal clear beach with less deeper water. The area is very less busy and traffic congestion is not found more in the area. The area has well furnished tourist resources within it which

attracts the tourist to come and enjoy the rays of sun by looking its beauty with the ocean.

Research Design: The research done in this was purely based on the observation and mapping of the tourist places and resources in the study area. In this paper we took the suggestion from the local peoples and the main heads of the area for the change of the environment by tourism development in the area. The both quantitative and qualitative point of view the research was designed. In this research paper we were trying to reveal the beautiful tourist spots in the coastal hamlets of Manavalakuruchi, Periyavallai and Chinnavalai. The important resources of the area are mapped by using the satellite imageries and Toposheet of the area. The questionnaire was prepared for knowing the views of the people residing there like local fishing communities, bishops and the VAO office. We take the probability random sampling for the research.

Tourism Resources of Manavalakurichi:

Indian coast are known for spectacular beaches. The beaches of Periyavalla and Chinnavalla are not popular destination. The coastal villages hold pristine and exotic beaches with tranquil along with the low current. The rear side of the fishing hamlet holds a vast stretch of coconut farms and serene environment. Periyavalla and Chinnavalla beaches emerge as alternatives to other popular spots. These spots can be best suited for alternate seekers with its isolated beaches. The beaches of the villages have all the essential characters and best suitable for developing coastal tourism.

Data Collection:

Type of Data	Source	Sheet Number	Scale/Band
Toposheet	Survey of India	58 H/08	1:50000
Satellite Imagery	NRSA, India	LISS III	23.5m

Field Work:

The field work was carried out for two weeks to extract the maps of the fishing villages and other tourism facilities in and around Manavalakurichi. The visit was also to extract information on the local lifestyle and the nature of job being engaged among the local villagers. The GPS is carried for seeing the exact location of the different tourist spots which are located in the map. While interviewing the fisher man they answer they will be much helpful if the government provides the work in that area via tourism. The ladies staying there are not engaged in any kind of work other than selling fishes and house work. They are willing to go for other work through which their income for home can increase. Periyavalai is seen more developed than the Chinnavalai. The scenic beauty of the beaches will attract the tourist to come there.

While doing the survey we noticed that the fishing hamlet peoples are not aware of any of the government schemes since no one came and provide that schemes to them. They are only engaged in fishing activities and say during non fishing season they would go somewhere out to work or else they will stay in house only. Since the income for the house is very less nearly 4k-6k the family is not enjoying any of the activities outside their area. The ladies are mainly not aware of any activities going on outside so they live inside and do their house work.

This tourism development in an area will bring the job for lot of fishing hamlet population like they can keep engaged by keeping some shops for tourist and the regular hip hop by tourist will be there which may be able to make the environment different for the fishing communities. There is one more advantage that they will not have to go to other places like Manavalakuruchi, Sandai and Nagercoil market for selling the fishes as the tourist people come there they can sell their fishes with different

ways and decoration so that tourist will be interested to have the fishes from that area.

Analysis and Discussion: Coastal Resources of Manavalakurichi: Physical features

It consists of Periyavalai and Chinnavalai beach in that area. The beautiful rock structure is seen in that area so that in which the people will go to watch ocean water. The cool breeze blow in that area with mild sun rays which is the good coolant for the human body. The total coast lines of beaches are nearly 14,474 km including both periyavalai and chinnavalai. The rocky features are seen along the shorelines in which the coastal plains are very narrow except from few areas with sand and invasive alien species.

Socio cultural features

The towns and villages nearby are found with the livestock grazing of hen, goats and buffaloes. The irrigated banana and coconut production are found mainly in these areas. The research area consists of two coastal villages such as Periyavalai and Chinnavalai. The national highway cross across these villages by which many of the residing communities are taking advantage by selling the local products such as coconut, fish, shells etc. The transport services are found very well in these villages. The people's main occupations are fishing and agriculture in these regions. There are two churches located in this area as the important prayer sites.

Tourism Facilities in Manavalakurichi :

The area is not much facilitated but near to that Nagercoil is well developed area where all the tourism facility are available like hotels, shops etc,. Which is near to Manavalakuruchi and for which the buses are available in frequent. Monday market is also the well developed area which is located near by the study area. Other destinations are Colachel where they can get the star hotels. In the Nagercoil there are n numbers of hotels in different rates which is just near 9.6 miles from the study area.

Accommodation: The well good accommodation facilities are provided in Colachel, Nagercoil which are near the interest of area. For going where the accessibility are provided in frequent services. So for the tourist people it becomes the very good tourist place

for visit with all kinds of facilities available nearby.

Accessibility: The accessibility is made good in the area. It has Nagercoil railway station 9 kms far away from Manavalakuruchi for which the road accessibility is well structured. The airport nearby is Thiruvananthapuram airport for reaching there so many buses are available in frequent service from national highway. National highway 47 runs through the areas which join the state from Kerala state via Thiruvananthapuram airport so it becomes easier to travel to the airport. It is around 56 km from Trivandrum airport. Even for moving to the nearby tourist spots like Muttom bus facility are available. The big bus stand near the study area is Vadasery bus stand where all the local and state bus arrives.

Interpretation of Tourism Resources: A tourism resource which makes the income for the people of the area is much important in any tourist study. The area is rich of coconuts which are mainly in demand for tourism. The other resources are different kinds of fishes and beach the major tourist resource of the area. The churches in both the area can come under the religious tourist spots of the area. There is Periyavalai Lake which is very beautiful lake which can be change as the boating spots for the tourist so that it will also attract the people out there.

Coastal Resources: The area is well furnished by the scenic beauty of the beaches located there. The fisher man sells the fishes in nearby Manavalakuruchi market or goes to Nagercoil market. The main resources of that area is coconut which plays one of the resources to attract the tourist peoples that area blow the very cool breeze and tastier to drink which takes our all tiredness. Different kinds of fishes are sale there. Mainly the shrimp

varieties which are selling in high cost are the major resource in that area.

Results & Findings: The area has rich tourism development with their beautiful look of the beaches and well developed road. The two churches located in the Periyavalai and Chinnavalai are also one of the tourist spots to be visited by the tourist people. The local peoples are willing for the change of the development in their area which should indirectly profitable for the fisher man and other local people residing there. So we try to look for the tourist spots in and outer diameter of those fishing hamlets. We seen the Periyavalai fishing hamlets are much developed than the Chinnavalai fishing hamlets but both are not aware by the government plans. The major finding by this paper was the finding of the beautiful beach other than the Kanyakumari which has its own beauty to attract the population. The Periyavalai beach is seen as the very good spot for the boating. There are coconut and many different fish's available resources.

Conclusion: The area is full of different kinds of tourism resources. To make it well developed area for as a tourist spot the government can provide the all facilities to the area. The nearby tourist spots are developed in Nagercoil and other sites. So the area can be well developed with all its scenic beauty and resources. By adding some more resources for tourism except from the beaches the area has beautiful churches in Periyavalai and Chinnavalai, lake in Periyavalai can be used for boating. The transportation facilities are very well furnished in the area. So may be the government and NGO can try to develop this area as a tourist spot which make the income for the Kanyakumari tourism department and government also. These areas can be developed inside rural tourism.

Tourist Flow In Udaipur City: Planning, Development & Dimensions

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Keywords: *Tourist Flow, Destinations, Dimension, Accommodation, Connectivity, Planning, Infrastructural Facilities, Development.*

Tourism has different meanings in different languages and different regions and can be defined in different ways. The present day tourism is not the same as travels of the early periods of human history. Tourism as a modern term is applicable to both international and domestic tourists. It is the temporary movement of people to destinations outside their normal place of work and residence. The human animal believe in mobility, in other words, travel provides that change. However, the level of satisfaction achieved from tourism depends on the age, health, energy and background of the individual. The younger and better education travel more than the elderly and less educated. Tourism is an activity, that takes place when people move to some other place for leisure of business and stay at least for 24 hours.

Introduction

Tourism as a form of education is a part of civilized existence. Tourism allows human being to escape from their normal, humdrum lives and from the nomadic wondering to the colonial expeditions and from the religious crusades to the pilgrim movement. The results of this movement and interaction of people benefits for social, cultural and economic development. Tourism is one of the many ingredients necessary to accelerate the pace of cultural and economic progress. In tourism people from one region of the world moves to another. It may be said to be a "Dream Machine." It helps to understand the other cultural behavior and tradition.

Udaipur is one of most popular tourist place not only in Rajasthan but also in the map of India or World, so that this development of accommodations essential thing for tourist stay in Udaipur city is rich for gardens, places and lakes. It is known as 'Kashmir of Rajasthan' consequently tourism wants to have good accommodation for stay in tourist centre because accommodation is very essential thing in hotel industry and the hotel industry is heart of tourist without it tourism is not progress. The present study is intended to undertake basic geographical analysis of the tourist accommodation and the

role of hotels in development of tourism in Udaipur city.

In this study we analysed the seasonal variation of tourist flow and role of transportation facility in development of tourism with respectfully the important places in Udaipur city and present condition in Udaipur.

Objectives of the Study

- To study the evolution of tourism in Udaipur.
- To study the geographical profile of city, and tourist flow in the Udaipur city.
- To propose the policy implications for further development.
- Thus in the present study it is intended to analyse the structure and type of accommodation in the Udaipur City as it exist today as it will develop in future and as it has different conditions.

Sources of Data and Information

To undertake the present study related literature has been read so that it might serve as a background for the problem. The sources of related literature were text book of tourism geography, different guide book of R.T.D.C. (Rajasthan Tourism Development Corporation), unpublished thesis from Udaipur university,

research paper from Udaipur university and other text.

Study Area

Udaipur city is known as "City of Lakes." It is a beautiful city regarded by many Indians and foreign visitors as one of the most romantic tourist centre in India. In contrast to some of its desert neighbours it presents an enhancing image of white marble places, placid blue lake and green hills that keep the wilderness of area. It is an oasis of colour in semi and arid region. Udaipur City is located at latitude 24°35'N and longitude 73°42' E and altitude of 577 meters set in the Girwa Valley amidst the Aravalli hill of South Rajasthan and it lies in the western part of India.

Udaipur city has become a nodal centre between tourist centres of Rajasthan. It is linked with Jaipur, Jodhpur, Ajmer, Chittaurgarh, Ahmedabad by national Highway No. 8 as well as by state highway at some extent it has also facility of air lines, which has daily flight for Delhi, Jaipur, Jodhpur and Bombay. At the same the city has railway facility with all the metro cities of India.

Places of Tourist Interest

Udaipur is a traditionally planned walled city its bastioned rampart walls pierced by 5 massive gates, each studies with Iron spikes a protection against enemy war elephants. High on the hill overlooking the lake stands the massive palace of Maharanas, probably the largest in Rajasthan.

Tourist Flow Analysis

Tourism has emerged very slowly as an economic in India. The receipts from Tourism Forum a very valuable invisible export and contribute substantially to the balance of payment. The share of India's tourism in terms of world arrival has been grown at Snail's pace from 0.23 percent in 1975 to 0.28 percent on 1980 and 0.46 percent 1984 despite its diversity and tourist riches. The foreign exchange from tourism amounted to be less than 3.0 percent in 1974-75 which increased to 11.50 percent in 1985. Response of tourist in Udaipur city from 1971 to 1980 is shown in table 1 and fig. 1.

Domestic tourism increased in tremendous proportion. Rajasthan proportion. Rajasthan

Table 1. Response of Tourists in Udaipur City During 1971-80

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Foreign Tourists	42500	48350	54611	55781	66207	92272	125112	166134	195837	208216
Domestic Tourists	880694	902769	1157959	998227	111663	1303633	1618882	2042586	2306550	2450282

Source : Tourism department, Dist. Udaipur.

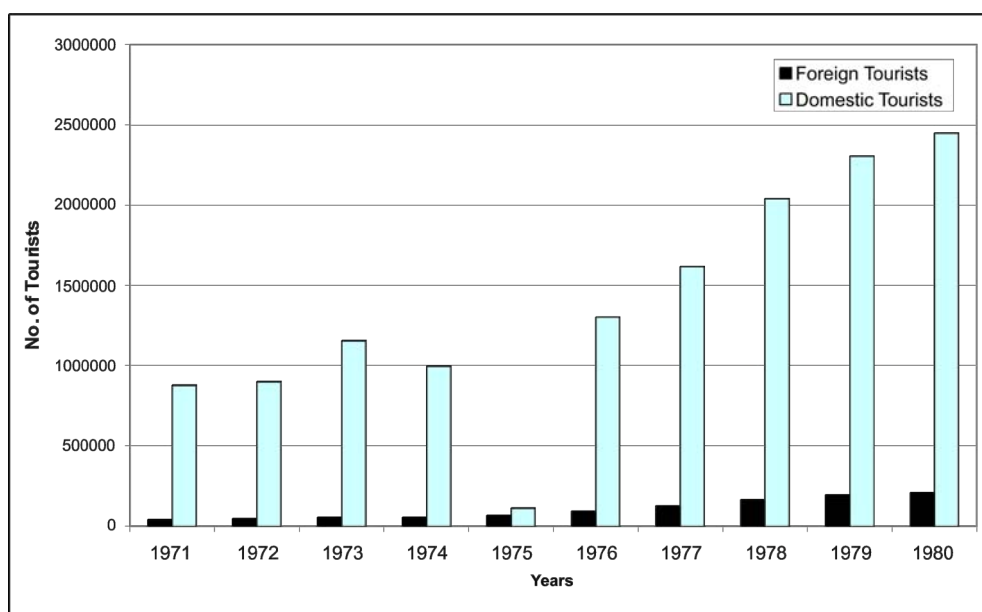


Fig. 1. Tourists flow in different years (1971-1980).

possesses the credit of having higher numbers of tourists, an increase of 180 percent in the decade. The domestic tourists increased from 24.5 lakh in 1980 to 34.24 lakh in 1987 while the inflow of foreign tourist in 1980 was 2.08 lakh, this number shot up to 3.48 lakh in 1987. People of our land prefer more to tour in Rajasthan than any other states of India. Rajasthan surpasses even in the number of inland tourists visiting Kashmir and even Goa. It is clear from the above statement that there is enough of scope and immense opportunities for the development of tourism in Rajasthan. The hindrance in this respect is lack of adequate system of movement. To attract large number of tourists it is the necessary infrastructure and various modes and means of movement of reach place of far and wide, and also places of cultural significance situated in the reposed corner of the state. Response of tourist in Udaipur city from 1990 to 1998 is shown in table 2 and fig. 2.

Transport factor has been important in influencing tourist destinations. The quality as well as frequency of transport are the key factors determining the accessibility of hidden and remote centres of tourist interest. Some example of such unknown place may be cited here with are none the less famous for their art and architecture of transport link. Joining this hidden centers of cultural significance as in case of (Jagat) Mewar and many others.

Table 2. Response of Tourists in Udaipur City During 1990-98

Year	Foreign Tourists	Domestic Tourists.
1990	417941	3735174
1994	436801	4699886
1995	534749	5248862
1996	560946	5726441
1997	605060	6290115
1998	591369	6403310

Source : Tourism department, Dist. Udaipur.

Another factors which may be cited here is inadequate publicity of the such hidden places which form a part of our rich cultural heritage in case of Delwara near Udaipur on N.H. 8. In this respect this may be said that even the smallest place of cultural significance should be highlighted in the brochures especially prepared for tourists alongwith the available transport facilities joining them. An example may be cited here of Ranakpur, which was formerly less known place for tourists. In 1985 only 561 foreign and 1921 domestic tourists visited and 101765 domestic tourists visited Ranakpur. This was mainly because of wide publicity of richness of art and architecture, the temple of Ranakpur possesses moreover frequency of bus transport was increased from Udaipur to Ranakpur, the number of daily buses being 22 playing regularly. Comparison of domestic and foreign tourist flow in Udaipur from 2008-2012 is shown in table 3.

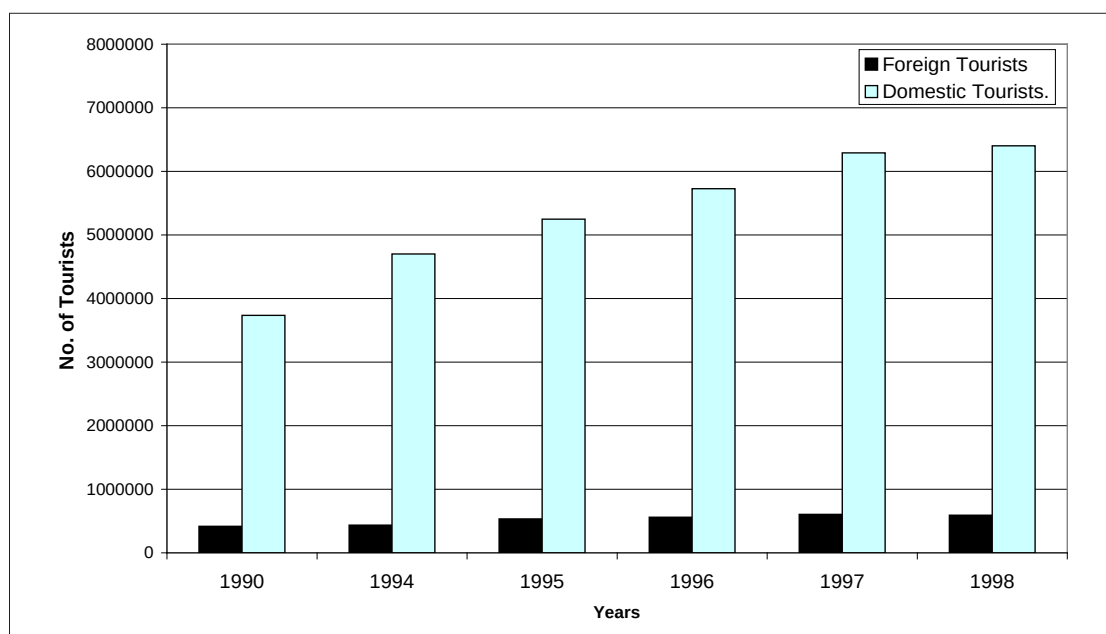


Fig. 2. Tourist flow in different years (1990 - 1998)

Table 3. Tourists Flow in Udaipur with comparison to Rajasthan 2008-12

Year	Domestic Tourist			Foreign Tourists		
	Rajasthan	Udaipur	%age	Rajasthan	Udaipur	%age
2008	28358918	572415	2.09	1477646	547102	37.02
2009	25558691	547102	2.14	1073414	165210	15.39
2010	25543877	582297	2.28	1278523	173016	13.14
2011	27137323	574444	2.17	1351974	177699	13.14
2012	28611831	588239	2.05	1451370	189373	13.05

Source : Tourism department, Dist. Udaipur.

In Rajasthan only 9.10 percent of tourists are served by air railway and road networks and receives 43.46 percent of the domestic and 75.77 percent of the foreign tourists in Rajasthan. The 11 percent tourists centers lying on both National Highways as well as on railway routes receives 22.59 percent of domestic and 5.34 percent of foreign tourists. The tourists center lying on major roads as well as on railway receives less than 4 percent domestic and 2 percent of foreign tourists arrival to Rajasthan. About 1/3 of tourists centers lying on major roads receives about 24 percent domestic and 14 percent foreign tourists. Whereas about 27 percent tourist centers lying on other roads receives less than 3 and 5 percent of domestic and foreign tourists to Rajasthan. The connectivity measures reflect very low values.

Conclusion and Discussion

The overall geographical analysis reveals the since tourism is the fastest increasing industry and Udaipur city is considered as one of the most tourist potential city. It has been observed that there is no touristic survey undertaken so far in the field of geographical study. An attempt has been made for the first time to undertake the study for dissertation purpose on tourism in this historic or glorious city.

In future point of view Udaipur tourism has a bright view future but the existing environmental problems need to be eliminated and resolved at the earlier. As a consequence such solutions will increase the value of the tourist markets as we known tourism as an economic activity or as and industry promoting economic benefits is a recent innovation in India. Therefore the main problem which are existing to day are in general not mainly due to any physical nature proper planning and in depth study of the available resources

can provide new directors and dimensions of growth and development to Udaipur City.

Tourism development can be achieved or maintained through urban planning particularly tourism activities in this city. In fact this city is know as "city of lakes" consequently every touristic activity depends on status of lakes such as, water should be clean, lakes should be at least full of water but fifty percent water should be there. Therefore following steps can be considered or suggested for further planning of this tourist centre :-

Suggestions

I. Geographical Sites of Tourist Centre

Each tourist should be clearly demarcated for the purpose to protect natural environment

II. Historical Places

Historical places must be protect properly, like forts, palace, temples etc. In Udaipur there are several places can be seen, which required proper protection like, Sajjangarh fort, MachlaMagra, City Palace, JagdishMandir, Neemcuh Mata Temple Jain Temples, Monuments etc.

III. Environmental Planning for Natural Lakes

The whole tourism requires proper environmental planning particularly for lakes like FatehSagar, Pichola, SwaroopSagar, Rang Sagar, UdaiSagar, Bari Talab, Thur Ki Pal, Jamri Dam etc.

IV. Pollution Report Should be Published Publically

Every citizen should known the consequences of pollution of water of lakes, and what are effects on human bodies, should also be high lighted.

V. Improvement in Infrastructural Facilities

The first step for tourism development requires better stay with comfort accommodation. Although Udaipur city has five star hotels like Lake Palace and Shiv Niwas but much infrastructural facilities yet to be provided according to the need of tourist. Udaipur city should also be linked with international air routes.

In Conclusion, it can highlighted that tourists of developed countries are surely very particular and sensitive also to this aspect property constituted powerful and skilled official body through surprise visits to these name and indeed reflects bad taste on part.

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Analytical Study of Providing Urban Amenities in Villages Acquired in Corporation Limit using Remote Sensing and GIS for Effective E-Governance

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Keywords: Urbanization, GIS, RS, Projects, Villages, Analysis, Infrastructure

Abstract: Indore is the largest city of central India. A central power city, Indore exerts a significant impact upon commerce, finance, media, art, fashion, research, technology, education and entertainment and has been described as the commercial capital of Madhya Pradesh. It is located on the south of Malwa plateau. According to 2011 census, the population is estimated to be about 2,167,477, which is distributed over an area of just 562 KM². Indore is most densely populated major city in the central India. Indore has been ranked as 14th largest city of India. Therefore, being a commercial capital; like other growing cities it has shown many signs of development. As a result requirement of amenities for the existing population has also hiked up. In last few years its fringe area has expanded and grabbed many of the villages under its corporation area. The rate at which it has merged the outgrowths under its limit has not shown the availability of basic amenities. Hence, in this paper we have focussed our objective to study the availability of some of the major primary amenities required for sustaining the growing population by using remote sensing and GIS.

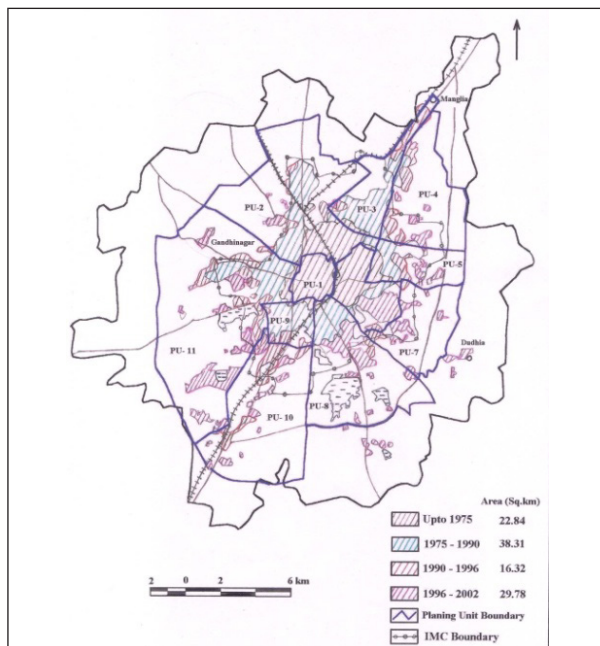
Introduction

Rapid urbanization and consequent haphazard growth of cities of 21st century is a common phenomenon. More than half of the population are now residing in urban habitat, which are main drivers of economic activity. This increasing urbanization, especially in 3rd world countries, is of an informal and unplanned nature and has led to tremendous social and environmental pressures on the cities. Indore is the largest city of central India. A central power city, Indore exerts a significant impact upon commerce, finance, media, art, fashion, research, technology, education and entertainment. It has been described as the commercial capital of Madhya Pradesh. In the last two decades it has shown rapid expansion. In this paper an attempt has been made to study the availability of some of the major primary amenities required for sustaining the growing population of the existing Indore city and the facilities those will be required by the villages which have been recently incorporated in the Indore Municipal area (Fig. 1).

Study Area

Indore is located on the South of Malwa plateau, which is scarped by Vindhyan ranges in the south. The territorial limit of the district falls between 22°20' N to 23°05'N latitude and from 75°25'E to 75°15'E Longitude. It covers geographical area of 3898 Sq. K.M. (calculated from satellite data). Average height of the district is 550 meter above mean sea level. The district has gentle slope towards north. It mostly has black clayey soil. Administratively the district consists of 4 tehsils, 12 urban centres and four developmental block having 627 inhabited villages. Among the urban centres of the tehsil Indore ranks itself as a metropolitan city.

According to the 2011 census the population is estimated about 2,167,447 (1,129,348 males and 1,03,699 females) which is distributed over an area of just 562 km². Indore is most densely populated (density 841 people / Sq. Km. in 2011, while 633 / Sq. Km. in 2001) major city in the central India. It has been ranked as 14th largest city of India. According to 2001 Indian



Source : Indore Masterplan 2011

Figure 1 : Sprawl of Indore City and Planning

census the city's population stood at a record high of 1,516,918 significantly greater than any other city from central provinces. As per 2011 census the average literacy rate of 87.38%, higher than the national average of 74% (91.84% males and 82.55% females). In Indore 12.72% of the population is under 6 years of age and the average annual growth rate of population is around 2.85% (2011 census). Population projection of the city by 2021 is estimated about 36.71 lacs, therefore about 1.5 times increase in population is expected. With regards to sex ratio Indore stood at 928 females per 1000 males compared to 2001 census figure of 912 females / 1000 males. The average national sex ratio in India is 940 as per latest reports of census 2011. Child sex ratio is 901 girls / 1000 boys compared to 908 girls / 1000 boys in 2001 census data. Out of total Indore population for 2011 census, 74.09% live in urban regions of the district. Sex ratio of the urban region was 922 females / 1000 males as per 2011 census data.

Total number of houses as per census 2011 are 7,88,318 of which 63,139 are vacant and 7,25,179 are occupied. Of these 81.10% is used for residence, 3.5% for residence cum other use, 6.4% for shops/ offices, 0.5% for schools/ colleges, 0.2% for hotels / lodges, 0.2% for hospitals, 0.9% for factory / workshops, 0.6% for places of worship and 5.8% for other non-

residential uses. There is about 62% shortage to the total housing need with the available housing supply in Indore city. The majority of housing shortage is for urban poor. Informal housing such as slums, unauthorized colonies constitute about 50% of the housing subsystem in Indore city. These 50% of housing (illegal) is been residing upon only 20% of the land. It shows that the living condition is sub-standard. In the city 11% of the household have no bathrooms, 26.3% have open drainage, 21.9% have no drainage and 22% of the households do not have access to water supply. (United Nations Human Settlement Programme, 2011)

The total water supply for Indore according to the IMC is 252.5 million litres per day (MLD) (Parmar A.S., 2011) from four sources and their actual respective contribution in 2011 are :

1. Three phases of Narmada - 200 MLD
2. Yashwantsagar reservoir on Gambhirriver - 22MLD.
3. Bilawali Tank - 3.5 MLD
4. Tube wells, open wells and hand pumps - 27 MLD.

There are 1450 tube wells, 446 hand pumps and 167 wells and bawdis which fulfil the deficit supply of water.

The waste water system is grossly inadequate and so most of the water is disposed off untreated into the streams running through the city, which have unacceptable levels of BOD and are highly polluted. There is no proper storm water drainage and since the natural drainages have become obsolete due to construction the city suffers from extensive flooding during the monsoon. Presently 610 Km. long underground sewage lone out of which 310 km. has been laid by Indore Municipal council and 300 km. laid by Indore development authority .In 148 slum locations of the city which covers about 35% of the city area has surface drains and septic tanks. The rest 65% of population is dependent on on-site disposable options. The colonies developed by IDA and private colonizers have installed common septic tanks. About 7.2 lacs of population is covered by this sanitation option. The rest (slums) depend on public toilets and have no other option but open defecation. Solid waste generated by the city (~500 Tonnes per day) 60% of this is collected by IMC and is

disposed at Devguradiya trenching ground. (United Nations Human Settlement Programme, 2011)

The connectivity of the city shows that it is well connected as it has an International airport and 5 platform railway station. Major national and state highways dissect the area, so it provides overall good connectivity. Public transport within the city is mainly road based, provided by an estimated 500 private mini-buses, 550 tempos / vans, 250 car-taxis, 10,000 auto rickshaws, city buses and BRTS also provide good service which runs through an length of 277 km. (Wikipedia a.)

In last few years the fact which came out offering economic opportunity are:

- Indore is the biggest centre for soybean processing in the country.
- Indore ranks 8th in India in quality of health services.
- Indore is established itself renewable energy destination and focus on wind and solar energy.
- Indore SEZ is the 1st greenfield project in India, 24 hours water and uninterrupted power supply apart from the tax benefits.

In the recent years seven key sectors have emerged:

1. Advanced Engineering: The automotive industry is a key growth area. A budget of GBP 728 million for building Asia's largest digital auto track for research and development has been announced. Plans to open specialized auto training colleges are underway.
2. Textile manufacturing: It has traditionally been a textile manufacturing hub. The government plans to establish the Malwa region of M.P. as a textile zone in which the Apparel park, Garment complex and power loom clusters would be developed.
3. IT Sector: Information technology sector is also developing in the city as a large Crystal IT Complex has been developed in the city.
4. Energy: With enough strong wind and sunlight for more than 300 days in a year, Indore offers great scope for companies

willing to set-up wind and solar energy plants. M.P. UrjaVikasnigam is carrying out various programmes to develop and exploit renewable energy.

5. Food and Drink: The city's easy access to raw materials as the city is surrounded by vast agricultural land. A food park spread over 27 acres has been set up in Nimrani near Indore. Health enhancing foods and solar food processing is a growing industry.
6. Health: Health is the other sector which is growing very fast and is rated 8th among all the cities of India. It has 51 public health institutions, including 1 district hospital, 2 civil hospitals, 8 primary health centres, 21 sub-health centres, 13 civil dispensaries. 12% of the hospitals have capacity of 50+ beds, 47% 11- 49 bed, 41% with capacity of 10 beds. It is becoming a centre for quality health care centre in years to come. (Wikipedia b.)
7. Education: Indore is home for range of schools and colleges. There are more than 70 engineering colleges, three medical colleges, two premium institutes like IIM and IIT, More than 50 management, nursing and pharmacy colleges. At present 3905 schools are there among which 75 are CBSE affiliates (Census, 2011).

The city has shown development of infrastructure basically with the introduction of Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005. It has struck a balance between the two goals of achieving financial and social sustainability in provision of urban infrastructure and services. For the capital investment required six agencies are

Indore Development Authority (IDA)	: 433.53 Cr.
Indore Municipal Corporation (IMC)	: 17553.03 Cr.
MP Public works Department	: 149.69 Cr.
Indore City Transport Limited	: 307.50 Cr.
Krishi Upaj Mandi	: 20.00 Cr.
MP Housing Board	: 30.00 Cr.

(Source: CAG Annual Report 2005)

responsible namely:

Therefore by the above analysis of some necessary amenities we can say that the city is growing very fast. The competitive

advantages in Indore include a land cost advantage strategic location, peaceful labour environment and good literacy rate. But as the city is growing fast, the load is mounting on the basic amenities, like the problem of water supply, solid waste, housing, power supply, transport, proper administration etc.

On the other hand this expansion of city has resulted in inclusion of 29 villages located on the fringes of the city. In 1974 11 villages were incorporated in IMC boundary, after 36 years due to expansion of city 29 more villages have been included in the city boundary. Current population of the city is 21.00 lacs, in which 1.10 lacs will be added due to this inclusion. It is estimated that within four years it will be doubled.

The 29 villages included are Nipania, Pipliyakumar, Kanadiya, Tigaria Rao, Bicholi Hapsi, Bicholi Mardana, NaytaMundla, Palda, Hukmakhedi, Limbodi, Bilawali, Fattankhedi, Kelod Kartal, Nihalpur Mundi, Sukhniwas, Ahirkhedi, Chhota Bangarda, Tigaria Badshah, Revti, Bardari, Bhaoursala, Kumedi, Bhangarh, Shakkarkhedi, Talawali Chanda, Aranya, Lasudiya Mori, Mayakhedi and BadaBangarda (The Free Press Journal, 2013). In these rural villages typical rural amenities are available which can only sustain the village population.

It is noteworthy here that within the ambit of these allocations the 29 villages which are included will require about 1000 crores for proper development and urbanization.

Sanitation	: 20 cr.
Sewerage for primary and secondary line	: 100 cr.
Maintenance	: 25 cr.
Road Infrastructure	: 260 Cr.
Other infrastructure	: 200 Cr.
Urban transport	: 25 Cr.
Small Bridges	: 150 Cr.
Street Light	: 50 Cr. (Dainik Bhaskar, 2013)

Apart from these an estimated amount of Rs. 100 Cr. will be needed for annual maintenance.

This requirement has to be fulfilled by these agencies as they are responsible for the new developments to the municipal limits (Fig. 2). Apart from the financial constraints major problem arises with the locals, because all

the services till date is issued to the projects which are coming up and not to the villagers or people who will reside out of the projects or sectors. It is also expected the population will be more than double in coming years to the present population.

Till date the construction of Narmada Phase III pipe line to these areas has not started. Couple of dozen townships are established specially in the eastern by-pass but water supply provisions for including these in the regular water grid has not been yet planned. These areas are totally dependent on ground water (TOI, 2013).

Major projects which have been started like in the "Super Corridor" by TCS, INFOSYS etc., water supply in the near future for the mentioned project will have to rely on ground water sources.

Out of these 29 villages main emphasis have been given to 4 villages coming under Super corridor in the north of the city. On the other hand the establishment of industries in the North-western side with the investment of about 400 crores is suffering due to poor infrastructure and lack of basic amenities, which shows the nonchalant attitude of the authorities concerned. The four villages in which these industries ranging from educations institute to automobile are located in Bardani, Bharasal, Limbodagiri and Revti. These are adjoining villages to super corridor.

As our aim is to study with the help of GIS and RS we have found after survey and overlapping with the GIS and RS data as well as related maps, we have been able to spot 90 more villages which are on the fringe around the city and can be incorporated in the municipal area of Indore (on the basis of population). Basically 10 villages are getting maximum benefits by these projects and the other 20+90 villages are remaining in poor condition. More or less it is creating so called Intra-city imbalance.

There is no provision made to stop slum development especially in the projected area. There are projects going on in the city which claims to eradicate all the slums by 2015, but the ground reality is that there are 410 slums in Indore and these upcoming projects will lead to the creation of many more. We suggest that these mega projects should construct houses

for the workers which can be later used by the people without houses at minimum possible rates. On the basis of hypothesis that the emerged area will require workforce for offices and all the residences will require a matching number of helpers. This strategy can prove effective in checking the slum development.

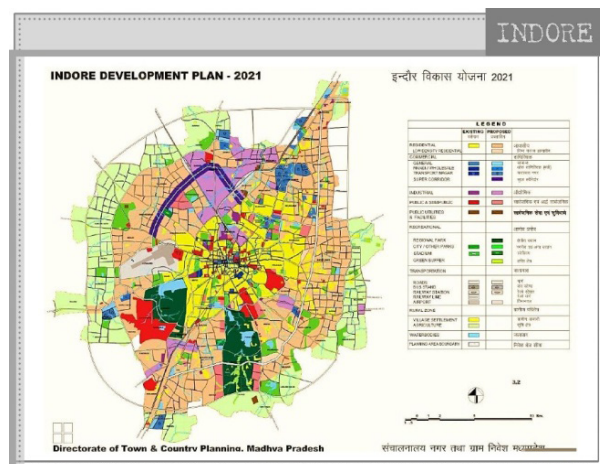


Fig. 2

The villages being included in the IMC boundary continue to suffer from poor connectivity as most of these are totally dependent on the National and State highways and on the dilapidated roads created under the Pradhanmantri gram sadak yojna.

Conclusion

Therefore, by the above analysis we cannot deny the fact that after the implementation of the upcoming projects Indore will become as a generator of employment and ultimately it will raise the living standard. It will also reduce the economic divide between the east and western part of the Indore city. Quality of public transport will increase as well as traffic congestion will deteriorate. It will act as a flagship project for the investors. And, it will play a diverse economic and infrastructure role to become a resource for future in the region provided if we can overcome the above discussed some basic problems generating in the newly incorporated area.

Suggestion

Thus projection can only be a success if there is a sound coordination between the concerned departments, ministries, executives, planners and the locals. In addition we have to take

advantage of geographic information systems in determining the land of urban sprawl in terms of area and sites which include land space, pockets of agricultural land, residential areas etc. It will help in classification of these areas in terms of importance and distribution of land uses proposed to be added to the cluster the current construction.

The geographic information systems will help us to identify a number of factors affecting the selection of the limits of urban sprawl the proposal and formed a number of classes to guide the areas of extension proposed and included the layered growth trends of urban area and of population densities, construction in the study area. And finally, it will help as adhesive to fill up certain gaps and loopholes which are found among the governing body which hinders as well as delays the execution of the projects. Therefore it is expected that use of advanced techniques like geographical information system and remote sensing with coordination of concerned departments an effective e -governance can be achieved which will help in execution of sustainable development of the Indore City.

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Understanding Spatial Inequalities in Provisioning of Basic Amenities through GIS: A Case Study of Delhi

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Abstract: Cities are engines of growth, propellers of economy; many a times growing at the expense of the peri-urban or the rural hinterland and the indigenous people. Often, the peri-urban areas are treated like backyards and are marginalised such that they end up becoming the source of resources and recipients of waste from the cities. These areas usually have the lowest water supply and sanitation coverage coupled with poor waste management facilities. Increasing population density, changing lifestyles and more awareness about city life make these areas vulnerable to social unrest as well. Inadequate attention to these areas today poses a great danger for the future as they eventually will be absorbed in the expanding city. This paper is an attempt to understand the discrimination in governance through disparity in service provision between the delineated urban and the rural areas in Delhi. The importance of this subject lies in the fact that an unhealthy peri-urban today will result in an unhealthy city tomorrow.

Delhi has a unique distinction of being a special state in the country. National Capital Territory of Delhi has both urban and rural areas within its boundary. The main objectives of the paper are to investigate a) growth of the urban and rural areas within Delhi in terms of population, spatial extent and b) compare basic amenities and services of urban and rural areas within the study area for the period 2001-2011. Satellite imageries and the present land use plan in various editions of Master Plan of Delhi has been utilised for studying the change in spatial extent while Census 2001 and 2011 have been used for population data. Census 2001 and 2011 data and various reports are the data sources for understanding the disparity in basic amenities and services of urban and rural areas within the study area. ArcGIS 10.1 has been used for spatial analysis and mapping. Findings reveal that Delhi urban area has been expanding rapidly at the expense of the surrounding rural areas. Far away from the centre of governance, these areas have the poorest access to basic services and amenities endangering the health of their inhabitants. The service delivery institutions can play a very critical role in bringing justice to the peri-urban people and increasing their sense of belonging to the future city by improving coverage in these areas. Improvement in infrastructure

and services would be the first step towards harmonious integration of peri-urban with the urban and herein urban governance has to play a pro-active and ameliorating role.

Introduction

Cities are the engines of growth but often this growth is not uniform within the city. Some parts of the city experience higher standard of living and more employment opportunities compared to others. Further, varying levels of standard of living are seen in the peripheral areas which bear the brunt of the expanding cities. Cities are not only growing within their statutory limits with respect to population but are also spatially expanding at the expense of rural areas. In this scenario, governance plays a critical role in responding to the basic needs of the people and subsequent efficient and adequate service provisioning. Good governance is also important to strike a balance between the urban aspirations and the rural sentiments and sustenance. In this study, an attempt has been made to understand the disparities in service provisioning between the statutory limits of the city, the census towns and the rural areas further juxtaposed with their respective Urban Local Bodies (ULBs). Governance is reflected in the efficiency of service provisioning and thus

has strong linkages with the latter. National Capital Territory of Delhi has been taken as the study area. The study is discussed in five sections in this paper. Introduction section is ensued by the second section on the objectives followed by the third section on study area, methodology and database. The fourth section is on discussions wherein a brief literature review is given followed by a sub-section on urban growth and expansion in Delhi. The fourth section also includes a brief description of the institutional arrangements in Delhi and an analysis on disparities in service provisioning in 2001 and 2011. The major findings are summed up in the last section.

Objectives

The main objectives of the paper are to investigate: a) growth of the urban and rural areas within the nine districts of Delhi in terms of population and spatial extent b) to find the levels of disparity of infrastructure and services among the various ULB jurisdictional areas juxtaposed with its urban and rural character for the year 2001 and c) to appreciate the change in levels of disparity of infrastructure and services based on urban and rural character for the year 2011.

Study Area

National Capital Territory of Delhi (NCTD) is located in Northern part of India flanked by the state of Haryana in North, West and South and Uttar Pradesh in East. It was one of the fastest growing mega cities of India in the past decade. In 1991-2001, the city witnessed 47 percent decadal population growth rate, nearly double of the country. It has a unique distinction of being a special state in the country, besides being the seat of the country's capital. It also is the seat of both the Union government and State government. Figure 1 presents the map of NCTD.

NCTD has nine districts and 27 tehsils. It comprised three Statutory Towns, 59 Census Towns and 165 Rural Villages in 2001 which has been reclassified in 2011 as 110 Census Towns and 112 Rural Villages. The Statutory Towns and Census Towns together form the urban area.

Delhi has a rich history with it being the centre of power for various dynasties over

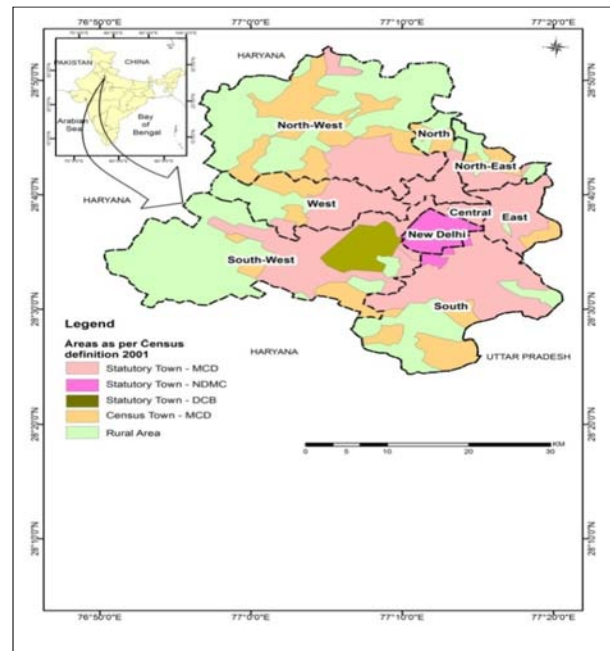


Figure 1: National Capital Territory of Delhi

several centuries. The present Delhi houses seven of the past cities, Quila Rai Pithora, Mehrauli, Siri, Tughlakabad, Firozabad, Shergarh and Shahjehababad. Modern Delhi was born in 1912 when the British shifted their capital to Delhi. Contemporary Delhi witnessed its fastest expansion post independence as captured in the 1951 census when its population grew at annual exponential growth rate of 6.8 percent. New areas in Delhi were urbanised and provisions made for housing lakhs of migrants from West Pakistan. Over the years the spatial extent of the urban area has grown to accommodate the increasing population while the rural area has declined. Some villages, as a result of their strategic location, historical importance have grown to be classified as census towns. With Master Plan of Delhi-2021 declaring another 276 sq.km of land as urbanisable, new rural land will soon be acquired to pave for further urban expansion.

NCTD has three Urban Local Bodies, Municipal Corporation of Delhi (MCD), New Delhi Municipal Corporation (NDMC) and Delhi Cantonment Board (DCB) responsible for service provisioning in different areas in NCTD. Out of these, MCD is responsible for providing amenities to both the urban and the rural areas and has the largest area under its jurisdiction. Further details about these

three ULBs are discussed in the section on institutional arrangements.

Methodology and Database

The methodology adopted for the study involves an analysis for the nine districts of NCTD juxtaposed with the areas under different ULBs. The rural and urban areas have been taken as defined by Census of India, 2001 and 2011. Within urban area, Census Towns and Statutory Town limit has been taken separately for 2001 but has been taken together for 2011 as disaggregate data has not been released yet. Further, four infrastructure and service indicators namely; households with tap connection (within and near premises), households with latrine, households with access to drainage and households with electricity have been taken as indicators. Solid waste management would have been an additional indicator but had to be excluded due to unavailability of data. The rural and urban boundaries along with areas under jurisdiction of different ULBs were digitised. Overlay of the following layers was done: rural and urban boundaries, jurisdiction boundaries of ULBs and each indicator to give the result.

The rural and urban area boundaries have been taken from Census of India, 2001 and 2011. Household amenities data has also been taken from the same data source. ArcGIS 10.1 has been used for mapping.

Discussions

Contextualizing the city and its periphery, service provisioning and inequality

The essence of urban planning is to create inclusive cities with equity in basic amenities and services for all sections. In most cases, this is only a utopian situation. Often, disparity in service provisioning is experienced in different parts of the city; among different sections of the society. Geographical and political research on urban service delivery on the sections of the

society who benefit and the reasons within the context of territorial justice (the relationship between provision and need) has proliferated during the past two decades (see Davies, 1968; Hay, 1995; Pinch, 1984; Smith, 1994 cit. in Parry et.al, 2012). Some scholars have also focussed on the factors responsible for higher level of service in certain neighbourhoods (Cingranelli, 1981; Mladenka, 1989 cit. in Parry et.al, 2012). In this context, though there is sufficient evidence for many of the city areas being deprived, yet the peripheral areas of the city are more at a disadvantage. Urban residents being more powerful and politically connected are able to corner most of the resources for themselves. The government being urban based, the urban sectors are favoured while allocating funds and framing development policies. (Unwin, 1989 cit. in German, 1999). Being urban, most potent interest groups are in direct physical proximity with the government, where they are effectively or potentially, a threat to stability through strikes, riots, demonstrations or other form of urban political protest. At the same time, rural dwellers are seen as spread across vast expanses of land, unorganised and without direct access to government offices (Lofchie, 1997; Shaw, 2005). In terms of environmental infrastructure, the peri-urban is still treated like the rural areas though the demand of these areas due to their transitional nature is much more leading to environmental degradation (Shaw, 2005). Arguably the most problematic areas would be the census towns which are part of the urban outgrowths but which have not been accorded municipal status (Shaw, 2005).

The Urban Growth and Expansion in Delhi: An overview

Population Growth

Delhi has been one of the fastest growing metropolitan cities in the country, not only in terms of population but also in terms of built-up spatial expansion. Population of megacities of India is given in table 1.

Table 1: Population of Megacities in India

City	Population (2001) Million	Population (2011) Million	Decadal Growth rate
Greater Mumbai UA	16.4	18.4	12.05
Delhi UA	12.7	16.3	26.69
Kolkata UA	13.2	14.1	6.87

Source: Census of India, 2001 and 2011

Table 2: Population of NCTD: 1981-2011

Year	NCTD Population ('000)	Decadal Growth Rate (%)	NCTD Urban Population ('000)	Decadal Growth Rate (%)	NCTD Rural Population ('000)	Decadal Growth Rate (%)	Natural Increase (in lakh)	Migration (in lakh)
1981	6220.4	53.0	5768.2	58.16	452.2	8.01	12 (55.8%)	9.5 (44.2%)
1991	9240.6	51.4	8471.6	46.87	949.0	109.8	18.9 (59.2%)	13.05 (40.8%)
2001	13783	47.0	12905.7	52.34	944.7	-0.45	26.6 (60.18%)	17.64 (39.82%)
2011	16753	20.9	16333.9	26.56	419.3	-55.61	24.2 (54.8%)	20.0 (45.2%)

Note: Figures (in bracket) indicate percentage to total net increase.

Source: Master Plan of Delhi-2021; Statistical Abstract 2012

Among the megacities, Delhi urban agglomeration has grown the fastest in the past decade. Population growth in National Capital Territory of Delhi from 1981 to 2011 as per place of residence is shown in table 2.

Population growth in NCTD shows interesting variation with respect to rural and urban growth (Table 3). Although the decadal growth rate for whole of NCTD has been showing a steady decline, urban population growth rate showed a fluctuating trend with it declining in the decade 1981-1991, increasing in the next decade and again declining drastically in 2001-2011. Rural population growth rate

North West district have registered the highest growth rate while in terms of urban population growth rate, South-West district (40.5 percent) followed by North-East district (36.5 percent) have highest population decadal growth rate. With respect to rural population decadal growth rate, West district (-92.6 percent) followed by South district (-92.4 percent) witnessed the highest negative growth.

Spatial Expansion of urban area

The NCTD area is 1483 sq.km and has been constant over the years. While the share of urban area has been increasing, the share of rural area has been decreasing. Urban area

Table 3: Constituents of NCTD

Urban/Rural	2001		2011	
	Number	Population (lakh)	Number	Population
Urban	-	129.0	-	163
a) Statutory Town	3	103.1	3	NA
b) Census Town	59	25.9	110	NA
Rural village	165	9.4	112	4.1

Source: Calculated from Census of India, 2001 and 2011

increased dramatically in the decade 1981-1991 which perhaps can be attributed to mushrooming of unauthorised colonies in rural areas, then declined sharply in the next two decades as these areas got incorporated in the urban areas as per Census definition.

An analysis of the population data for the decade 2001 -2011 for the nine districts of NCTD reveal that in terms of total population growth rate, South-West district followed by

share of the total NCTD area increased from 46 percent in 1991 to 62 percent in 2001 and 75 percent in 2011. On the other hand, rural area share decreased from 54 percent in 1991 to 38 percent in 2001 and 25 percent in 2011. The share of urban and rural area in NCTD is given in table 4.

An analysis of the change in area classified as urban and rural by Census of India in the decade 2001-2011 revealed that urban areas

Table 4: Share of Urban and Rural area in NCTD

Year	Urban Area (sq.km)	Share of total area (%)	Rural Area (sq.km)	Share of total area (%)
1991	685.34	46.2	797.66	53.8
2001	924.68	62.4	558.32	37.6
2011	1113.65	75.1	369.35	24.9

Source: Statistical Abstract, 2012

in West district have experienced the highest growth rate (118.6 percent) followed by urban areas in South district (97.7%). As the rural areas have been classified as urban areas, the loss in rural areas gets reflected in the gain in urban areas. Thus, these two districts have also experienced the highest negative growth in the decade 2001-2011.

Rapid growth of cities often results in supply of basic amenities not being able to keep pace with the demand. Lack of updated population data and economic activities are failure in correct projection of population in an area results in inadequate provisioning of infrastructure and basic amenities by the institutions. Further, poor control over resources and the distribution system by the institutions lead to pilferage of water and electricity resulting in deprivation of population. Good governance is reflected in responsiveness to the needs of people in the form of equity in access to basic amenities by all sections of the society among many other aspects. Disparity in service provisioning and inter-linkages with governance is discussed in the next section after a brief discussion on institutional arrangements in NCTD.

Institutional Arrangements in National Capital Territory of Delhi

The institutional framework for urban management in Delhi has a multiplicity of agencies, both central and state. The critical aspects of Delhi's governance are in control of the Union government. Delhi Police, Delhi Development Authority (DDA), Municipal Corporation of Delhi (MCD) and New Delhi Municipal Corporation (NDMC) report to the Union government. The National Capital Territory of Delhi (NCTD) has an area of 1483 km² and comprises three Urban Local Bodies; Municipal Corporation of Delhi (1397.29 km²), New Delhi Municipal Corporation (42.74 km²) and Delhi Cantonment Board (42.97 km²) respectively.

MCD covers the largest part of NCTD and nearly 97 percent of the population resides in MCD areas. MCD wards comprise both urban and rural areas. Of the total area under MCD, 558 sq.km (40%) is rural comprising 165 villages (Delhi Human Development Report, 2006). The major function of MCD are: city cleanliness, solid waste management, maintenance of gardens/dividers/circles, street light, bio-medical

waste, slaughter house, encroachment removal, stray cattle management, community toilets, community halls, parking lots, development works, establishment and maintenance of health centres, advertisement, property tax, and licensing. Over time, some responsibilities have been taken away from MCD and handed over to other agencies. In 1996, the function of generating and distributing electricity was handed over to the Delhi Vidyut Board. It was unbundled in 2002 into six companies. In 1998, the responsibility for providing water supply and drainage systems was transferred from the MCD to the Delhi Jal Board under the jurisdiction of the state government. Delhi Jal Board is the agency of the Govt. of NCT of Delhi responsible for procurement, treatment, transportation and distribution of water in the MCD areas. MCD was trifurcated in 2012 into three smaller corporations namely; North Delhi Municipal Corporation, East Delhi Municipal Corporation and South Delhi Municipal Corporation.

NDMC is the oldest of the three ULBs. It became a first class municipality in 1932 and was renamed as New Delhi Municipal Committee. The area covered by the functioning of the NDMC includes the most prestigious parts of the city, like the Presidential quarters, the Prime Minister's office and residence, the offices of the Central Government, embassies of foreign countries, the official residences of ministers and Members of Parliament, of diplomats, and of Central Government employees. The population residing in this area of approximately 42 sq km is around three lakh (Census of India, 2001) though many more pass through or work in the NDMC areas during the day. NDMC's civic responsibilities are similar to that of MCD's and its discretionary functions encompass promotion of sports, art, music and culture, maintenance of libraries, and care for the old, mentally and hearing impaired. DJB supplies bulk water to NDMC which it further distributes.

DCB is responsible for both the mandatory and discretionary functions of the Board such as education, public health, sanitation, roads, street lighting, water supply and birth and death registration within the Delhi Cantonment area. It is under the administrative control of Directorate General Defence Estates, New Delhi and Principal Director, Defence Estates,

Table 5: Provision of Services by place of Residence and ULB in NCTD: 2001

Place of Residence	Urban Local Body	HH with tap connections (%)	HH with Latrines (%)	HH with drainage (%)	HH with electricity (%)
NCTD	-	72	78	90	93
Rural	MCD	47	63	75	86
Urban	Statutory town (MCD)	81	80	94	96
	Statutory town (NDMC)	76	85	93	97
	Statutory town (DCB)	86	78	93	93
	Census Town (MCD)	44	77	75	83

Source: Compiled from Census 2001

Western Command, Chandigarh Although, NCTD is divided among the three ULBs, many a times, service provisioning within the same area is done by other agencies. This, often, results in increase in tendency to pass the buck in case of a mishap.

Disparity in Service Provisioning and inter-linkages with Governance

The present analysis involves understanding the disparity in level of services in the zones of the three ULBs for the year 2001 using Census 2001 data.

Analysis of data pertaining to provision of services by place of residence and ULB in NCTD for the year 2001 revealed that census towns are poorly placed in terms of household amenities, worse than rural areas in some cases (Table 5). This may be attributed to increasing density of population in these revenue villages without proper infrastructure support. Many a times, these areas comprise big villages, unauthorised colonies etc. Thus, these are the worst victims of urbanisation and uncontrolled growth. Among the three ULBs, area under NDMC fares the best in all the indicators except households with tap connections in which both DCB and MCD (Urban) outperform NDMC. In

almost all the cases, urban areas are better off with respect to the four indicators reiterating an urban bias in service provisioning. Table 6 shows the district wise disparity in availability of basic amenities.

Although the whole of NCTD is divided among the three ULBs, separate areas under the same ULB also show differences in service provision. Differences in access to basic amenities on the basis of ULB and rural/urban character of the area are presented in figure 2 to figure 5.

In this parameter, the areas within the Statutory Town limits of NCTD perform much better than the surrounding areas with more than 75 percent of the households with tap connections. MCD Urban areas in most districts are at par with NDMC and DCB areas. The situation in Census Towns is commensurate with rural areas in each district except in North-West district where the situation in Census Town is better than the rural areas and North-East district where it is vice versa.

The Statutory Town itself does not perform very well on this indicator perhaps due to the presence of slums and squatter settlements within the limits. Nearly 20 percent of the

Table 6: District Wise Availability of Basic Amenities: 2001

District	HH with tap connections (%)		HH with Latrines (%)		HH with drainage (%)		HH with electricity (%)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
North-West	50	78	61	69	72	91	83	93
North	13	82	72	76	50	91	70	95
North-East	65	57	60	85	94	89	88	84
East	69	79	62	82	75	98	95	97
West	14	77	68	82	52	90	75	95
South-West	49	68	55	85	82	91	91	96
South	47	70	73	79	72	88	86	89

Source: Census of India, 2001

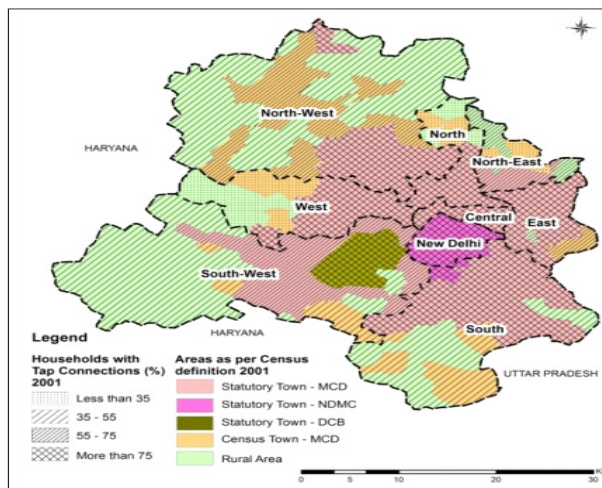


Figure 2: Availability of Tap Connections (%) as per ULB and place of residence

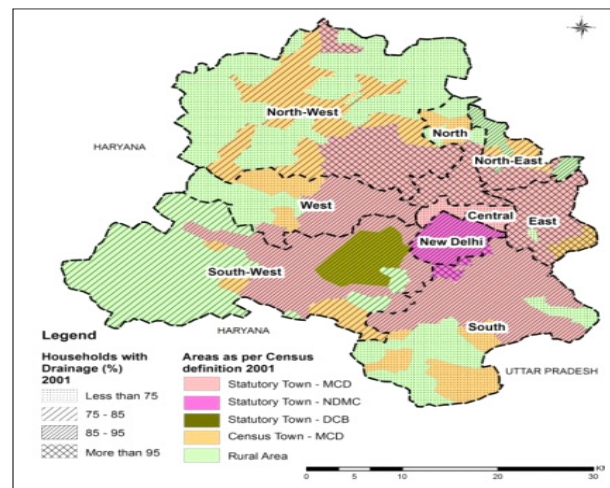


Figure 4: Access to drainage as per ULB and place of residence

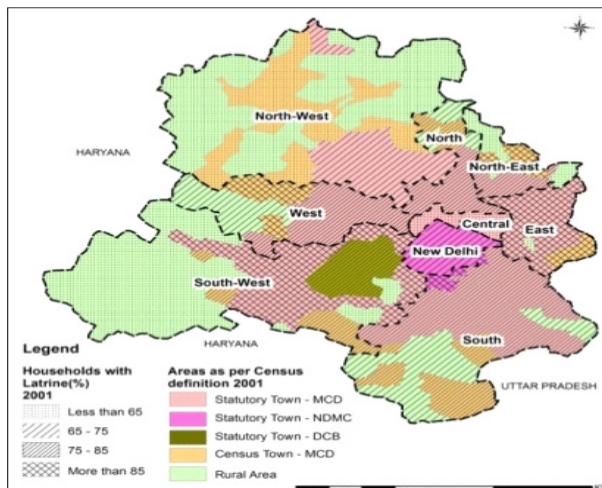


Figure 3: Availability of Latrines as per ULB and place of residence

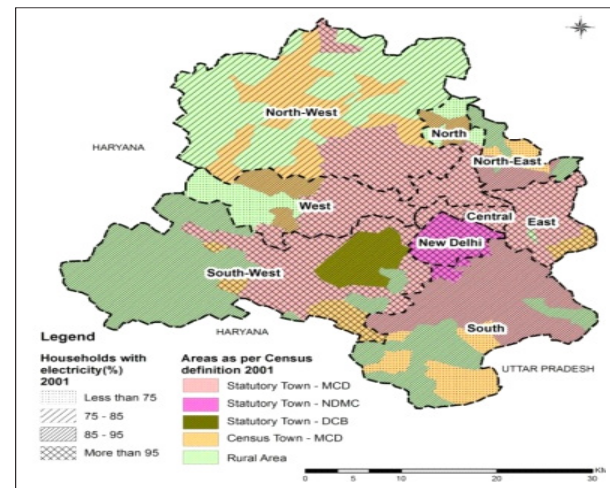


Figure 5: Access to electricity as per ULB and place of residence

households within the statutory limits live in slums as compared to 6 percent in the Census towns. South-West and East districts have the highest percentage of households with latrine while Central district has the lowest. Nearly 70 percent of the households reside in slums in Central district. Surprisingly, only 73 percent of the households have latrines in NDMC area in the prestigious New Delhi district. The reason may be attributed to nearly 20 percent of the households living in slums in that district. Census Towns in East, West and North-East district have the highest percentage of households with latrine. Census Towns in North-West Districts fare the worst with less than 65 percent households with latrine. Rural areas in South, West and North district fare better than rural areas in other districts.

Within the Statutory Town limits, North-West, North-East, North and East districts and a small portion of south district have the highest percentage of households connected to a drainage system. All of them are under MCD-Urban jurisdiction except for the last one which is under NDMC. MCD areas within West, South-West and South Districts, NDMC area in New Delhi district and DCB area in South-West district have similar coverage. Census Towns of East District perform well on this parameter, at par with the East district Statutory Town limit. Census Towns of West, South and North district have the least coverage of less than 75 percent of households connected to drainage system. Rural areas fare poorly on this account, South-West and North-East district performing better than the others.

There are stark differences in percentage of households with electricity connection across the National Capital. Figure 5 presents district wise percentage of households with electricity for areas under jurisdiction of MCD-Rural and Urban, NDMC and DCB. Areas under NDMC and MCD, except in South district, within the Statutory Town limits exhibit similar high levels of electricity coverage. The Census Towns fare at par with the statutory town in South-west and East district while are worse than rural areas in North-east and South districts.

Overall, among the areas within statutory limit, area under NDMC in South district has the best situation with respect to all the four indicators followed by area under MCD in east district and NDMC area in South-West district. Area under MCD in New Delhi district has the poorest levels of amenities among all the areas. Among the Census Towns, those in East district are ahead of other districts with respect to the four basic amenities indicators. Census Towns in South district have the worst situation. Among the rural areas, villages in North-West district are better placed compared to villages in other districts while ironically villages in the adjoining North district have the poorest level of amenities.

Status of Infrastructure and Services: 2011

Census 2011 has not released Household amenities data for various jurisdictional areas at the time of writing this paper. Thus, the analysis is restricted to rural-urban disparity at inter-district level for the four infrastructure and service indicators. With increase in overall coverage, rural-urban disparity has also lessened in the past one decade especially in

the case of households with electricity, latrines and drainage. The disparity in percentage of households with tap connections is still stark (Table 7).

Disparity between urban and rural areas is the starkest in the case of percentage of households with tap connections. West district fares the worst with respect to percentage households with tap. In the case of percentage of households with latrines, interestingly rural areas fare better than urban areas in North, East and South districts. It is difficult to say that whether this is because of improvement in infrastructure or due to mushrooming of unauthorised middle to upper class colonies.

With respect to households connected to drainage, urban areas in all districts fare better than their rural counterpart except in West district. Although the electricity coverage status in 2011 is better than the status in 2001, urban areas fare better in the case of North-West, North-East and South districts while rural area fares better by one percent in West district.

Conclusion

The major findings of the study reveal that urban Delhi has grown the fastest in terms of population and spatial extent in West, South-West direction in the past decade. The urban bias in service provisioning is reiterated in the case of National Capital Territory of Delhi with urban areas within statutory limits experiencing higher levels of access to basic amenities. Overall, NDMC areas fare the best. The Census Towns are at a great disadvantage as they support higher population than rural areas but do not have adequate infrastructure support resulting in poor per capita levels of

Table 7: District Wise Availability of Basic Amenities

District	HH with tap connections (%)		HH with Latrines (%)		HH with drainage (%)		HH with electricity (%)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
North-West	60	77	64	86	92	94	97	99
North	32	81	98	90	92	96	99	99
North-East	47	77	95	95	77	99	93	99
East	100	93	98	93	98	99	100	100
West	21	85	87	90	97	96	100	99
South-West	53	75	88	91	81	96	99	99
South	53	68	91	88	89	95	98	99

Source: Census of India, 2011

basic amenities. On the positive side, rural-urban disparity with respect to the four basic amenities selected for the study has reduced in 2011. Although the study is a preliminary one, it identifies the need to study the reasons for such skewed basic amenities level within the same jurisdictional areas and the subsequent means to address these issues.

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FOSSGIS Study on Extending Corporation Limits of Rajahmundry in East Godavari District of Andhra Pradesh, India

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Abstract: Rapid pace of development and growth in population of urban areas demands putting in place, effective governance that enables understanding the problems and other issues faced by citizens. The knowledge and understanding of geospatial information of the city and its surrounding areas plays an important role in making right decisions by local government and planning amenities to the citizens. Use of geospatial technology using Geographic Information System (GIS) and Remote Sensing helps in overcoming these problems and development of Spatial Data Infrastructure for governance. However, sustainability of these implementations in the long run has always been a contentious issue, mainly due to the costs involved in keeping the system up to date and the need for highly trained manpower for manning such systems. Use of open source GIS software (FOSSGIS) will not only helps in overcoming the difficulties arising due to high cost factor associated with proprietary GIS software but also helps to customize, localize and redistribute the software tools. An attempt is made through a Department of Science and Technology (DST) funded project to showcases the feasibility of adopting these FOSS GIS tools to develop web based geographical information system for Municipal Corporation of Rajahmundry (MCR) in East Godavari District of the state, Andhra Pradesh. Comprehensive GIS data sets using open source GIS tools on education facilities, health facilities, transport network, drinking water distribution and sanitation etc. in the MCR area is developed. An attempt is made in this paper to show how FOSS GIS tools can be effectively used in decisions support and transparent administration. Easily browsable geospatial data helps in selection of appropriate number of facilities like schools, health centers, fair price shops, drinking water, road network etc. Hosting the geospatial data, on the web can explain the population how decisions are made taking into consideration the other factors like socio-economic conditions, geography, land use / land cover in the proposed area of expansion. Attempt is also made to show how Free and Open Source GIS tools can provide the capabilities of managing and visualising diverse information on a common platform and in understanding various processes for a holistic developmental approach.

Introduction

Expansion of existing cities and towns due to rapid growth in population and industrialization is a common global process, particularly in the developing countries. Understanding of the relationships between existing urban regions with the natural environment surrounding them is essential for a planned and sustainable development of any city/town. Understanding of the surrounding environments of a city/town not only helps the concerned government departments to have planning how to provide efficiently the basic needs (viz. adequate & safe

shelter, accessibility to social services, efficient transport systems, energy & telecom services, government services, water & sanitation etc) to the residents and to those who visit the urban areas for economic or other activities and also to estimate the vulnerability of any area to various natural disasters.

Geospatial information has been proved in recent past as a vital element in the quest of sustainable & planned development of any region. Future development of any urban area depends on how the planner understands the current situation and the historical development

of that area. Urbanization/ urban development requires mainly three basic layers in and around urban regions viz. natural environment layer; infrastructural network layer and the occupation layer consisting of existing features (buildings etc) and the activities taking place at different locations.

Use of GIS and Remote Sensing helps to have a holistic view of all these layers and for development of a spatial data infrastructure (SDI) for governance. The SDI enables understanding the existing problems and to give suitable solutions to these problems. Use of FOSSGIS in these implementations not only makes them sustainable in the long run but also helps to overcome various difficulties arising due to the proprietary GIS software and helps to customize, localize and redistribute the SDI tools. Utility of FOSSGIS tools for development of SDI for civil and public administration and in creation of Web-GIS both in English and in local language (i.e. Telugu) is demonstrated by Prasad et.al (2008). Ravi Kumar et.al (2008), Ajay Kumar et.al (2012) and Sarma et.al (2012) have demonstrated how FOSSGIS tools can be used for developing a GIS for a parliamentary constituency in India; for identification, mapping and study of slums and in urban crime mapping and analysis respectively.

In the present paper a preliminary study has been taken up to understand the infrastructural networks layer in the proposed limits of expansion of Municipal Corporation of Rajahmundry (MCR) in association with those existing in its present limits using FOSSGIS tools.

Study Area

MCR in the East Godavari District of Andhra Pradesh (A.P.) and the gram panchayats that are proposed to be merged with MCR forms the study area. The study area falls within the latitudes $16^{\circ}55'42''\text{N}$ and $17^{\circ}07'46''\text{N}$ and longitudes $81^{\circ}55'11''\text{E}$ and $81^{\circ}42'50''\text{E}$. Recently i.e. in the month of March, 2013 the Government of Andhra Pradesh has issued an order extending the limits of the MCR with merging 21 surrounding gram panchayats to its limits. Thus after merging these gram panchayats the area of MCR increases to about 255 sq.km. The location of Rajahmundry in A.P. state and the administrative limits of the present MCR along with that of the proposed

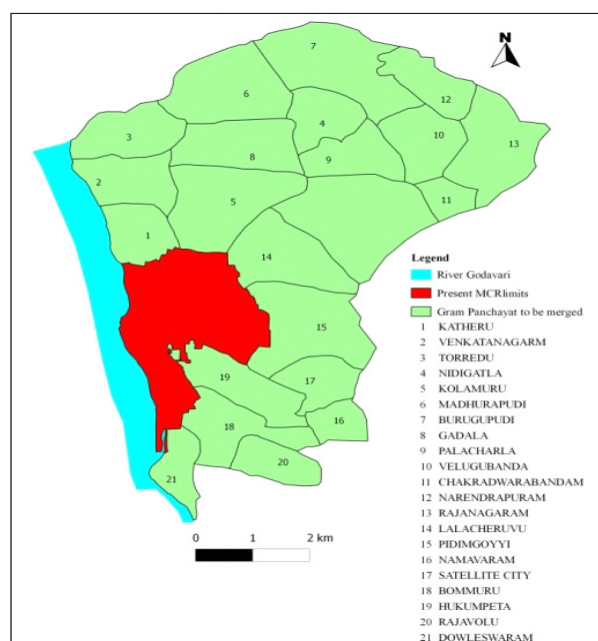


Fig.1.The study area

21 gram panchayats to be merged into MCR is shown in Fig.1

Data, Materials & Methods

The attribute details regarding various public amenities like schools, primary health care centers, government offices and road networks in the study area are collected through field surveys. Blumax Global Positioning System (GPS) was used to geo-register them. Built-in tools of open source GIS software QGIS are utilized in this work for geo rectification, mapping and GIS data sets creation. Similarly OpenJUMP tools are utilized for extracting query based information on the created GIS data sets. Open layer plug-ins available in QGIS is used for getting Bing satellite image and for extracting complete road network in the study area. Remote sensing image (IKONOS-MSS) is used to distinguish road types and attribution in MCR and its adjoining areas. Created GIS data sets of road network is rechecked and attributed through field checks.

Analysis

The geospatial information (or data bank) regarding various infrastructural facilities and public amenities in digital form and also in a map form is very useful for making proper developmental plans to meet the demands of the growing population and ever expanding urban regions. A preliminary analysis of this

data bank is very essential for future detailed analysis and planning. Thus in this section a preliminary analysis of various geospatial information collected through field surveys in the study area is carried out and presented.

Population

As per the 2011 census, the total population of 21 villages that are planned to be merged with MCR is 1,79,282 (89,375 male + 89,907 female) which adds up to the existing population of 3,43,903 (1,69,786 male + 1,74,117 female) of MCR to make the total population of MCR 5,23,185 (2,59,161 male + 2,64,024 female) after the merging of the villages. There are five villages with population having more than 15,000 and 5 villages having population between 5,000 and 10,000 and 11 villages with population less than 5,000.

Dowleswaram is the highly populated village with a total population of 44,646 (22,228 male + 22,418 female) and followed by the Katheru, Pidimgoyya, Hukumpeta and Bommuru in the decreasing order of population. The average population of the wards in the present limits of MCR is 6,878 and the population of highly populated five villages viz., Dowleswaram, Katheru, Pidimgoyya, Hukumpeta and Bommuru are much higher than the average population of wards in MCR. The average population of the rest of the 16 villages is less than the average population of the wards in the present MCR. This information about population of villages is quiet useful for planning the number of wards boundaries and their boundaries in the newly emerging extended/greater MCR.

(i) Road Network

There are 3 major roads (1 national highway and 2 state highways) that pass through the Rajahmundry town connecting various villages to be merged with MCR. While NH-16 (previously no. 5) connects Dowleswaram, Bommuru, Hukumpeta, Lalacheruvu, Divancheruvu, Chakradwarabandam and Rajanagaram gram panchayats with Rajahmundry town, the Rajahmundry-Seetanagaram state highway connects Katheru, Venkatanagarm and Torredu gram panchayats and Rajahmundry-Maredimilli-Bhadrachalam state highway connects Kolamuru, Gadala,

Madhurapudi and Burugupudi gram panchayats with Rajahmundry town. The other villages viz. Narendrapuram, Velugubanda and Palacherla are well connected to one of these major roads through properly laid permanent blacktop (BT) roads and are at a distance of 1 to 2 km. from one of them. Thus connectivity wise all the villages are well connected to the main center of Rajahmundry town and all are within 20 km. from it.

As of now MCR is having about 355 km. length of roads within its limits out of this 355 km. 40% (142 km) of roads are of black top (BT) roads, 50.47% (179.1 km.) of the cement concrete (CC) roads and 9.45% (33.54 km) of katcha type. Of the 142 km. BT roads, 33.7 km. belong to Roads and Buildings (R & B) department which maintains them and 108.5 km. is maintained by MCR itself. At present majority of population is depending on Auto Rikshaws, Rikshaws and their own vehicles for their commutation within the limits of corporation and between the above villages and Rajahmundry. As the limits of MCR is going to increase, transport authorities can think of running some city bus services for public transport, for which GIS can help to identify the major routes or transport network. Also remote sensing and GIS can be used for distinguishing and mapping different types of roads available in the extended MCR limits and also for their regular maintenance. Fig. 2 shows the connectivity between Rajahmundry main town and different gram panchayats proposed to be merged.

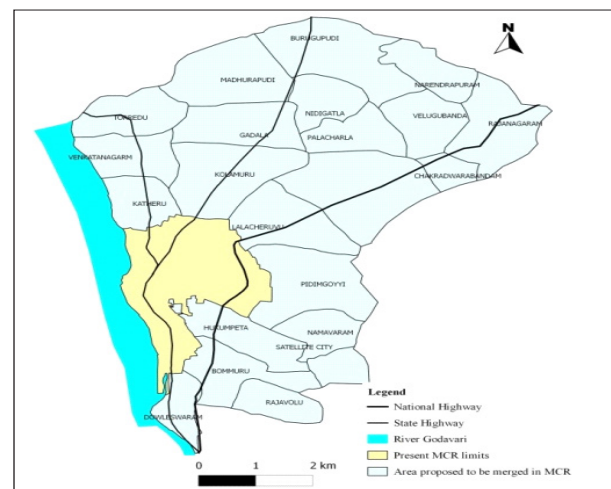


Fig. 2. Road network connecting Rajahmundry main town with different gram panchayats proposed to be merged in MCR.

(ii) Education

Accessibility of government educational institutions is an important and beneficial factor to the economically backward population living in villages. Thus, an attempt is made in the study to identify government educational institutions viz., primary schools and high schools which are accessible to the proposed villages. Preliminary analysis has been carried out through GIS queries which show that all the above 21 gram panchayats are having at least one government or government-aided primary school and 17 of them are having a government or government-aided high school within their limits. Remaining 4 gram panchayats are accessible to a government or government-aided high school within 2 km. distance. Fig. 3 shows the spatial distribution of government primary and high schools in the proposed extended MRC area.

(iii) Health

Provision of health care facilities for its residents is a major concern to any local body. Hence an analysis has been carried out to find out the accessibility of government hospitals to the extended area population. Much of the poor from a number of surrounding villages including the above mentioned 21 villages depend on the government general hospital (GGH) located within the present limits of MCR for their major health problems. There are only 11 primary health centers (PHC) available for primary health needs of common public

that are located in 9 gram panchayats to be merged. These PHCs are located in Katheru, Torredu, Palacharla, Lalacheruvu, Bommuru, Dowleswaram, Rajanagaram, Venkatanagaram, and Narendrapuram gram panchayats and are within 5 to 6 km. to the rest of the villages.

GGH is run by Andhra Pradesh Vidya Vidhana Parishad (APVVP). PHCs are run by grants of Zilla Praja Parishad (ZPP) and Mandal Praja Parishad (MPP). The present study indicates that only 9 gram panchayats are having a PHC within their limits, and Katheru panchayat itself is having 3 PHCs within its limits. Dowleswaram gram panchayat has a Employees State Insurance (ESI) dispensary in its limits. An eye hospital run by missionary is available in Rajavolu gram panchayat, and a private medical college cum multi specialty hospital is available in Rajanagaram gram panchayat.

Three gram panchayats viz. Rajanagaram, Torredu and Rajavolu have veterinary dispensary within their limits. Madhurapudi, Burugupudi, Pidimgoyyi, Hukumpeta, panchayats are not having even one PHC within 5 km. to them. There are 52 first-aid-clinics run by individuals or private organizations available to all the gram panchayats. Fig. 4 shows the spatial distribution of health care facilities in the proposed extended limits of MCR.

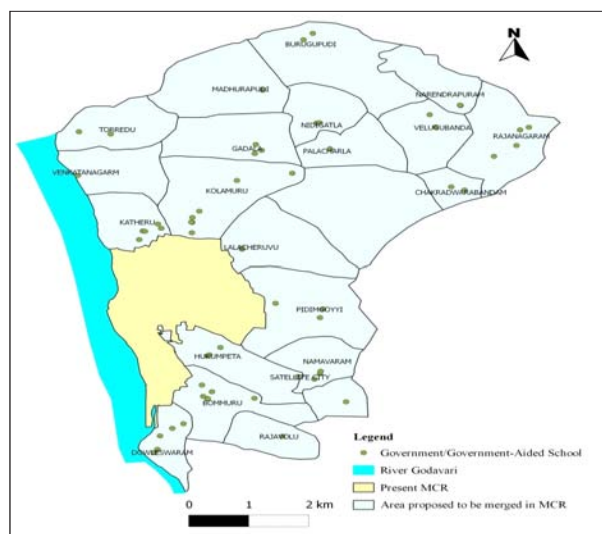


Fig. 3. Spatial distribution of educational facilities in the proposed extension limits of MCR.

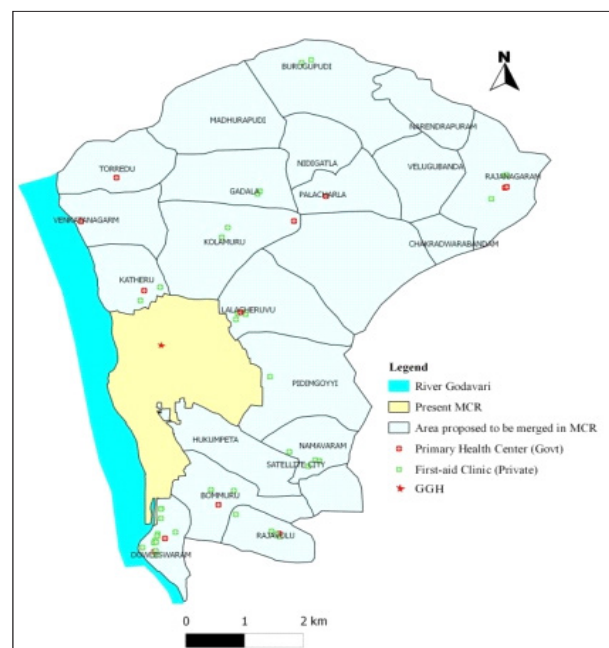


Fig. 4. Spatial distribution of health care facilities in the proposed extension limits of MCR.

Conclusions

The present paper is a preliminary study about various facilities available in the 21 gram panchayats proposed to be merged with MCR. The analysis of the spatial data of connectivity, education and health centers is carried out using FOSSGIS tools. This type of study is still under progress to identify and create GIS data sets on other facilities like Banks, Colleges, ATMs, Government Offices etc. for feature utilization and for further detailed spatial analysis using FOSSGIS tools. A detailed spatial analysis of the comprehensive GIS data sets on various themes is essential for proper planning and sustainable development of MCR for which FOSS GIS tools can be utilized effectively.

Acknowledgment

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Accuracy Analysis of Urban Growth Model of Hyderabad City by Remote Sensing and GIS

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Keywords: SLEUTH Model, Urbanization, Accuracy Analysis, Confusion Matrix and Kappa Coefficient

Abstract: Urban development is a complex and dynamic process. The rapid urbanization process especially in developing countries like India causes more and more people get attracted to urban areas. Models are perhaps the best way for understanding the land use change phenomenon. Owing to availability of high resolution satellite imageries with its dynamicity and receptivity, Remote Sensing data and spatial dynamic modelling such as SLEUTH are advantageous to predict the urban growth precisely and plan for its developmental activities efficiently using GIS tool. Although the models are used to identify the changes of land use in future by prediction, it is a question that how much it is accurate. Accuracy analysis is very important aspect in anticipating correct planning activities for development of urban infrastructure. This study has made an attempt to evaluate the accuracy of the urban growth of Hyderabad city predicted by using SLEUTH model. To assess the accuracy of the SLEUTH Model, the predicted urban areas for the year 2012 was verified on ground using GPS. 250 control points all over Hyderabad District have been taken from the model prediction and verified on the ground. In this study, a statistical comparison was undertaken between 2012 predicted urban extent and 2012 observed urban extent. Error (confusion) matrix and kappa coefficient were computed to quantify the degree of comparison accuracy. The model obtained a 93% overall accuracy with kappa coefficient of 0.85. Kappa values are also characterized into 3 groupings: a value greater than 0.80 represents strong agreement, a value between 0.40 and 0.80 represents moderate agreement, and a value below 0.40 represents poor agreement. The results showed that the kappa coefficient value worked out to be 0.85, which represents a strong agreement. Based on high overall classification accuracy and kappa coefficient value, the model predicts in high accuracy.

Introduction

Urbanisation is an inevitable process globally, and an important topic for the planners, managers and environmentalists. Urbanisation is an index of transformation from traditional rural economies to modern industrial ones. In the last 200 years, the Earth's urban population has increased over 100 times while the total global population has increased only six times. In 1975, about 38 per cent of the Earth's population lived in urban areas and by 2025, this will rise to 61 per cent (UNDP, 1995). Urban land use changes have been studied for many years; however, the advent of satellite images and geospatial technologies opened a new dimension for assessing and monitoring land use cover changes. Remote sensing

techniques and the availability of free to less expensive data sources of satellite imagery and their temporal frequency has greatly enhanced the potential for monitoring urban growth, urban land use dynamics, landscape pattern analysis, and urbanization.

Study Area

Hyderabad is the capital city of Andhra Pradesh. The geographic location of Hyderabad extends from longitude 78° 22' to 78° 33'E and latitude of 17° 17' to 17° 30' N. The size of the study area which is shown in figure 1 accounts for about 2,880 sq.km. Hyderabad is one of the fastest growing metropolitan cities in India. Hyderabad Urban Agglomeration (HUA) is the fifth largest in India, with increasing population.

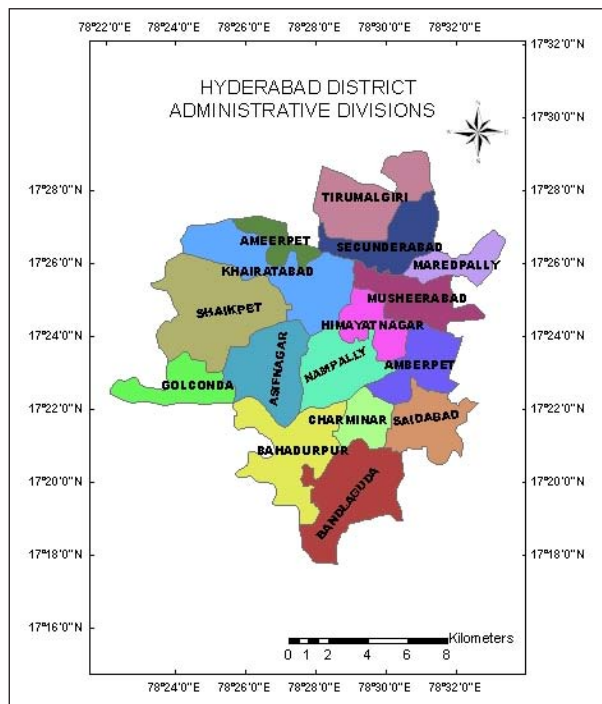


Figure 1: Location of Hyderabad District

The rapid rate of urbanisation being experienced in Hyderabad has created serious environmental problems. The city is experiencing expansion in all directions resulting in large scale urban sprawl and changes in urban land use.

3. Data Used in the Study

The Satellite Imageries used in this research are Landsat (MSS), IRS 1C/1D (LISS III) and Landsat Imagery of Enhanced Thematic Mapper (ETM) (Source - NRSC, Hyderabad), Master Plan of Hyderabad City (Source - HUDA, Hyderabad), Topographical Maps 56K, 56K/6, 56K/7, 56K/10 and 56K/11 and Guide Maps (Source - Survey of India, Hyderabad) and Demographic Data (Source - Census of India) were used for this study.

4. Methodology of the Study

The methodology of this study rests on an integration of GIS, Remote Sensing and spatial modelling to identify the proper scenarios for urban growth in Hyderabad city as shown in Figure 2. This study of predicting urban sprawl of Hyderabad is carried out in three stages. In the first stage, the input data are prepared by digitization of maps and classification of imageries using GIS techniques. The pattern of land use and land cover changes is also

measured by Entropy as a tool. In the second stage, the input layers for the SLEUTH model are prepared from the classified imageries and maps. The Model has been tested, calibrated and predicted the urban growth. In the final stage, the model outputs are derived on desired formats such as textual and graphical.

4.1. Urban Land use Modeling using SLEUTH

Evaluating the impact of urban growth on the environment and understanding the dynamics of complex urban systems involves modelling and simulation which require innovative methodologies and robust techniques. Among several available land use modeling tools and techniques, SLEUTH model is used in this study due to scale independent, dynamic, and future oriented, conforming to the essential requirement of urban growth simulation. Results of the quantified and analyzed data can be presented in a graphical and/or map outputs. Hence, the landcover of 1989 and 2000 were analyzed and major driving forces were identified in the Change Analysis.

4.2. Model Validation

In this study validation has been done by ground truth verification. The predicted urban areas for the year 2012 were verified on ground using GPS. 250 control points all over Hyderabad District have been taken from the model prediction and verified on the ground. In this study, a statistical comparison was undertaken between 2012 predicted urban extent and 2012 observed urban extent. Error (confusion) matrix and kappa coefficient were computed to quantify the degree of comparison accuracy.

5. Results and Discussion

5.1. Land use and Land cover (LULC) Classification

The spatial distribution of different land use/land cover is identified and the statistics of the same is represented in Table 1. The extent of urbanization between 1988 and 2011 is depicted in Figure 3. It is observed that there is decrease or increase in areas for each of the broad categories. The total built up land of Hyderabad is about 6575.66 hectares or 30.59 per cent of the total geographical area in 1988. Its development is not proportional

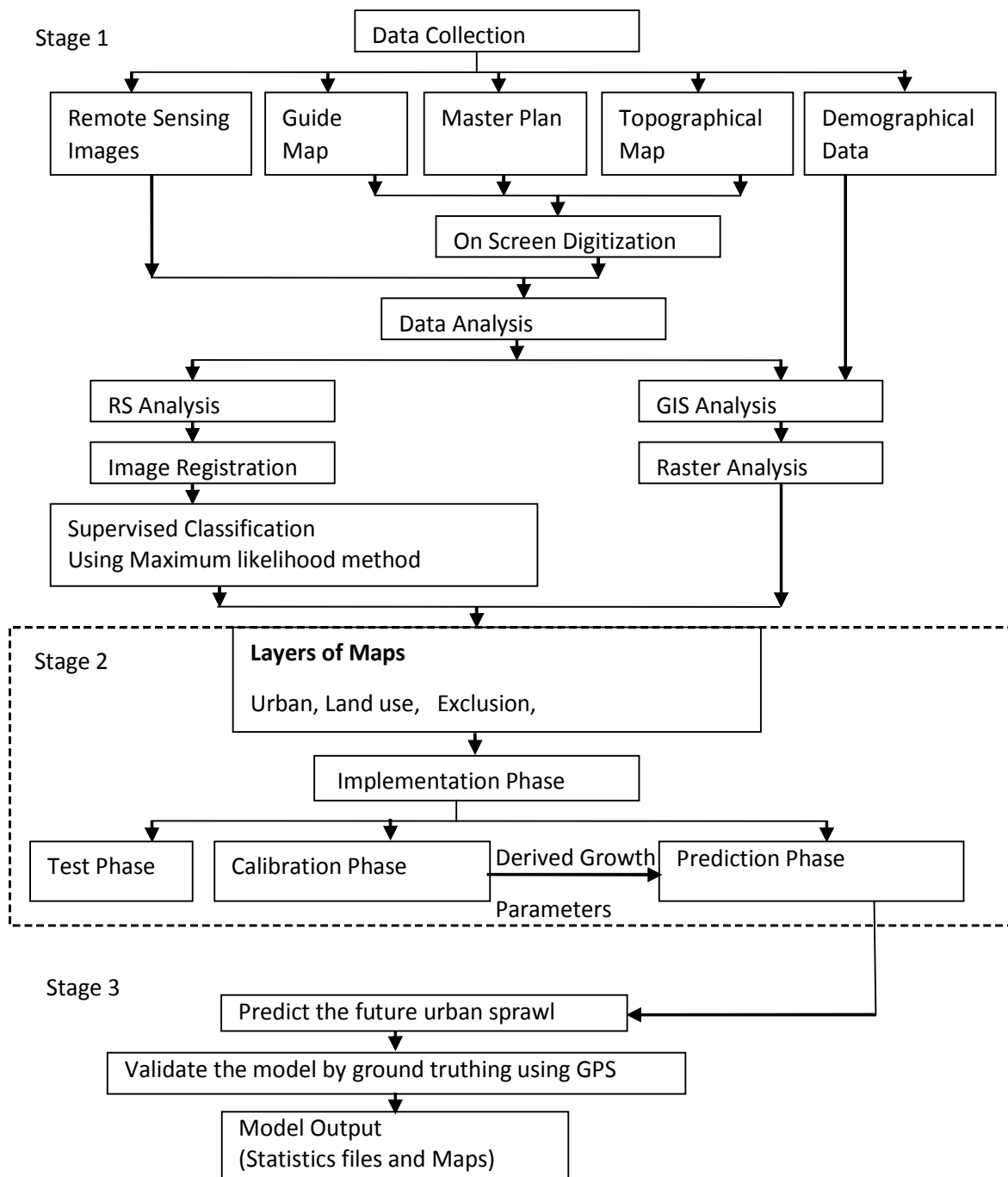


Fig. 2 General Outline of Methodology

on the two sides of the Musi River. In the north the residential activity is stopped at Alwal due to the frontage with Cantonment (institutional) along the state highway to Warrangal. Towards the south, Shali Banda is the limit. By 1998, the residential land use is estimated to be about 8323.1 hectares or 38.72 per cent of total geographical area of total built-up land. The development is almost stagnant

towards the south. The south eastern direction along Vijaywada highway has seen a phase of growth during this period. Settlements of Medchal, Shamirpet and Ghatkesar have also shown a little growth around their respective surroundings.

By 2011, this category has increased to about 11996.5 hectares or 55.81 per cent of the total

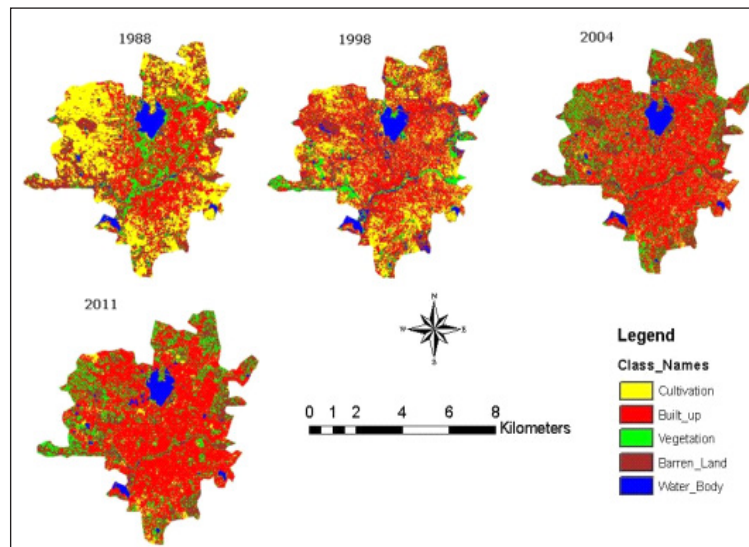


Figure 3: Land use land cover maps from image classification

geographical area. The major share of this category is occupied by the residential land use. The residential land use of Hyderabad was about 82 per cent of the total built up land. The northern extension along transport routes have increased and enlarged to occupy large areas. Especially there exists a continuous corridor in the north eastern direction on Mumbai highway upto Patancheru (Medak District). In the south eastern direction along Vijaywada highway residential activity has extended upto Hayatanagar which till 1970 was a suburban area. In the southern direction the development is well within a short distance from the nodal point of city formation. The industrial development which has been recently established is a pull factor for the urban sprawl.

5.2. LULC Detection, Quantification and Analysis

The increase in built-up area of the total geographical area from 1988 to 2011 is 30.59 per

cent, 38.72 per cent and 55.81 per cent which is shown in Table 1. After 2011, the number of apartments increased in Hyderabad having more than 5 storey buildings. When the same is related with the increasing population it shows a high degree of congestion. Its development is not proportional on the two sides of the Musi river.

Agricultural areas on the peripheries of built-up land have been encroached by new constructions. The agricultural land has decreased from 1988 to 2004. The percent decreased is 18.05 per cent to 10.65 per cent of the total geographical areas. This is due to the invasion mostly by the built-up land and partly by scrub land which is subsequently occupied for construction.

The percentage of water bodies decreased from 23.19 per cent to 6.71 per cent during the year 1988 to 2011. It shows the shrinkage of river and lake and the smaller water

Table 1: Land use Land cover Distribution and changes

Sl. No.	Land use Categories	1988		1998		2004		% change between 1988-2004
		Area (Hectares)	Area (per cent)	Area (Hectares)	Area (per cent)	Area (Hectares)	Area (per cent)	
1	Water_Body	4,986.15	23.19	3,579.13	16.65	1,442.45	6.71	-71.07
2	Agriculture	3,881.14	18.05	3,056.51	14.22	2,288.78	10.65	-40.99
3	Built_Up	6,575.66	30.59	8,323.1	38.72	11,996.5	55.81	82.44
4	Barren_Land	4,730.84	22.01	5,459.55	25.40	5,501.44	25.59	16.26
5	Others	1,323.069	6.15	1,078.568	5.02	267.685	1.25	-79.67
	Total	21,496.86	100.00	21,496.86	100.00	21,496.86	100.00	

bodies were dried up either naturally due to the impediments caused in the drainage or deliberately by infilling the depressions. Water bodies are being affected by impediments to their natural drainage by urbanization, which are stopping the inflow of water or infilling the depressions with garbage, so as to be occupied for future construction.

In 2011, barren land occupied the high class with 25.59 per cent of the total class, taking up more than one quarter of the total classes. Furthermore, the high percentage of barren land may be due to the onset of autumn season at the time of the year in which the area was imaged which happens to fall within a major contributing factor to the observed classification. The encroachment of this land use category on agricultural land is quite evident on the map. The barren rocky land is identified in the north-western and north-eastern parts of the study area. In case of waste lands which are more or less remaining same over the given period of time are the deliberate creation of the real estate agents.

5.3. Land Use Modelling

The Model has been tested, calibrated and predicted the urban growth. The predicted urban area change in Hyderabad City is shown in Figure 4 between 2005 and 2055. The predicted urban area is given in Table 4. The extension of urban sprawl of Hyderabad has been inhibited. The hitherto unoccupied area of places like Banjara hills and Jubilee hills were occupied. In the northern direction the sprawl have crossed Bolaram and reached

Hakimpet. As observed the pull factor was the Poultry farms and grape gardens, especially around Shamirpet. Some of the measures taken by the transportation department to develop Shamirpet lake as a holiday resort has been attracting people along the transportation artery linking the city with the lake. The areas along the Highway are being built up. The urban sprawl in Hyderabad city is not only in radial direction i.e from the core of the city but also in linear along road sides.

5.4. Accuracy Analysis

Accuracy analysis is undertaken of the model predictive performance using statistical validation. This is done by running the model in prediction mode using the historical urban extents of 1950, 1975, 1987 and 2004 to predict 2012 for the study area. A statistical comparison is undertaken between 2012 predicted urban extent and 2012 observed urban extent. Error (confusion) matrix and kappa coefficient (Table 2) are computed to quantify the degree comparison accuracy.

The model obtained a 93% overall accuracy with kappa coefficient of 0.85. Kappa values are also characterized into 3 groupings: a value greater than 0.80 represents strong agreement, a value between 0.40 and 0.80 represents moderate agreement, and a value below 0.40 represents poor agreement. The kappa coefficient value came out as 0.85, which represents a strong agreement. Based on high overall classification accuracy and kappa coefficient value, the model predicts in high accuracy.

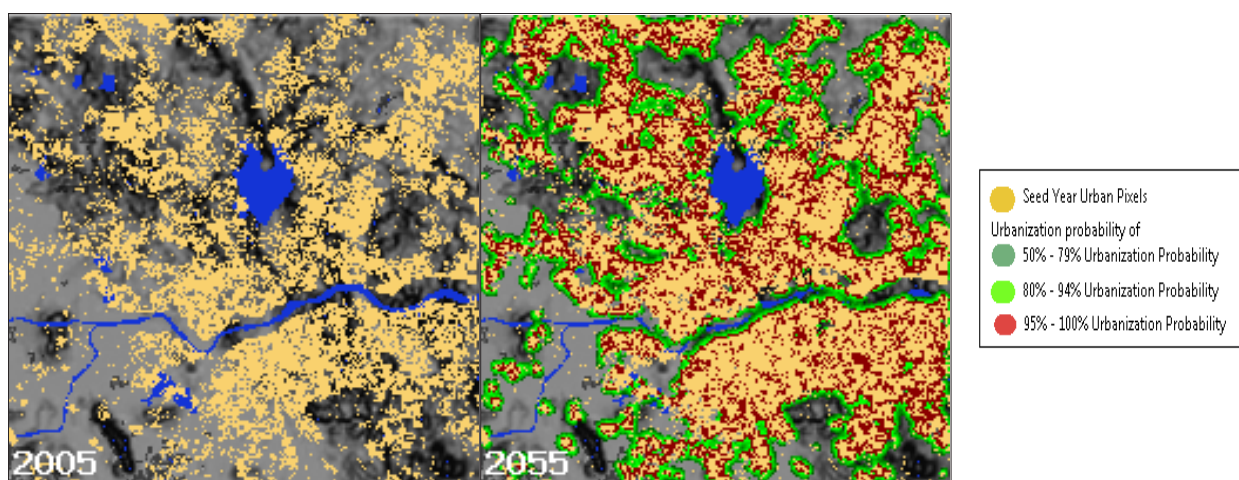


Figure 4: Predicted Urban Growth Map of Hyderabad for year 2055

Table 2: Confusion matrix and Kappa Coefficient for 2012

Classification	Urban	Non Urban	Total	Producer Accuracy	User's Accuracy
Urban	256	14	270	95.17	94.81
Non Urban	13	123	136	89.78	90.44
Total	269	137	406		

Overall Accuracy 93.34975

Kappa Coefficient 0.85

6. Conclusion

This study uses the potential of Remote Sensing, GIS and modelling tools for predicting land use change in the future and analyze LULC changes. Conversion of agricultural land and water body area cover to human settlements, urban fragmented growth, challenges in urban planning. The results of the study indicate that, Hyderabad experienced rapid horizontal urban growth from 1988 to 2011, which resulted in loss of valuable land resources for urban decline in agriculture. The growth trend of built-up areas in the coming years is also likely to keep expanding at an alarming rate. If the sprawling cannot be regulated by strict policy instrument, in future the urban environment of Hyderabad might reach a stage where the situation is critical and irredeemable. Population growth and urban sprawl are placing immeasurable amount of stress on natural systems in and around Hyderabad. The model obtained a 93% overall accuracy with kappa coefficient of 0.85. The results showed that the kappa coefficient value worked out to be 0.85, which represents a strong agreement. Based on high overall classification accuracy and kappa coefficient value, the model predicts in high accuracy. Hence this model may be implemented to the

cities where all the input parameters of SLEUTH model exist. To conclude, the model helps the urban planners and managers to understand the urban growth process, which is essential in their planning activities. In addition, they can simulate the urban growth through inputs of proposed activities and predict the future growth patterns. This will help the planners to develop the necessary constraints and policies that can be implemented to avoid stress on urban space and infrastructure facilities.

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Analysing the Urban sprawl through entropy of Gulbarga city and its spatial promoters of growth through Geoinformatics

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Keywords: *Shannon's entropy, sprawl quantification, landmarks, spatial indicators of growths, promoters of growth.*

Abstract: Understanding the urban growth is the most challenging aspect in urban studies. Shannon's entropy combined with satellite image processing and GIS techniques provide better efficiency in quantifying the urban fringe growth and further analysing its characteristics. Unplanned urbanization causes concerns by rapidly changing landscape. Understanding the growth patterns of cities helps us to plan a sustainable growth for the future. The entropy value calculated for Gulbarga city for fringe areas for two different periods, gives a clear indication of direction of growth and spatial pattern of expansion. The values of entropy at some part of the city's fringe increases closely to the value of $\log(n)$ which clearly indicates the occurrences of sprawl, but at some other part, the value reduces which attributes to densification of settlements there. In such places, it gives more scope for spatial promoters of growth. Such growth is also correlated with spatial indicators of growth that promote urbanization in such regions, and can be considered to induce change wherever their presence are noticed.

Introduction

Abstracting urban change in cities is a long tradition of urban geography. Historically, geographers examine the patterns of similarity or dissimilarity behind the urban patterns and seek for the reasons. However, demographic, socio-economic and political trends were the driving reasons behind these patterns. The concentric ring theory (Ernest, 1925), the sector theory (Hoyt, 1939), the multiple nuclei theory (Harris & Ullman, 1945) try to explain about the demographic arrangements of the city. From ideas derived from these models, geographers derive new models to explain urban process through amalgamating the census data with multivariate statistical methods. Numerous models have been developed to study urban sprawl (Hasse, 2004). Urban sprawl is inherently a dynamic phenomenon and hence can be better analysed over time. Recent studies have developed several aspects of understanding sprawl (Galster et. al, 2001). However, there is great need for further understanding of spatial and temporal patterns of sprawl, especially in the dynamic suburban and exurban areas (Hasse & Lathrop, 2003). The sway of each spatial indicator of sprawl has a special influence

in driving sprawl in that particular spatial unit. These indicators will help in assessing the growth management policies (Nelson, 1999).

Study area

Gulbarga city is located in the Hyderabad-Karnataka region. It is being situated in the northern most part of Karnataka state boundary bordering the states of Maharashtra and Andhra Pradesh. It is located at 17.330 N, 76.830E with a population of 5.41 lakh with a geographical spread of 64 sq.km., according to 2011 Census extracts. The city of Gulbarga has strong imprints of Indian history. Being formed by the Bahami sultans in 14th Century, the etymology of Gulbarga in Persian denotes land of lavish living. This clearly suggests that, during this time, Gulbarga was prosperously wealthy. Before the Bhami sultans, it was under control of the Sultans of Delhi. In 1347, the revolt of officers appointed from Delhi resulted in the formation of Bahami Sultanate by Hassan Gangu. From 1728-1948, Gulbarga was a part of Hyderabad state. In 1948, after the defeat of Nizams of the Indian army, Gulbarga became a part of the Indian Republic. Gulbarga has an average elevation of 454 meters above mean sea level and has a

gently rolling topography. Its strategic location in the centre of Indian southern peninsular enjoys the advantage of transportation and becomes an important landmark for the north-south connectivity.

Methodology

The research first attempts to analyse sprawl through shannon's entropy.

Entropy 'E' is calculated using this formula

$$E = \sum_i^n P DEN_i \cdot \log_e(P DEN_i) / \log_e(n) \quad ..(1)$$

$$\text{Where } P DEN_i = (DEN_i) / \sum_i^n DEN_i$$

$$\Delta E = (t + 1) - t \quad ..(2)$$

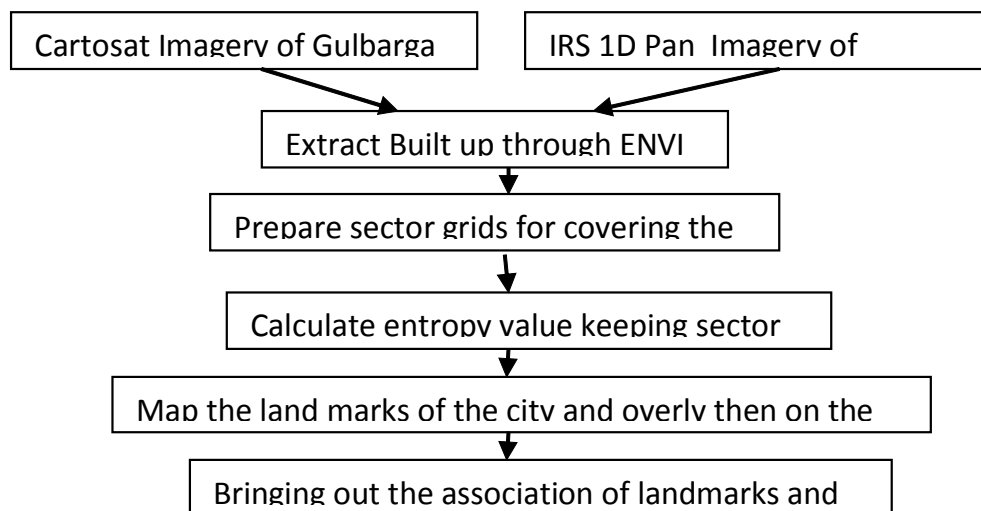
'Deni' is the proportion of variable in the ith zone (i.e. in this case area of built up in 'ith' zone) divided by the total amount of land in the ith zone, given to an understanding that there are 'n' number of zones. While applying this formula using two time period satellite data, extracted with the built-up, for every section of 'n' we get the value of 'hn' which is the entropy value. Applying this value one can find out the entropy value for two time period (Anthony et.al. 2001). The entropy value ranges from 0- $\log_e(n)$. A value closer to 0 shows a situation where the built-ups are compact in totality. A value closer to $\log_e(n)$ shows highly dispersed or sprawled situation (Shekhar, 2004; Verzosa & Gonzalez, 2010). With this as the background, the entire sector grid was analysed for sprawl conditions and were divided.

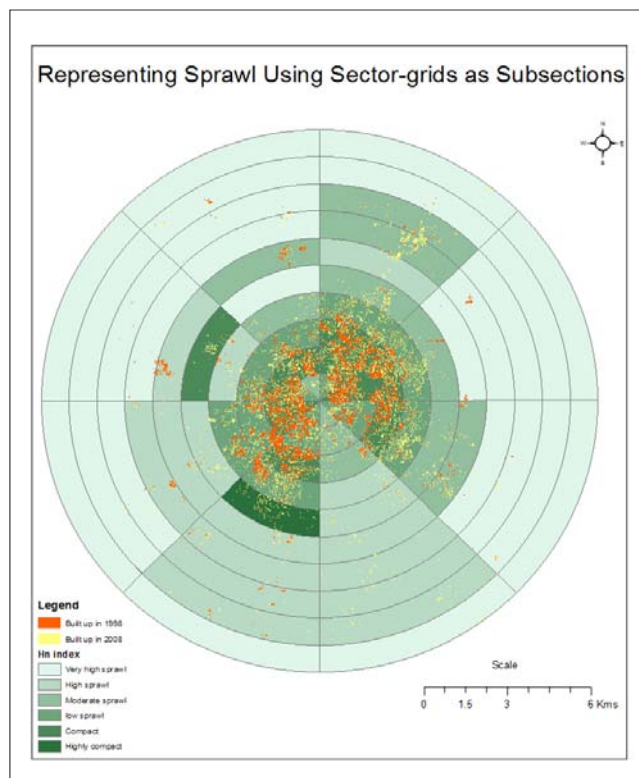
In the next level, all the landmarks of the city were mapped using GPS. These landmarks are the waypoints well recognised by the public, as are such spatial locations that are used as relational references to convey their residence address to a third person. Such can be educational centres, malls, theatres, conventional halls, commercial centres, recreational and/or religious centres. While this showed some pattern of association that the high sprawls were associated with some kind of spatial indicators. These can be interpreted as the promoters or associates of sprawl.

Work Flow

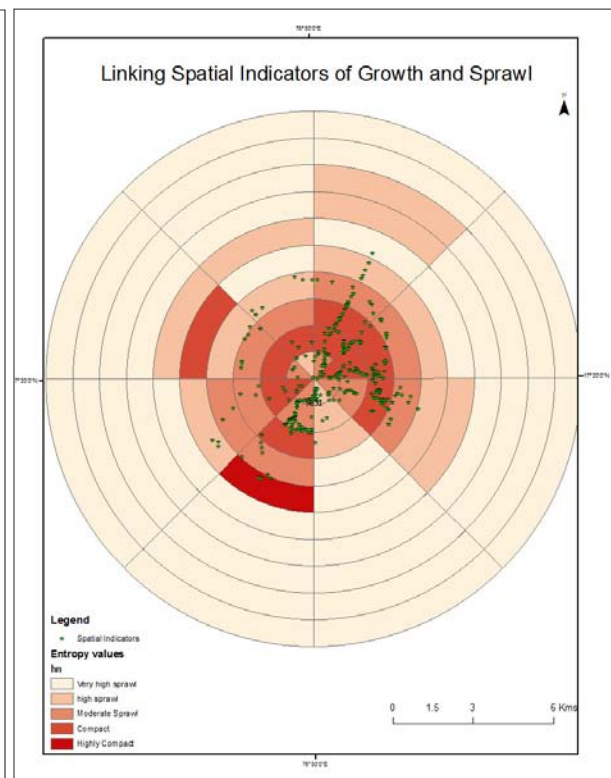
This method has proved very significant in identifying the specific spatial units where sprawl occurs and the region of influence of the factors which drive sprawl in that region. Several landmarks were marked in this process. Spatial indicators such as educational institutions from college, schools, montessaries etc., government establishments and service sectors, commercial shops, malls, industrial establishments, religious spaces like temples, mosque churches etc., requires large space and hence are forced to move out of the city. They in-turn influence their sphere to mushroomed constructions around. This can be related to fractal geography at a point. But, this research attempt to find what kind of promoters develop sprawl through time. Thus, a simple spatial association is worked out between the zones of sprawl and presence of spatial indicators.

Map 1 explains the spatial pattern of sprawl, which clearly indicates that South east and





Map 1: Entropy Results of Sprawl of Gulbarga City



Map 2: Spatial Indicators of Growth along the Sprawl

some portion of North West are the areas which high sprawl had been occurring. There are the places where compactness of settlements is hardly noticed.

Results

The spatial association of land marks and sprawl are well depicted in Map 2. This helps us in understanding that amenities such as school, social/religious spaces and government organisations that do not need to be located in the city, and which depends on only road for their accessibility are the driving forces of sprawl of this region. Its sphere of influence is more than 5 km. Other amenities like park, malls and commercial establishments are seen compact or near compact regions and they need easy accessibility for their commercial benefits. Hence, they are not seen away from the city in sprawl regions. But they are sure to occupy these regions of sprawl once the settlement there develops compactness.

Discussion

This method is more practicable in indentifying factors to induce growth to achieve compact circular growth of city. In a

circular pattern of growth of cities, extension of amenities is easier than allowing the city to grow in a random manner. Hence, in order to achieve compactness and circular growth, these factors or indicators of growth shall be introduced in the north-eastern and south western parts of the city, so that growth also occurs in more compact manner. This shall also save random leap frog sprawl spreading to the nearby farm lands that gulp-up valuable productive lands to permanently lost towards buildings.

Acknowledgement

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Integration of Remote Sensing & GIS for Urban Land Use / Cover Change Analysis of the Jodhpur city

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Keywords: LU/LC, Urban Sprawl, Remote Sensing, GIS, Change Detection

Abstract: Monitoring and management of urban sprawl require huge amount of information pertaining to natural and man-made features predominantly available in the area. Until lately, such a study could be achieved through days of exhaustive field data, thematic map and planning. Urban expansion is the key factors in changing land use/cover which has caused major problems like agricultural lands loss, water pollution, soil erosion and some social and economic disadvantages. One of the major advantages of Remote Sensing technique is timelines in the availability of information over large area and simultaneous observation making it possible to detect temporal changes. Geographical Information System (GIS) serves as a powerful tool for spatial and non-spatial analysis of remotely sensed data. This paper presents the spatial extent, magnitude and temporal behavior of land cover changes around Jodhpur city in past two decades. The second largest city of the state, Jodhpur is fast growing city surrounded by sand stone mining activities, rocky area, fallow land and industrial zones. While most of the commercial activities and unplanned settlement are located in the old city area and planned urban settlement, industries & mining area lies in the outskirts of the city. Satellite Data of Landsat, IRS-P6 L3, SOI toposheets and ground truth data were used for the change detection and preparation of GIS based outputs maps of the Jodhpur city and surrounding areas. These images were classified for finding different changes using urban sprawl techniques viz shannon's entropy and chi-square. Results revealed significant changes in land cover and urban settlements of the city during the study period. These results could help city planners and policy makers to attain and sustain future urban development.

Introduction

The use of Remote Sensing data in recent times has been of immense help in monitoring the changing pattern of LU/LC. Change detection, as defined is the temporal effects as variation in spectral response involves situations where the spectral characteristics of the land cover type in a given location change over time. Using these techniques to develop land use classification mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and industrial areas of a region. In the present study area of Jodhpur city and surrounding the land use has been changing, with new developments (urban, industrial, commercial and agricultural) are emerging. The purpose of this work is to

map the LU/LC features in the study area in the time from 1973 to 2011.

Study area

Jodhpur city is located at latitude of 26° 18' North and longitude of 73° 1' East and is located in the middle of the Thar Desert tract of western Rajasthan about 250 km from the Pakistan border (Fig.1). Its general topography is characterized by the hills located in the North and North-west. The city has a natural drainage slope from North-North East to South-South East towards Jojari River and extensive stone quarries in the Northwest direction.

Data Used & Methodology

Geocoded False Colour Composite scene of LANDSAT data on scale 1:50,000 and Survey

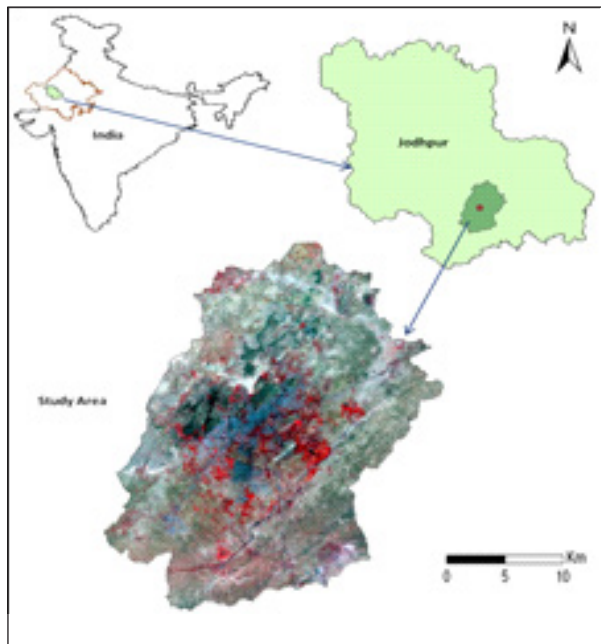


Fig. 1 Location Map of the Study Area

of India (SoI) maps are used in the present study (Table 1).

Table 1. Satellite Data used in the Study Area.

Reference year	Satellites/ Sensors	Resolution	Path/Row	Date of Acquisition
1973	Landsat MSS	57 m	149/42	07-10- 1973
1991	Landsat TM	30 m	149/42	29-10- 1991
2001	Landsat TM	30 m	149/42	29-10- 2001
2011	Landsat ETM	15 m	149/42	27-10- 2011

In the given flowchart multi date Images has been done using georeferenced SOI maps of by identifying the ground control points (GCP's) from the map and the corresponding points on the satellite images and finally applying the map-image transformation model(Fig 2).

ENVI software has been used for classification of geometrically and radiometrically images. Nearest-neighbor resampling method has been used to transform the images so that the original pixel value can be retained. Observed urban growth has been compared with the expected urban growth to understand the nature of discrepancy in urban growth. Chi-Square analysis has been performed to find out the degree of freedom. Many attempts have been made to measure sprawl (Sudhira *et al.* 2004; Bothale and Sharma, 2007; Dasgupta, and Paul, 2013). One of the most commonly used approaches, in most urban sprawl studies, is to integrate Shannon's Entropy with GIS tools. Shannon's entropy is a well accepted method for determining the sprawled urban pattern. To identify the nature of sprawling, the area has been divided into eight directions from the centre at the city of Jodhpur city. Since the Chi-square (degree-of-freedom) and entropy (degree-of-sprawl) are different measures and the result of one may contradict other

in some of the instances (as it is evident in this study), the 'degree-of-goodness' of urban growth has been determined. It refers to the degree at which the observed growth relates to the expected growth and the magnitude of its compactness

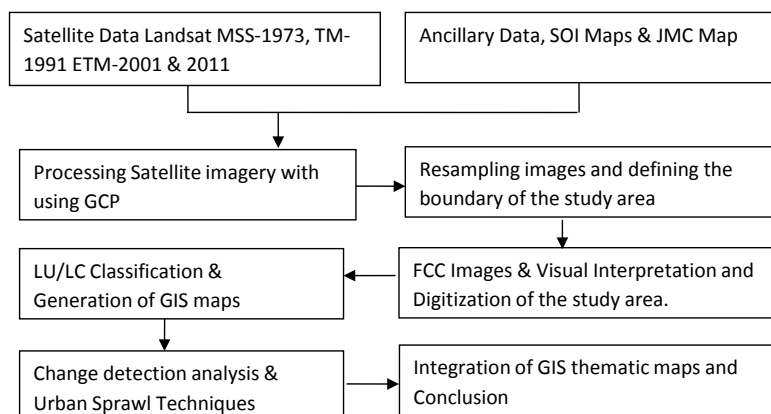


Fig. 2 Methodology Flow chart

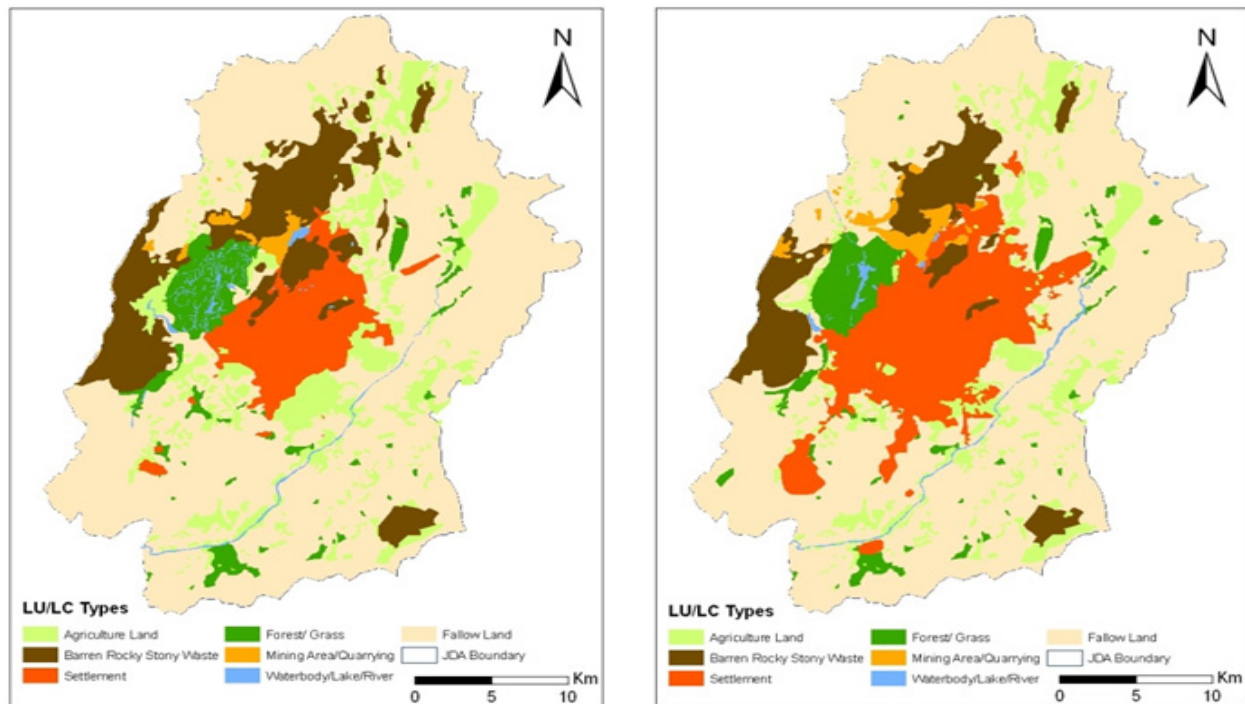


Fig. 3 LU/LC Classification of Study Area in 2001 and 2011

Result and Discussions

Land Cover Change Maps and Statistics: Using the approaches adopted in the methodology, land cover maps were generated for two periods (Fig.3) and area estimates and change statistics are computed. In the study periods covered, the major land cover classes identified includes seven LU/LC classes, mainly forest/grass, water bodies/lake, agricultural land, settlement, fallow land, Barren rocky waste land & Mining Area/Quarrying. Individual class area and change statistics for the two periods were summarized in Fig. 4.

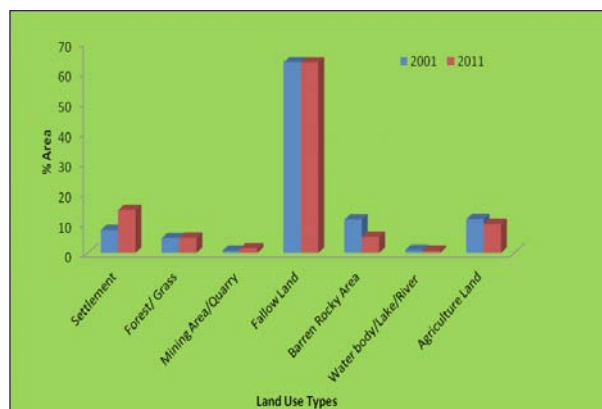


Fig.4. Nature of relative Land use/ Land cover change 2001 to 2011

In this study, it was found that there is approx 1% decrease of forest/grass cover since last 10 years i.e. from 2001 to 2011, The water bodies in the study area are showing decreasing trend. There is approximately 21% decrease of water bodies, 7% increase in settlement area due to increasing of human population. There is 3% decrease of agricultural and vegetated, 3% decrease of fallow due to increasing human population and their needs. The study shows that wasteland in part of Jodhpur city is showing decreasing trend and 1% increase of Mining area / Quarrying due to availability of large sandstone quarries.

Measurement of Urban sprawl: Urbanization takes place either in radial direction around a city center or linearly along major road networks. Such dispersed nature of urban development along major road networks or surrounding city center is often referred to as sprawl (Sudhira *et al.* 2004). In this study, urban sprawl over the period of 1973 to 2011 was determined by computing the area of all the built lands from the land cover maps. The Shannon's entropy along with GIS tools was also applied to measure the sprawl during the study period. For calculation of the entropy the city area was divided into eight zones and temporal span of three decades has been analyzed in GIS (Fig. 5).

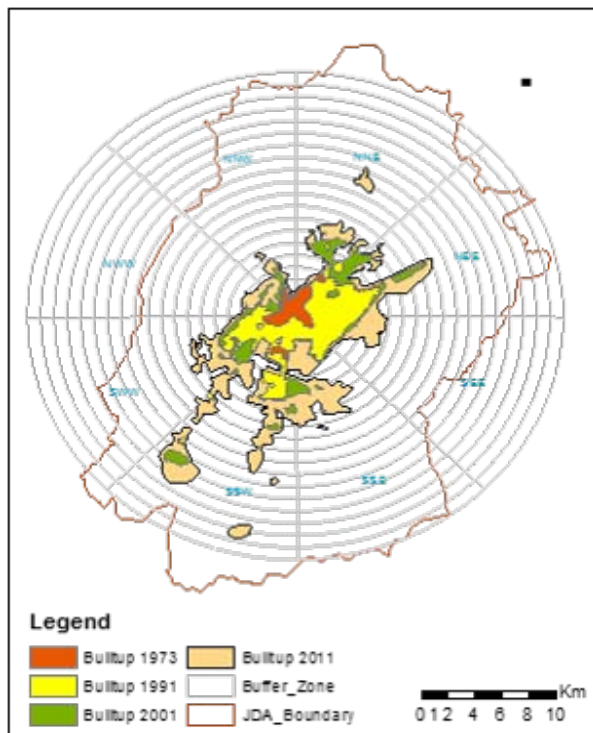


Fig.5. Landuse dynamics zones of the Jodhpur city (1973-2011)

The Built-up Area and Urban Growth: The proportion of an area covered by impervious surfaces such as asphalt and concrete is a straight forward measure of urban growth. So the more urbanized area has greater proportions of impervious surfaces compared to the less urbanized areas. Table 2 shows that the built-up area of the Jodhpur city has changed over the time in different directions. Observed growth in built-up area has been calculated for the time spans 1973-1991, 1991-2001 and 2001-

2011. The rates of decadal variation have also been computed. It shows that the rate of urban growth fluctuated with time and all the zones have achieved maximum growth rate during 1991-2011.

Pearson's chi-square statistics helps in checking of freedom amongst pairs of variables chosen to explain the same category of land-cover change (Almeida *et al.*, 2005). Therefore, to determine the 'degree-of-freedom', chi-square test was performed to reveal the freedom or degree of deviation for the observed urban growth over the expected. For observed and expected was calculated with Equation 2 (Table 3) as:

$$\chi^2 = \frac{\sum (UG_i - UG_j^E)^2}{UG_j^E}$$

Where, UG_i = observed built-up area in j column for a specific row, = expected built-up area in j column for a specific row. Now, if we replace j (column) by i (row), and m (number of columns) by n (number of rows) in eq. (2), we can determine the degree-of-freedom for each zone also.

Table 3 clearly shows that the degree of freedom is low (i.e., similarity between observed and expected values) for both of the temporal spans. It is low (i.e., similarity in observed and expected values or very near) for only north, north east and south directions whereas it is high for west and east directions. Lower overall freedom indicates equal weightage and consistency in planning with the entire city in consideration.

Table 2. Built-up Area of Jodhpur City and Surroundings (1973-2011) (sq. Km.)

Year	Direction (Zones)								Column Total
	NNE	NEE	NNW	NWW	SSE	SEE	SSW	SWW	
1973	2.1	0.36	1.16	0.79	0.07	0.72	0.66	1.26	7.12
1991	5.1	10.35	1.44	1.95	3.51	5.88	8.52	8.02	57.89
2001	9.57	13.28	2.72	3.44	4.92	5.99	12.88	11.57	64.35
2011	15.57	22.51	5.77	6.21	18.07	11.4	38.34	19.83	137.7
Row Total	32.34	46.5	24.1	12.39	26.57	2.08	60.4	40.68	245.06

Table 3. Decadewise Chi-square values for Growth of Built-up Area in each Zone

Temporal Span	Direction (Zones)							
	NNE	NEE	NNW	NWW	SSE	SEE	SSW	SWW
1973-1991	0.2036	2.1394	0.8311	0.1054	0.5967	1.393	0.842	0.3617
1991-2001	2.946	0.038	0.4958	0.5580	0.6221	0.6221	0.3021	0.2047
2001-2011	0.3184	0.898	0.0839	0.0236	0.9279	0.9279	0.8909	0.4439

Entropy of Urban Growth:

Shannon's entropy (H_i) is a popular method for determining the sprawled urban pattern (Kumar et al., 2007; Lata et al., 2001; Li & Yeh, 2004; Bothale and Sharma, 2007).

$$H_i = -\sum P_j \log_e P_j$$

Where, P_j = proportion of the variable in the j column (i.e., proportion of built-up growth rate in j zone, and m =number of zones (8). As the entropy values are much higher than the half-way mark of $\log(m)$, the city is said to be experiencing sprawl with increasing tendency (Table 4).

The entropy value is higher than the halfway mark of $\log(n)$ i.e. 0.55 in every direction except to the west which means these zones are sprawling, especially the south and northwest zone has a highest possible sprawl.

Table 4. Decade wise and Direction wise Shannon Entropy

Temporal Span	Direction (Zones)							
	NNE	NEE	NNW	NWW	SSE	SEE	SSW	SWW
1973-1991	0.270	0.5247	0.0456	0.2776	9.2934	1.3552	2.2521	1.014
1991-2001	2.5890	0.8360	2.6257	2.2573	1.1867	0.0552	1.5116	1.3075
2001-2011	0.5524	0.3495	0.7101	0.3882	0.6412	0.4181	1.7412	0.6290
Entropy (H_i)	1.0170	1.4959	0.8400	0.9974	0.7982	0.959	1.5648	1.5252
H Maximum $\log_2(3)=1.585$; $H/2=0.792$								

Table 5. Degree-of-Goodness (Zones wise)

1973-2011	NNE	NEE	NNW	NWW	SSE	SEE	SSW	SWW
Degree-of-Goodness	-0.80	-1.07	0.291	0.84	-0.08	-1.78	-0.70	0.028

Degree of Goodness of Urban Growth:

This can be calculated for each zone as (Equation 4):

$$G_i = \log_e \left[\frac{1}{\chi^2 \left(\frac{H_i}{\log_e n} \right)} \right]$$

Where, G_i = degree-of-goodness of urban growth, n =total number of zones. where χ^2 is the overall degree of freedom and H_i is overall sprawl. It is a straightforward measure, positive values indicating 'goodness' or good growth, whereas negative values indicate 'badness' or not spectacular growth. Magnitudes (Table 5) show how goodness varies in different directions (positive or negative).

Conclusion

This study amply demonstrates the use of remote sensing and GIS to analyze the urban sprawl mapping and detect changes of urban land use through different year. The urban expansion in the study region is governed by the road network mainly following a ribbon shaped linear spread. A marked growth has been noticed along the national highways roads connecting the city in three directions namely Pal Road in SSW, Pali Road in SSE and Mandore Road in NNW. The impact of urban sprawl is felt mainly on agricultural land, forested land, and fallow land. Results provide a methodology for better estimation of urban growth and sustainable land use planning with time.

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Water and Sanitation Situation in Urban Villages of Municipal Corporation of Gurgaon – India: A Geographical Analysis

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Keywords: *Urban Growth, Urban Villages, Transition, Landuse, Sanitation and water*

Abstract: Urban growth in India has faced an unexpected pressure and urbanization has left its impact on many sphere of our environment. Rising migration, major shifts to tertiary occupations and increasing stress on limited resources are some of the many challenges which we are witnessing. This process of urbanization has left its impact on both urban and rural settlements. The nature of urban impact on rural settlements varies according to the kind of relations a village has with city and the response of its inhabitants to the surrounding developments. Broadly, three different situations of urban impact may be distinguished. Firstly, there are villages in which a sizable number of people have sought employment far-off cities. In such villages, urban employment itself becomes a symbol of higher social prestige. The second kind of urban impact is seen in urban villages near an industrial town. The influx of migrant workers not only stimulates demand for houses and a market within the village, but creates problems of ordering relationship between the native residents and the immigrants. The growth of metropolitan cities accounts for the third type of impact on surrounding villages. It is with this third type of urban impact that this paper is concerned. Gurgaon, located 30 km southwest of Delhi in Haryana, is the industrial and financial centre of the state. This city is one of the Delhi's four major satellite cities and is part of the National Capital Region. Recently the population of Gurgaon Municipal Corporation has increased from 1,00,877 in 1981 to 8,76,824 in 2011 and is continuously increasing. However, Gurgaon is two cities living within a bigger ecosystem - Old Gurgaon and New Gurgaon. While old Gurgaon has poor infrastructure and is very congested, new Gurgaon is a complete contrast with skyscrapers and well planned development. The growth of urban areas and engulfing of villages in the city boundaries is a reality of the continuous process of urbanisation in India. Gurgaon's laissez faire development saw many of these urban villages being left as ugly eye sores with no addressal of growth and development of the existing villages. The Gurgaon Municipal Corporation consists of 28 such urban villages. These compact villages scattered across the four zones of the Gurgaon Municipal Corporation is caught between a rural and an urban lifestyle and requires special attention. These villages represent an area of transition and have marginal characteristics not only with respect to the land use but also with respect to degree of acceptance of urban norms and customs. The change in occupation and land use pattern in Gurgaon is largely responsible for the transformations, because that is what made the urban villages viable in the city after their agricultural land had been acquired. Thus, from a primarily residential one, the landuse changed to largely commercial or industrial or in some cases even residential for the purpose of renting out in order to generate income. Provision for water, sanitation, drainage and the safe disposal of wastes is a challenge for maintaining good housing and living conditions of the villages as well as to health. Therefore it is of utmost importance that appropriate initiatives are taken to channelize their growth in the right directions thereby benefiting the entire city. In the present paper an attempt has been made to study the sanitation and drinking water facilities of the four urban villages of Gurgaon Municipal Corporation.

Statement of the Problem: Gurgaon, the second largest city of Haryana, has been on

the faster pace of development and emerged as the industrial and financial hub during the last

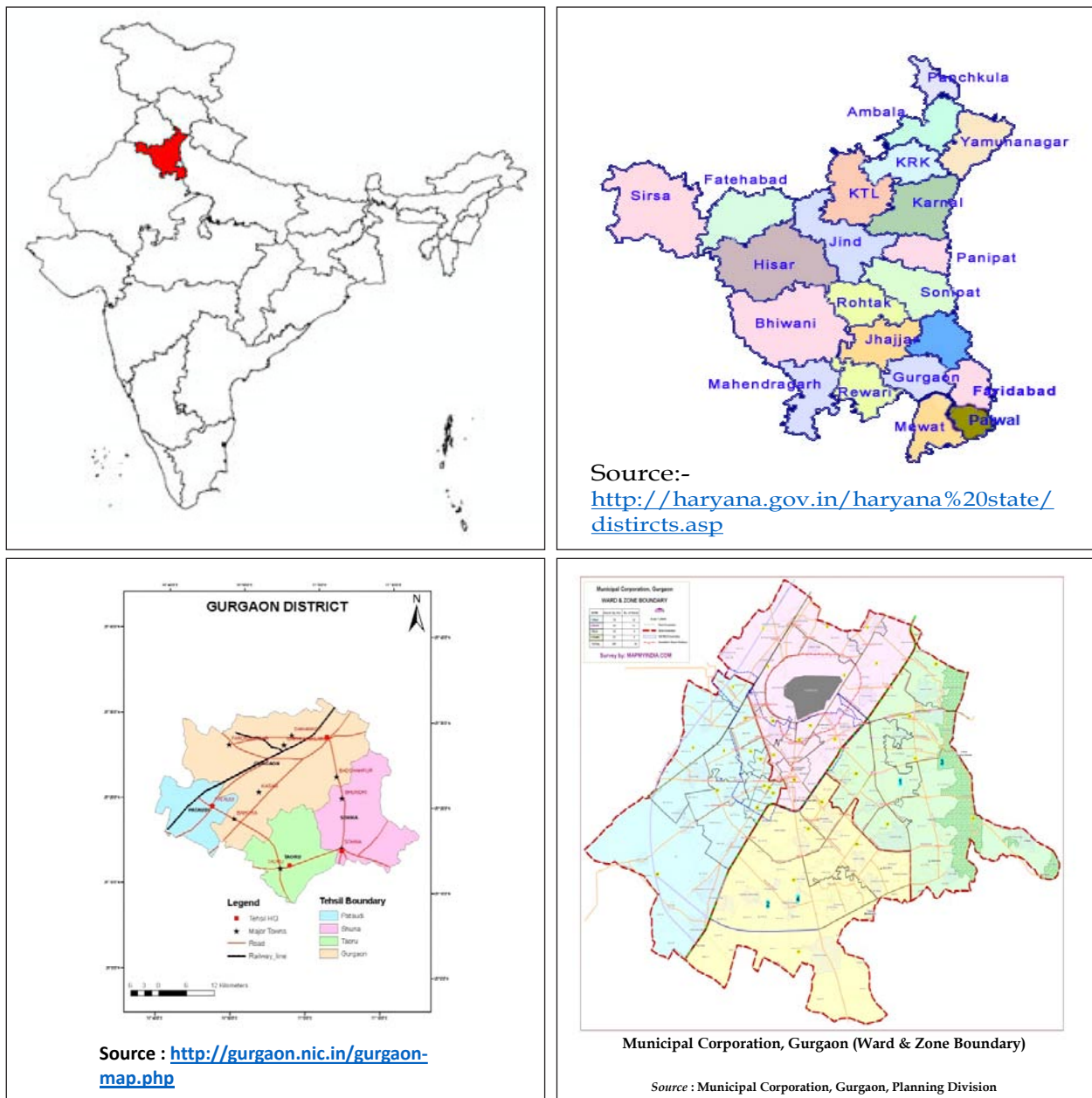


Fig. 1 Location Map

two decades. The population of Gurgaon has increased from 1,00,877 in 1981 to 8,76,824 in 2011, registering a growth of more than eight times in the last three decades. Two reasons are responsible for this rapid urban growth. **Firstly**, the mechanisation of agricultural sector and Green Revolution resulted in surplus farm-labour and output, which were pushed to urban areas and **secondly**, it is an important attraction for industrialists to establish their industries which is in the close vicinity of international market.

The rapid urban growth of the state as well as of Gurgaon is a symbol of Haryana's economic development in the field of industries, commerce, transport and communication on one hand and urban environmental degradation in terms of congestion, housing shortages, and inadequacy of community facilities, services and utilities on the other. The urban villages squeezed between private colonies lack basic amenities including good roads, proper water supply and sanitation. Though the urban villages form an important part of the city, their urban

Table 1: Population of Gurgaon M. C. between 1981 to 2011

	Total Urban Population			
Year	1981	1991	2001	2011
Haryana	2827387	4054744	6115304	8821588
Gurgaon M.C.	100877	135884	228820	876824
Percentage	3.6 %	3.4 %	3.7 %	9.9 %

Source: Census of India, various years

form and spatial characteristics have often been neglected in practice. In Gurgaon too, these villages that surround the developed areas face the perennial problems of overflowing sewage, broken roads and inadequate health facilities in most cases. These settlements, caught between a rural and an urban lifestyle need special attention to harness their resources and manpower. The present study is an attempt to focus on the existing gaps in terms of safe drinking water and sanitation in such urban villages of the Gurgaon Municipal Corporation.

Introduction to the Study Area

(a) Introduction to the District

The district has been in existence since the times of Mahabharata and was named as Gurugram, which in course of time distorted to Gurgaon. Gurgaon district falls in the southern most region of the state with headquarter at Gurgaon (Map 1). It lies between 27° 39' N and 28° 32' 5'' N latitude, and 76° 39'30''E and 77° 20'45''E longitude. Its boundary touches Rajasthan and south Delhi which makes Gurgaon to be an important strategically located place. On its north, it is bounded by the district of Jhajjar & the union territory of Delhi; Faridabad district lies to its east and on south it shares its boundaries with Mewat while Rewari lies in its west. At present Gurgaon district is comprised of three subdivisions namely Gurgaon (North), Gurgaon (South) and Farukh Nagar and five tehsils of Gurgaon, Sohna, Pataudi, Farukh Nagar, and Manesar.

(b) Introduction to Gurgaon Municipal Corporation

Gurgaon, located 30 km southwest of Delhi in Haryana, is the industrial and financial centre of the state. Its geographical coordinates are 28° 28' N latitude and 77° 01'59'' E longitude. This city is one of the Delhi's four major satellite cities and is part of the National Capital Region. Identified in 1962 as a satellite city in Delhi's

Master Plan, Gurgaon began to be urbanised in earnest when the Maruti Suzuki car factory opened shop in the early 1980s.

During 1990s Gurgaon's growth really took off, as the Haryana Urban Development Authority (HUDA), loosened all controls on the area's development. Being less productive and less in demand for agricultural purposes, Gurgaon's land was more readily convertible to non-agricultural purposes and government policies allowed this conversion. Dozens of foreign companies began opening offices or locating their outsourcing operations in Gurgaon. Moreover, the proximity of Gurgaon to the international airport also supported the growth of export oriented units such as in the garments sector.

However, Gurgaon is two cities living within a bigger ecosystem - Old Gurgaon and New Gurgaon. While old Gurgaon has poor infrastructure and is very congested, new Gurgaon is a complete contrast with skyscrapers and well planned development. The Municipal Corporation is divided into four zones (namely Zone 1, 2, 3 and 4 known as West, North, East and South zones respectively) and 35 wards. Map 1 also depicts zones in Gurgaon in Municipal Corporation. The rapid growth of population in Gurgaon Municipal Corporation is depicted in Table 1.

There are 28 urban villages under the jurisdiction of the Municipal Corporation. The study, however, focuses on the four urban villages of the city, viz. Khandsa, Gurgaon, Kanhai and Badshahpur.

Objective: To study the current situation of drinking water and sanitation in four urban villages of Gurgaon Municipal Corporation namely Badshahpur, Gurgaon, Kanhai and Khandsa.

Data - Base and Methodology: The present study is primarily based on the field

survey conducted in the four urban villages located under the jurisdiction of the Gurgaon Municipal Corporation. Primary data has been generated through questionnaire survey, while the secondary data has been collected from various published government reports available from respective Departments and Census reports. The District Census Hand Book and District Gazetteers of Gurgaon have also been consulted for data pertaining to 'Urban Villages'. The villages were selected from each of the four Municipal Zones on a random basis and 100 households irrespective of the population size were surveyed in each of the urban villages. The questionnaire mainly focussed on the water and sanitation facility available in the urban villages besides the provision of basic infrastructure. The field survey was conducted during the month of February-March 2013 in these urban villages. Data collected was tabulated using simple mathematical calculations.

Having described the objective of the study, it is important to understand the concept of urban villages. The concept of urban villages was formally born in Britain in the late 1980s with the establishment of the Urban Villages Group (UVG). Following pressure from the UVG, the concept was prioritized in British national planning policy between 1997 and 1999. The concept of urban villages in India on the other hand is different. Urban growth in India has faced an unexpected pressure and urbanization has left its impact on many sphere of our environment. Rising migration, major shifts to tertiary occupations and increasing stress on limited resources are some of the many challenges which we are witnessing. This process of urbanization has left its impact on both urban and rural settlements. The nature of urban impact on rural settlements varies according to the kind of relations a village has with city and the response of its inhabitants to the surrounding developments. Broadly, three different situations of urban impact maybe distinguished. Firstly, there are villages in which a sizable number of people have sought employment far-off cities. In such villages, urban employment itself becomes a symbol of higher social prestige. The second kind of urban impact is seen in urban villages near an industrial town. The influx of migrant workers not only stimulates demand for houses and a

market within the village, but creates problems of ordering relationship between the native residents and the immigrants. The growth of metropolitan cities accounts for the third type of impact on surrounding villages. It is with this third type of urban impact that this study is concerned. The change in occupation and land use pattern in Gurgaon is largely responsible for the transformations, because that is what made the urban villages viable in the city after their agricultural land had been acquired. Thus, from a primarily residential one, the land use changed to largely commercial or industrial or in some cases even residential for the purpose of renting out in order to generate income.

Gurgaon – the new face of cities in the 21st century India., unlike what Nehru had envisioned, erratic, unplanned, sporadic and lacking in infrastructure, yet functional. In 2003, Gurgaon was named the Millennium City owing to its exponential growth post 2000. Interestingly, Gurgaon had a plan on paper dating back to 1966. It went nowhere till after the establishment of Haryana Urban Development Authority (HUDA) under the HUDA Act in 1977. One of the first major changes was the acquisition of land by Sanjay Gandhi to start an automobile company. The plot is now the Maruti Suzuki factory. With the advent of private developers from 1981 onwards, the area experienced a great boom in construction activity when developers such as DLF Ltd began to acquire farmland along the Delhi border. However, while Gurgaon was commercially functional, it is a city plagued by serious civic problems ranging from clogged roads and erratic power supply.

Even at the fringes of Gurgaon's affluent areas, large pools of black sewage water are easy to spot. The water supply is vastly inadequate, leaving private companies, developers and residents dependent on borewells that are draining the underground aquifer. Local activists say the water table is falling as much as 10 feet every year. Gurgaon, has a long to-do list: fix the roads, the sewers, the electrical grid, the drainage, the lack of public buses, the lack of water and the lack of planning. The Municipal Corporation was formed in 2008 and even after a passage of good five years nothing much has been done to address their problems. One of the villages absorbed into

the sprawling new territory of the Municipal Corporation, most are actually former farmers, having sold their land to the developers constructing the office parks and apartment towers now ringing the village. Many of them had bought new cars or new plots of land or invested in the new developments. They were now richer. Their frustration was their village. It was becoming an urban slum. The drains are broken and accidents are happening, yet no one is answerable. Whatever water they get is dirty, but they have nowhere to complain. When India's public and private sectors are compared, the contrast is usually stark: the private sector is praised for its efficiency, linear command structure and task-oriented ethos; the public sector is condemned for its opacity, lack of accountability and the fact that often no single agency seems in charge. Even as many Gurgaon residents hope that the Municipal Corporation can improve services, others worry that its authority is too limited, given that state agencies will maintain authority over licenses and infrastructure.

With this brief background the present study will try to assess basic civic amenities and infrastructure like safe drinking water and sanitation in the four 'urban villages' of Gurgaon Municipal Corporation.

Water and Sanitation in Surveyed Villages – A Comparative Study:

As is known, these villages existed prior to any planned intervention, as is seen in new Gurgaon and accommodates a significant number of poor people, particularly the migrant labourers working in the newly settled factories and industrial houses. As mentioned in Chapter 3, the low incomes and the ever-widening gap between the rich and the poor directly and indirectly are contributing to the gap in basic services in these villages. As found during the survey, these settlements have electricity supply but don't have adequate basic physical infrastructure. The social infrastructure provided by the local body, like schools and health services are also inadequate. Most of these needs are catered to by the private sector.

Drinking Water and Sanitation Scenario: In these villages where population is young and occupies mainly the productive age group, it can be assumed that facilities in these villages in terms of availability of safe drinking water

and sanitation are satisfactory. During the survey it was observed that not even a single household were aware of any government schemes regarding drinking water supply or /and sanitation provision. The Haryana Government however, has spent over Rs 380 crore on water supply projects under the Indira Gandhi Drinking Water Scheme, according to official records, for ensuring piped water supply to the underprivileged sections of the society. Though the residents were not aware of any govt. scheme for the supply of safe drinking water, it was noticed during the survey that supply of water in these villages was satisfactory. Field visit observed that water supply has been ensured by the Municipal Corporation of Gurgaon (MCG) in Badshahpur village, either within the premises of each household or at least with a tap fitted at their door-step.

Ninety-four out of hundred households in Badshahpur village are getting their drinking water through piped water in the dwelling. On the other hand, villages of Gurgaon, Kanhai and Khandsa depicted a different picture. 69 Households in Kanhai, 55 in Gurgaon village and 33 households in Khandsa village had piped water supply. All these three villages are more dependent on borewell water for drinking purpose or for other activities like cooking and washing compared to Badshahpur village.

The maximum number of tubewell is found in Khandsa village which is located on the National Highway. Out of the 100 households surveyed, 42 of them had tubewells as their water source. Many households had dug tubewells in their own land, either in their courtyard, or toilet or in the open space available within the household compound. Many households were even found to have underground water tanks for storing water. This indicates the gap in demand vs. the water supplied by the Municipal Corporation of Gurgaon to these villages. Perhaps the size of the village of Badshahpur has provided being cost effective to the MCG in ensuring tapped water supply as most of the households received piped water. However, the picture in terms of ground water extraction is not much different in Badshahpur.

Water treatment at the Household level

It is interesting to note that though 94 households in Badshahpur receives piped

water supply which is assumed to be safe, they prefer treating the water before drinking or using it for other domestic use. 68 households responded positively to the adoption of water treatment facilities. Many households have adopted the modern technique of water purifying by installing Reverse Osmosis (RO) systems in their households. Plate No. 4.4 shows some of the households with ROs installed in their kitchen for ensuring safe drinking water.

Residents of Khandsa and Kanhai too are very health conscious as 60 and 56 households out of 100 treat water before using the same for drinking and cooking. Though Gurgaon village also has borewell facilities and piped drinking water provided by the MCG, 71 households reported that they don't treat their drinking and cooking water. The behaviour pattern of the households gives an opportunity for further research on the issue of safe drinking water.

During the field survey it was found that households understand the importance of safe drinking water and practice some form of water treatment to make water safe for drinking purposes as is seen above.

Some households use the RO system, the process of water purification at the household level. It is interesting to note that in Kanhai village, substantial number of households even today make their water safe by straining the water through a clean cloth. 16 out of the 100 households surveyed, practice this even today. The other most popular method is candle filters. Candle filtering process for getting safe drinking water seems to be quite popular as this is user friendly, is cost effective, includes hassel free maintenance and removes impurities of water easily. The number of households using this technique out of 100 households is 43 households in Khandsa, 36 in Badshahpur, 35 in Kanhai and 25 in Gurgaon village. It is equally important to note that 65 households in Gurgaon village rely completely on the municipal water or water supplied by the public health department, which they believe is safe for consumption. Nearly 71 households do not treat water at all.

Water Storage Facilities: As far as storage of drinking water is concerned coloured plastic vessels are being used by 52, 45, 39 and 34 households in villages of Khandsa, Kanhai,

Gurgaon and Badshahpur respectively. This is due to the fact that coloured plastic are cost effective and durable for people working in industrial areas. This may be attributed to the fact that Khandsa and Gurgaon villages are near to the industrial area, while in Kanhai most of the population are migrant labourers from Bihar and West Bengal and works in nearby housing societies as construction workers. Some households use the *matkas* (earthen pot) made locally and others use stainless steel containers for storing water. During survey, it has been found out that people do not know that using coloured plastic container for drinking water causes chemicals to enter in their water leading to major health problems; in spite of cheap earthen pots available in the market only few households are using the same. In Gurgaon, 93 households clean their drinking water utensil daily, while 78 households in Khandsa village, 60 in Kanhai and 50 in Badshahpur village have responded positively.

Sanitation Scenario: The World Health Organisation (WHO) states that: Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal.

Safe water supply and hygienic sanitation facilities are basic essential amenities required for a community for healthy living. About 80 *per cent* of water used by the community comes out of houses in the form of waste water which, unless properly collected, conveyed, treated and safely disposed off, may eventually pollute the precious water resources and cause environmental degradation. Lack of proper sanitation causes diseases. One of the most significant diseases that arise from poor sanitation is diarrhea. Most of the affected are young children below the ages of five. Other diseases that are caused by poor sanitation include schistosomiasis, trachoma, and soil transmitted Helminthiasis. The importance therefore is immense. In the following few paragraphs, an attempt has been made to illustrate the sanitation scenario in the study

villages. The sanitation analysis is divided into two parts – household level and village level.

Household Level Sanitation: In the surveyed villages only few households use shared toilets and no one goes outside for defecation. More than 90 of the surveyed households use their own household toilets. In Kanhai village, the number of households using community toilets reported was more as there are migrant labourers staying in the village in rented accommodation.

About 94 out of 100 households in Kanhai village, 84 in Gurgaon, 77 in Khandsa and 61 in Badshahpur village told that their household toilet flush is connected with piped sewage system, while 36 out of 100 households in Badshahpur Village, 23 in Khandsa, 12 in Gurgaon and only 6 in Kanhai responded that their toilet flush were connected to septic tank.

In all the surveyed villages, no household responded about going outside for open defecation, which clearly marks a good sign of cleanliness. But loitering of Pigs in Kanhai Village in open areas found during the survey requires immediate attention. Pigs can transmit serious bacterial disease through urine and water.

Though the households do not defecate in the open, their behaviour in disposal of stool of children was quite disturbing as the majority of them have been throwing the stool in the garbage. Few proportions of households throw the stool of children and infants on the streets directly while only a few bury the stools. The disposal of stool in the garbage by adults is a bad behaviour because smelly stools attract flies, which are considered risky since they can transport faeces and contaminate food. It also may get mixed up with the ground water and local taps resulting in contamination of drinking water.

Hygiene Behaviour of Households: Access to improved water and sanitation facilities does not, on its own, necessarily lead to improved health. There is now very clear evidence showing the importance of hygienic behaviour, in particular hand-washing with soap at critical times: after defecating and before eating or preparing food. Hand-washing with soap can significantly reduce the incidence of diarrhoea, which is the second leading cause of death

amongst children under five years old. Recent studies have shown that personal hygiene practices like washing of one's hand with soap and water after defecation and before eating could reduce diarrheal disease incidence and worm infestation by 43%. With this objective, questions with regard to hand washing were framed for the household survey. Nearly 89 per cent of surveyed households in Badshahpur village, 74 per cent in Kanhai, 72 per cent in Gurgaon and 68 per cent in Khandsa village wash their hands with soap and only a few wash their hands with water and sometimes with soap after defecation.

Majority of surveyed households told that they wash their hands before and after meal, only a few per cent of surveyed households told that they don't wash their hands.

About 64 per cent households in Khandsa village, 58 per cent in Gurgaon village, 57 per cent in Badshahpur village and 53 per cent households in Kanhai do not use any disinfectant for cleaning the household. While it cannot be emphasized that the importance of disinfectants like phenyl etc., is useful for ensuring hygiene, the practice is yet to settle in these four villages.

Hygiene behaviours of the households in the surveyed villages are also in transition. More than three fourth of the surveyed households in all the three selected villages uses the same water storage utensil for drinking, bathing, toilet, washing and cooking, paving the safe way for the germs to enter the human body which may cause serious health problems and less than one fourth of the households had responded that they use different storage utensils for different purposes.

Village level Sanitation and Cleanliness: Outside the household premises, the first thing that the households are responsible is the disposal of garbage or household waste. Only a few of the surveyed households throw garbage on the streets and in open areas outside their homes and do not know the proper procedure for disposal of garbage while the majority of the surveyed households collect the garbage in their household bins. The same is later collected by the municipal sweeper and disposed off in the municipal van carrying the solid waste for the landfill site at Bhandwari.

Garbage is collected daily from 70 Households in Gurgaon and Kanhai and from 67 households in Badshahpur. The collection of garbage from Khandsa is weekly, though some households have reported that their garbage is collected regularly.

The Municipal Corporation of Gurgaon however, claims that their garbage vans visit all the urban villages daily and their garbage vans are fitted with Global Positioning Systems (GPS). Trash vans deputed by Municipal Corporation of Gurgaon have been installed with GPS devices to ensure that the task of garbage disposal is carried out properly. As part of the 'Clean Gurgaon' initiative, MCG has allotted 73 vehicles in Gurgaon to provide door-to-door service for collecting garbage and disposing it at the city's solid waste management plant at Bhandwari village. The drivers, however, were not collecting garbage daily. News item published during our field-survey on March 18, 2013 in Hindustan Times, Gurgaon Edition also reported that 33 per cent GPS devices in garbage vans not in working order.

Perception of the People: More than half of the surveyed households in all the villages Badshahpur, Kanhai, Khandsa and Gurgaon told us that their area is in extremely bad condition and nearly one-fourth respondents answered that their village was clean in some places while less than one fourth of the surveyed households are happy with the prevailing situation. The locational advantage of such households can be contributed major as the factor for such perception.

Perception in young and old generation about sanitation: Young generation in all the four villages agree that sanitation condition is generally unclean. One-third said that their locality is clean in some places. Merely 6-15 per cent deem that their locality is clean everywhere. The response of the old generation was exactly reverse as according to their opinion more than half of the respondent feels that their locality is generally clean. In Gurgaon and Kanhai villages 22 households out of 100 feels that their locality is clean everywhere, while 9 households in Badshahpur and 19 in Khandsa village responded that their locality is clean at all places. This difference in perception may be due to the fact that

the young people, the migrants can compare their area with that of the private builder colonies while for the women and the aged mainly the original residents of the village have emotional attachment and are satisfied with the gradual process of urbanisation of these erstwhile villages.

Nearly 88 per cent of households of Khandsa village, 58 per cent of Badshahpur Village, 38 per cent of Gurgaon village and 32 per cent of Kanhai Village have said that their children's education is affected by the prevailing unhygienic conditions. It was reported that the small children in many cases skip schools, because the streets leading to their school is generally flooded with mud and filth and little children are unable to cross these open muddy drains in these villages. Poor drinking water and sanitation facilities in school and related problems are other deterrents for the small kids taking leave from the school particularly during the rain.

The sanitation condition of these four villages exposes the residents particularly children and women to severe health and environmental risks because they are un-served by the city's sanitation systems. Tangible problems connected with the sanitation scenario include:

- The production of enormous amounts of waste including construction waste and wastewater in these villages that is insufficiently collected and treated; and
- Pollution of shallow ground water, due to open drainage system by leaking sewers, waste, and latrine contents thereby polluting the source of drinking water for the residents.

In the present chapter an attempt has been made to summarise the study. As mentioned earlier, the population of Gurgaon has increased from 1,00,877 in 1981 to 8,76,824 in 2011 and is continuously increasing. These compact villages scattered across the four zones of the Gurgaon Municipal Corporation is caught between a rural and an urban lifestyle and requires special attention. From a primarily residential one, the land use of these urban villages have changed to largely commercial or industrial or in some cases even residential for the purpose of renting out in order to generate income. Therefore it is of utmost importance that appropriate initiatives are taken to channelize their growth

in the right directions thereby benefiting the entire city.

Population Characteristics of the Study Villages: In terms of total population, Badshahpur has the largest share followed by Khandsa, Kanhai and Gurgaon according to 2001 census. The major concentration of Scheduled Caste population is in Kanhai village with 25.72% and the lowest in Gurgaon with 5.63%. The population distribution according to the age group in these villages indicates that most of the population are in the productive age group. In Badshahpur village, more than 60 per cent of the population is between 20-45 years of age, while in Gurgaon, Kanhai, and Khandsa villages the percentage of population in the 20-45 age group is 57, 66 and 64 per cent respectively. This can be due to the migration of young persons in search of new jobs, educational and medical opportunities on the one hand and concentration of cheap labour for doing menial jobs on the other. Migrants from Rewari, Bhiwani, Narnaul, Mahendergarh, Sonapat districts of Haryana as well as from the states of Uttar Pradesh, Assam, Rajasthan, Madhya Pradesh, Bihar, Uttarakhand and Delhi and even Nepal have reported staying in these villages. In terms of occupational profile of the respondents, majority of the males were engaged in private sector jobs. From the survey, it is found that 71.57% in Gurgaon, 62.36% in Kanhai, 58.52% in Badshahpur and 56.22% in Khandsa were engaged in private sector jobs in different capacities. Very few males around 15% in all the villages under study were into government jobs. Women in these villages were mostly housewives as more than 90% of them reported the same during the survey.

As the capacity of the workers varied, so did the household level earning. In Badshahpur, and Kanhai village, half of the households reported that they had monthly earning of 15,000/- and less. Almost similar conditions prevailed in Khandsa, with 47 households reporting income of Rs 15,000 and less and in Gurgaon, it was 37 households. Very few households reported having more than 50,000/- monthly income. in all the villages. In Gurgaon while only 9 households mentioned that their income was above Rs. 50,000/- per month, in Kanhai it was 4 households, and in Khandsa 6 households. In Khandsa, out of the 100 households surveyed, 87 households were earning upto Rs. 35, 000/-

per month. The economic status of the residents is an important indicator as it gives confidence to bargain for better infrastructure and services from the implementing agencies.

Education & Health: In terms of basic education & health facilities, the service provided by the state government or the municipal corporation is not satisfactory. Badshahpur village has two government schools namely senior secondary school and govt girl's school, one government public health centre. Other than the Government, there are a number of private schools and hospitals which includes prestigious Pathways World School, Delhi Public School, Maruti Kunj and Ekta Hospital. Gurgaon village has one government high school for boys one government public health centre. Other than government, there are a number of private schools and hospitals. Kanhai village has one government high school and eleven anganwadis. The govt. high school was recently upgraded to Government Senior Secondary at Khnadsa village.

Water Supply and Sanitation - Basic Requirements for staying healthy: The provision for water, sanitation, drainage and the safe disposal of wastes is a challenge for maintaining good housing and living conditions of the villages as well as to ensure good health. Water and sanitation is the key in ensuring that one is healthy. One can neither cook nor drink unsafe water due to the risks of being infected with diseases. Opportunistic infections like diarrhoea are also caused by lack of clean water and proper sanitation. It was observed that the households in the selected villages realises that. They do realise that it is not only for health but also for the time that is spent on collecting and ensuring safe drinking water that can be invested productively by the families to do other tasks and enterprises. The behaviour of the households and their preparation towards ensuring the same was captured during the survey.

It was observed that though the households surveyed were not aware of any government scheme related to drinking water and sanitation, piped water supply has been ensured by the Municipal Corporation of Gurgaon in almost all the dwelling units or at their door-step. 94 per cent in Badshahpur village, 69 per cent in Kanhai, 55 per cent in Gurgaon and 33 per cent

of households in Khandsa are getting piped water in the dwelling.

The residents however, are not sure of the quality of the water supplied, as most of the surveyed households in the four villages were using some form of filtration process to ensure safe drinking water. Many households have started spending more in the form of new gadgets like ROs and on electricity bills to ensure safe drinking water. This has definitely resulted in a recurring addition in household expenses. It was surprising though that nearly 71 per cent of the households in Gurgaon drink water directly from the source without passing it through any filtration process. It is also interesting to note that in Kanhai village, substantial number of household even today make their water safe by straining the water through a clean cloth. The other most popular method is candle filters. Candle filtering process for safe drinking water seems is quite popular as this is user friendly, is cost effective, hassle free maintenance and removes impurities of water easily.

It is equally important to store the treated water for drinking and cooking purposes, in such unclean surroundings. Coloured plastic vessels are used by 52 per cent, 45 per cent, 39 per cent and 34 per cent of households in villages of Khandsa, Kanhai, Gurgaon and Badshahpur respectively. This is due to the fact that coloured plastic containers are cost effective and durable for people working in industrial areas. However the question as to whether the plastic containers used are food-grade water storage containers remains unanswered. Some households still use the traditional *matkas* (earthen pot) and stainless steel containers for storing water. The water storage container is also cleaned regularly in most of the households. It was reported that in Gurgaon, 93 percent of the households, 78% in Khandsa village, 60 per cent in Kanhai and 50 per cent in Badshahpur village cleaned their drinking water storage utensil daily.

It was found during the survey that another important source of water for all purposes was the borewell dug by individual households. The maximum number of borewell, 42% was found in Khandsa village followed by 36% in Gurgaon. The village is located on the bank of a seasonal rivulet coming from Badshahpur

via Fazilpur. Most of the households had dug tubewells in their own land, either in their courtyard, or toilet or in the open space available within the household compound. Many households were found to have constructed underground water storage tanks for storing water extracted through electric submersible pumps. This indicates the scarcity of water and the gap in demand vs. the water supplied by the Municipal Corporation of Gurgaon to these villages.

Hygiene as Part of Home-Based Care: The sanitation situation within the households in surveyed villages was adequate though there is ample scope for improving the sanitation situation in the households. It was observed that there is a general lack of knowledge on sanitation issues, though people had complaints about the environmental sanitation scenario in all the four villages. Though the households do not defecate in the open, their behaviour in disposal of stool of children was quite disturbing as the majority of them have been throwing the stool in the garbage. Few proportions of households throw the stool of children and infants on the streets directly while only a few bury the stools. The disposal of stool in the garbage by adults is a bad behaviour because smelly stools attract flies, which are considered risky since they can transport faeces and contaminate food. It also may get mixed up with the ground water and local taps resulting in contamination of drinking water. A small proportion of the population surveyed used community toilets. In Kanhai village, the number of households using community toilets reported was more as there are migrant labourers staying in the village in rented accommodation. In such situation it goes beyond mentioning that unless the water supply points and latrines are accessible, ensuring hygienic behaviour of the user is impossible.

Good access to safe water and sanitation is indispensable for home-based care too. Water is needed for bathing, washing clothing and linen and keeping the home environment clean. There is now very clear evidence showing the importance of hygienic behaviour, in particular hand-washing with soap at critical times: after defecating and before eating or preparing food. Hand-washing with soap can significantly reduce the incidence of diarrhoea, which is

the second leading cause of death amongst children under five years old. Majority of the households around 70% in all the villages, are aware of the importance of hand washing and wash their hands with soap, regularly. Majority of the surveyed households told that they wash their hands before and after the meal too.

Majority of the households in all the four villages do not use any disinfectant for cleaning the household. While it cannot be emphasized that the importance of disinfectants like phenyl etc., is useful for ensuring hygiene, the practice is yet to settle in these four villages. About 64 per cent households in Khandsa village, 58 per cent in Gurgaon village, 57 per cent in Badshahpur village and 53 per cent households do not use any disinfectant like phenyl etc., for keeping the home environment clean.

Ensuring Environmental Sanitation: It is widely acknowledged that inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. In the surveyed villages, outside the household premises, the first thing that the households are responsible is the disposal of garbage or household waste. Only a few of the surveyed households disposed their garbage on the streets and in open areas outside their homes, in empty plot of land, while the majority collected the waste within their household premises, in small bins. It was reported that the same is later collected by the municipal sweeper and disposed in the van carrying the solid waste for the landfill site. Most of the households in all the three villages responded that garbage is generally collected daily by the trash vans deputed by the Municipal Corporation of Gurgaon. However, as the GPS provided in the trash vans for better monitoring were not functional in some vans, drivers skipped the villages. This was complained by the residents and overall observation of the sanitation situation of the villages substantiates the fact.

Hygiene behaviours of the households in the surveyed villages are also in transition. The awareness level of the households on sanitation issues were found to be poor as in few households in all the four villages, wastewater from the homes were seen pouring out in the broken lanes. This needs no mention that this

waste water unless properly collected, treated and safely disposed off may lead to water clogging, blockage, pollution of water resources and cause environmental degradation. It is important for the community to realise that potholes in the streets, pools of stagnant water in the kutchha lanes, and waste gushing from bathrooms and kitchens provide breeding sites for malarial mosquitoes and other spreaders of disease.

Another basic requirement is the improvement in drainage system in these villages to ensure environmental sanitation. Open drains in these villages are the main collector of garbage and even though they are cleaned by the municipal sweepers, the sewage is transported back to the drains as the liquid waste is not removed by the municipal vans. Silting and frequent blockages of the drains with rubbish and construction debris in these villages are frequent phenomena. The foul smell of the drain pollutes the entire area and the presence of the drain reduces the usable width of the already narrow lanes. In combination with poor road and sanitation, open drainage in these urban villages presents a recipe for disaster which is always present and can erupt at any time and wreak havoc amongst the populations.

The general perception of more than half of the surveyed households in all the villages of Badshahpur, Kanhai, Khandsa and Gurgaon is that the area is in extremely bad condition and requires immediate attention. In young generation, more than half of surveyed households in all the four villages agree that sanitation condition is generally poor. The sanitation condition is affecting the education of school going kids as the streets leading to their school is generally muddy and filthy with waste water and children are unable to cross the filth even during the normal season.

Recommendations: Following three recommendations may be considered by the competent authorities for improving the situation in such urban villages.

1. Map the open drainage areas through GIS for better urban planning.
2. As ground water table in Gurgaon is at an alarming stage, the old wells and *bawaries* and open water sources may be protect-

ed and upgraded through the technique of Rainwater harvesting. This would enhance the ground water level and ensure continuous water supply as the practice of borewell digging will continue in this area.

3. For improving the behaviour of the community and thereby the sanitation situation of the area, the Municipal Corporation of Gurgaon under its cleanliness drive may use innovative techniques like engaging volunteers to act as watchdog, besides Information, Education and Communication (IEC) tools.

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ICT for farmers in Dry land Water Management: In-Field Water Harvesting for Sustainability

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Keywords: *In-field water harvesting, runoff calculation, annual precipitation, RWH sites, software (GUI)*

Abstract: The water harvesting and management in dryland is a regular practice. Use of modern technology for the same is discussed in this paper. The amount of water available in each field is calculated based on the precipitation, area, runoff coefficient. The runoff coefficient is highly influenced by the type of vegetation, slope and the soil of the location. Soil composition, soil texture and soil moisture affects runoff the most. The calculation is done based on the annual as well as event based precipitation. Few water harvesting sites have been proposed based on the farm size and potential drains generated using the DEM data. To fill the gap between the scientific outputs and the farmers adoptability, IT is integrated for designing GUI to provide better visualization of farm, surrounding area, potential drainage, amount of water available and type and size of cistern to store water. This software demonstrates the sustainable strategies for rainwater harvesting. It gives the complete idea about farm level rainwater harvesting. It is semi-automated software program for quantitative analysis of sustainable rainwater harvesting techniques.

I. Introduction

Population in dry lands of the world is increasing; more fresh water is required in order to meet the growing demands. To meet this challenging situation developing new technologies for identification of potential sites for rainwater harvesting (RWH) is an important step towards maximizing water availability in semi-arid areas.

Dry lands are typically defined as those areas of the world where the potential average yearly loss in the form of evapotranspiration (1500-2000mm/y) exceeds average yearly moisture gain in the form of precipitation (100-420mm/y). Rajasthan, which is located in the arid zone of India, has been the worst affected of drought. Around 26 million people of 23,406 villages in 26 (of the total 32 districts) of the state are affected. Livelihood security in parts of Rajasthan is strongly dependent on rainfall

distribution and land management practices among smallholder farmers. Depending upon the local environment conditions water harvesting provides supplementary supply, an alternative supply or the only feasible improved supply, especially in the rural areas of arid and Semi-Arid countries. The potential very much depends upon climate, hydrology, landscape and Vegetation.

In-Field Water Harvesting

In-Field approach to RWH has a high potential for improving land conservation. In-Field rainwater harvesting is a method of collecting surface runoff from a small catchment area.

The advantages of In-Field rainwater harvesting systems are:

- Simple design and cheap to install, therefore easily replicable and adaptable.

- Higher runoff efficiency than medium or large scale water harvesting systems; no conveyance losses.
- Erosion control function
- Can be constructed on almost any slope, including almost level plains.

The need for information in user friendly formats and which is easy to update, query, manage and utilize, has popularized the use of GIS in this field. So keeping in mind the requirement of the farmers of our country various efficient strategies have been proposed for locals who wants to harvest rainwater in a safe, productive, and sustainable way. It allows for the decentralized control and community management of water. The aim is to realize the maximum effectiveness for the least effort and cost. The study provides in spatial domains the expansive opportunities for RWH.

II. Study Area

Jodhpur and Barmer are among the most water insecure districts in the state. The contributing factors for this dismal scenario include non-existence of perennial rivers, erratic rainfall pattern and excessive salinity. The unpredictability of rainfall has badly affected agriculture production in most areas of the both districts and has resulted in a threat to the survival and livelihood of the rural population due to almost complete crop failure. Therefore, rainwater harvesting will meet twin objectives of long term water conservation and generation of extra income for farmer.

Fifty villages of Jodhpur and Barmer districts of Rajasthan state (Latitude: 27° 00' N, Longitude: 74° 00' E) of India was used to provide data for development, testing and validation. Study area is covering about 18375.26 km² area. Latitudes and longitudinal extend of Jodhpur are 26° 18' N, 73° 04' E and Barmer are 25° 45' N, 71° 25' E. Thirty four villages of tehsil Luni in district Jodhpur and sixteen villages of tehsil Pachpadra in district Barmer were selected based on potential of rainwater harvesting.

There are scattered open Hills and sand dunes in the north, west and south. The average height of the district above the mean sea level is between 250-300 meters. The general slope is towards the West. Soil type is mainly sandy

and the weather is dry. The groundwater table levels runs very deep and with scanty rainfall.

III. Role of Earth Observation and GIS

Remote Sensing information is used to derive latest land cover, slope and terrain conditions; to prepare the land use/ land cover and geomorphology of study area which was needed for runoff estimation using GIS. Soil maps are required for identification of soil type. Amount of runoff generated depend upon size of the soil particle. Infiltration rate is high in coarser soil particles like sand and loam as compared to fine soil particles like clay. Therefore the volume of runoff generated varies according to soil type of an area.

Daily rainfall data from year 1998 to 2011 is used to study rainfall pattern in study area. Rainfall is required to compute runoff generated from individual fields. The knowledge of rainfall characteristics (intensity and distribution) for a given area is one of the pre-requisites for designing a water harvesting system. Runoff volume estimation was done using the complete database from the Access sheets and GIS derived output. The GIS derived output was obtained by after merging the curve number map and village map with field boundaries. These combinations were used as input with rainfall data for runoff estimation.

DEM is used for delineation of the drainage for the whole area, slope and the determination of lowest point in agricultural fields. Lowest points are required to identify site for construction of water harvesting structure. Slope identifies the rate of maximum change in Z value from each cell. For each cell, slope calculates the maximum rate of change in value from selected cell to its neighbours. Slope classes were generated. The slope map was merged with the village shapefile. It identifies the steepest downhill slope for a location on a surface. The slope gradient of the drainage line is a key factor for the selection of water harvesting locations in order to get the maximum storage capacity in the channel. It also affects the amount of runoff. Basically, the maximum change in elevation over the distance between the cell and its eight neighbours identifies the steepest, downhill descent from the cell.

GIS was useful in preparing the primary data which involved the village boundaries

for each village. The cadastral maps for some villages of Luni and Pachbadhra district were obtained from settlement office, Jodhpur. Cadastral Maps were digitized at a scale of 1:4000.

IV. Methodology

A. Calculation of Runoff Coefficient:

The runoff coefficient, C , is a dimensionless ratio intended to indicate the amount of runoff generated by a watershed given an average intensity of precipitation for a storm. The intensity of runoff is proportional to intensity of rainfall; calibration of the runoff coefficient has almost always depended on comparing the total depth of runoff with the total depth of precipitation,

$$C = R/P$$

Where: R = Total depth of runoff (L), and P = Total depth of precipitation (L). The runoff coefficient represents the fraction of rainfall converted to runoff.

Amount of rainwater harvested can be calculated based on:

B. Based on Annual Rainfall:

The formula for the calculation of total amount of rainwater available that can be harvested is:

$$\text{Rainwater Harvested (L)} = \text{Annual rainfall (mm)} \times 0.8 \times \text{Area (sq.-m)} \times \text{Runoff coefficient}$$

Annual rainfall is the total amount of rainfall that an area receives in a year. Here we calculate the volume of rainwater that can be harvested in a year. During the rainfall in the initial phase some of the water goes as soil moisture & seepage and after that runoff begin depending upon intensity of rain. This runoff factor depends on various factors like the type & size of catchment, the slope, land use, the soil characteristics, the texture of soil, its depth etc. Based on these factors run off coefficient is decided as per field observations in an area. This runoff coefficient is a dimensionless figure and can be estimated from the individual field data.

On the basis of Table -1 below, the runoff coefficient factor is decided (Murthy, 2003; CGWB, 2007). These coefficients have been adjusted for the agricultural land (no crop, early crop and late crop) and considering the soil factors:

- Soil Compaction
- Crop Canopy
- Stored Soil Moisture and Soil Infiltration

This coefficient is multiplied with the annual rainfall (mm) and the drainage area (sq-m),

Table 1. Values of Runoff Coefficient Factor (C) for different Soil Conditions

Type of Vegetation	Slope Range (%)	Runoff Coefficient (C)		
		Coarse(Sand, Loamy Sand, Sandy Loam)	Medium (Silty Loam, Loam, Silt, Sandy Clay Loam, Clay Loam, Silty Clay Loam)	Fine (Sandy Clay, SiltyClay,Clay)
Dense scrub	0-2	0.1	0.3	0.4
	2-5	0.1	0.3	0.4
	5-10	0.16	0.35	0.50
Open scrub/Open land	0-2	0.10	0.30	0.40
	2-5	0.10	0.30	0.40
	5-10	0.25	0.36	0.55
Agricultural Land (No crop)	0-2	0.28	0.47	0.58
	2-5	0.30	0.50	0.60
	5-10	0.40	0.60	0.70
Agricultural Land (early crop Stage)	0-2	0.17	0.31	0.33
	2-5	0.20	0.33	0.37
	5-10	0.30	0.39	0.40
Agricultural land (late crop stage)	0-2	0.24	0.38	0.40
	2-5	0.25	0.42	0.45
	5-10	0.35	0.48	0.50

which gives the estimate of the amount of water (L) that can be harvested in that particular area. We assume that around 20 per cent of water is loss due to various factors like evaporation, seepage etc.

The runoff coefficient depends on different factors as:

- a) Type of vegetation of the area
- b) Slope Range (%) and
- c) Soil texture

The coefficient is based on two years' experience at the pilot site, the intensity of rain observed and last ten years daily rainfall data of the area (Table 1).

C. Based on Event Rainfall:

The amount of water that can be harvested in a particular event/day is:

Rainwater Harvested (L) = Rainfall (mm) × R factor from Table 2 × Area (sq.-m) × Runoff coefficient

This concept takes the last 48 hrs.rainfall and particular day intensity of rainfall. Table 2 shows R factor of amount of rainfall occurrence.

Table 2. Rainfall factor values for different intensity rainfall

Intensity of rainfall (mm)	No wetness (Last 48 hrs. < 20 mm rainfall)	Wetness (Last 48 hrs.>20 mm rainfall)
<20	0.10	0.20
20-30	0.40	0.60
>30	0.50	0.80

V. Identification of potential RWH sites:

Aster data have sinks and peaks which are often errors due to the resolution of the data or rounding of elevations to the nearest integer value. Using fill tool all sinks and peaks in Aster data are filled.

Fill = <input raster> <output raster>

The function iterates until all sinks within the specified Z limit are filled. As sinks are filled, others can be created at the boundaries of the filled areas, which are removed in the next iteration. Sinks is filled to ensure proper delineation of flow accumulation. If the sinks are not filled, a derived drainage network may be discontinuous.

Then correct Aster is used as input to flow direction. The direction of flow is determined by the direction of steepest descent from each cell. This is calculated as change in z-value / distance * 100

Flow direction = <input_fill> <output_name>

The distance is calculated between cell centers. Therefore, if the cell size is 1, the distance between two orthogonal cells is 1, and the distance between two diagonal cells is 1.414 if the descent to all adjacent cells is the same. The Neighborhood is enlarged until a steepest descent is found. If all neighbors are higher than the processing cell, it will be considered noise, filled to the lowest value of its neighbors, and have a flow direction toward this cell. The output of flow direction is used in flow accumulation.

Flow Accumulation tool determine how much rain has fallen within a given watershed. The output of Flow Accumulation would then represent the amount of rain that would flow through each cell, assuming that all rain became runoff and there was no interception, evapotranspiration, or loss to groundwater. Finally a Con operation is used to extract drainage.

Drainage = Con (Flow accumulation > 75, 1, 0)

Final drainage extracted from Aster data is used to identify the lowest point for construction of rainwater harvest structure. Site shape file was digitized as point feature using derived drainage for all the villages in study area.

VI. Development of IT based tools for facilitating farmers

The use of IT provides a powerful, efficient and effective mechanism to offer rainwater harvesting planning in a way that is simple to use and has low investment requirements. A desktop based application is made for the user with basic hardware and software requirements.

This software demonstrates the sustainable strategies for rainwater harvesting. It gives the complete idea about farm level rainwater harvesting. It is semi-automated software program for quantitative analysis of sustainable rainwater harvesting techniques. This software is farmer centric hence it has extremely intuitive GUI.

The software module displays the village wise cadastral fields. The drainage map is overlaid on the fields for the user to identify the slope and lowest point in the field. The farmer has the option to see the drainage map on the field by turning off / on check box at any point of time. This will typically be the site where most of the rainwater falling on his field will converge and may serve as the site for construction of rainwater storage tank.

The software has been designed to calculate amount of In-Field Rainwater Harvesting Potential based on site/field conditions like the rainfall intensity, current land use, slope etc. The farmer provides input regarding his village name, type of vegetation and slope by making selection in dropdown box. As the user farmer selects any village from the combo box, the map is zoomed to that village and the name of the village as label appears on the screen. Various tools are provided to make map interactive. Software assists in identification of corresponding field by highlighting field on satellite imagery and cadastral shape file.

VII. Results

The volume of rainwater harvested can be calculated annually or event based. This numerical value is the excess of rainwater that can be harvested. The value is obtained by considering all the factors that affects the runoff. There are many factors like soil seepage, slope range, vegetation, amount of rainfall and soil infiltration rate. The combined effect of all these factors is taken into account and the runoff is calculated. Soil texture map can also be overlaid on the fields for runoff calculation. The purpose of the application is to get an estimate of the amount of excess of rainwater that can be stored into the desired structures.

Annual Based:

Based on the input provided by the user with respect to slope, vegetation and soil characteristics the runoff coefficient is calculated and multiplied with the annual rainfall (mm) and the drainage area (sq-m), which gives the estimate of the amount of water (L) that can be harvested in that particular area. We assume that around 20 per cent of water is lost due to various factors like evaporation, seepage etc.

Event Based:

In addition to the input parameters like slope, vegetation and soil characteristics, last two days rainfall (48 hours) and particular day intensity of rainfall is also provided to calculate the runoff coefficient and estimate of the amount of water (L) that can be harvested in that particular area.

Total Volume is calculated independent of the event selected. Total volume is the total rainfall an area receives without any prior losses. It is basically calculated by just multiplying the rainfall value to the area, will give the total volume of rainfall an area receives. The percentage of rainwater harvested of total volume of Rainfall is displayed as result.

A. Size and Type of Cistern

Water consumption in a house is throughout the year and water availability from rainfall is for a limited period restricted to number of rainy days in a year. To make rainwater available in non-rainy days, storage device need to be designed with an optimum capacity to suit the need / requirement. Optimum size of the storage device and cost effective methods to store water are the key issues for viable rainwater harvesting system. The storage structures may vary from permanent masonry tanks, Ferro-cement tanks to plastic or metal tanks. The capacity of storage structure can be decided by considering parameters such as catchment area like surface runoff etc. water usage and space availability.

B. Tank size and type calculation:

There are three tank types calculators viz., circular, rectangular and Trapezoidal depending upon the amount of water and utilisation, site suitability and choice of the farmer.

1. Circular Tank: It is basically suitable for collection of small amount of water and sandy areas.

Circular Tank Volume:

$$\text{Volume} = \pi * r * r * h$$

Where

$\pi = 3.142$, r = Radius, h = Height of the cylinder

2. Rectangular Tank: It is basically suitable in areas with stones.

Rectangular Tank Volume

$$\text{Volume} = L * w * h$$

Where: L = Length, w = Width, h = Height

3. Trapezoidal Tank: These structures are used to impound larger runoff volumes from a larger area. It is simple to design and construct and requires minimum maintenance. They are basically used to grow annual crops in dry areas. All those crops which are drought tolerant like sorghum are preferred as it can withstand temporary water logging.

Trapezoidal Tank Volume

$$\text{Volume} = \frac{1}{2} (L*b_1 + L*b_2) * h$$

Where: b₁ = Base 1, b₂ = Base 2, L = Length, h = Height

Side Slopes are based on the angle of repose of the soil. Side slope considered for different soil types are: Loam: 1.5:1(horizontal to vertical), Sand: 2:1(horizontal to vertical)

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Morphometric Analysis of Rupangarh Watershed in Ajmer District Using Spatial Information Technology

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Abstract: Morphometric analysis is quantitative description and analysis of landforms as practiced in geomorphology that may be applied to a particular kind of landform or to drainage basins and large regions generally. Spatial information technology (SIT) has proved to be an efficient tool in delineation of drainage pattern and overcome most of the problems of land and water resources planning and management on the account of usage of conventional methods of data process. The study area covers Rupangarh watershed in Ajmer district, which is drained by Rupangarh Nadi. The total area it covers is 515 sq km. The drainage network was delineated using Remote sensing data-Landsat-8 (May 2013) on 1:50,000 scale and SOI toposheets were used as reference data. GIS and image processing techniques have been adopted for the identification of morphological features and analyzing the properties of Rupangarh watershed. The morphometric parameters such as linear and aerial aspects of the watershed were determined and computed, maximum order observed is 7. The study mainly focuses on the quantitative analysis of morphometric parameter, which is of immense utility in river basin evaluation, watershed prioritization for soil and water conservation and natural resource management at micro level. This study would help the local people to utilize the resources for sustainable development of the watershed area.

Introduction

The measurement and mathematical analysis of the configuration of the earth's surface shape, and dimension of its landforms is called morphometry. Evaluation of the morphometric parameters requires preparation of drainage map, contour map, ordering of the various streams and measurements of catchment area, perimeter, relative relief, relief ratio, length of drainage channels, drainage density, drainage frequency, bifurcation ratio, texture ratio, circulatory ratio and constant channel maintenance, which help to understand the nature of the drainage basin. The present study involves the Geographic Information System (GIS) analysis techniques to evaluate and compare linear, relief and aerial morphometry of Rupangarh Watershed.

Remote Sensing and GIS techniques have been proved to be efficient tools in the delineation, updating and morphometric analysis of drainage basin. The present study incorporates a morphometric analysis of Rupangarh watershed, Ajmer district using remote sensing and GIS techniques. The morphometric parameters of the sub-basins are classified under linear, areal and relief

aspects. The drainage pattern exhibited by the study area shows a dendritic pattern indicating homogenously underlain material while the mean bifurcation ratio values suggest that the geological structures are not disturbing the drainage pattern.

GIS and Remote Sensing have proved to be an indispensable tool in morphometric analysis. The identification of morphometric properties based on a geographic information system (GIS) was carried out in 10 sub watershed of Ajmer district. GIS generated more precise data on morphometric parameters (Srivastava, 1997, Agarwal, 1998, Nag, 1998, Das and Mukherjee, 2005) and concluded that remote sensing has emerged as a powerful tool and useful in analyzing the drainage morphometry.

The objective of the present study is to analyze the morphometric attributes of Rupangarh Nadi, Ajmer district.

The study area Rupangarh Watershed is part of Ajmer district. The Geographic location is 26° 79' latitude and 74° 85' longitude. It belongs to Ajmer division (Fig. 1). It is located 49 KM towards North from District head quarters Ajmer, 29 KM from Kishangarh (Rural), 113 KM from State capital Jaipur.

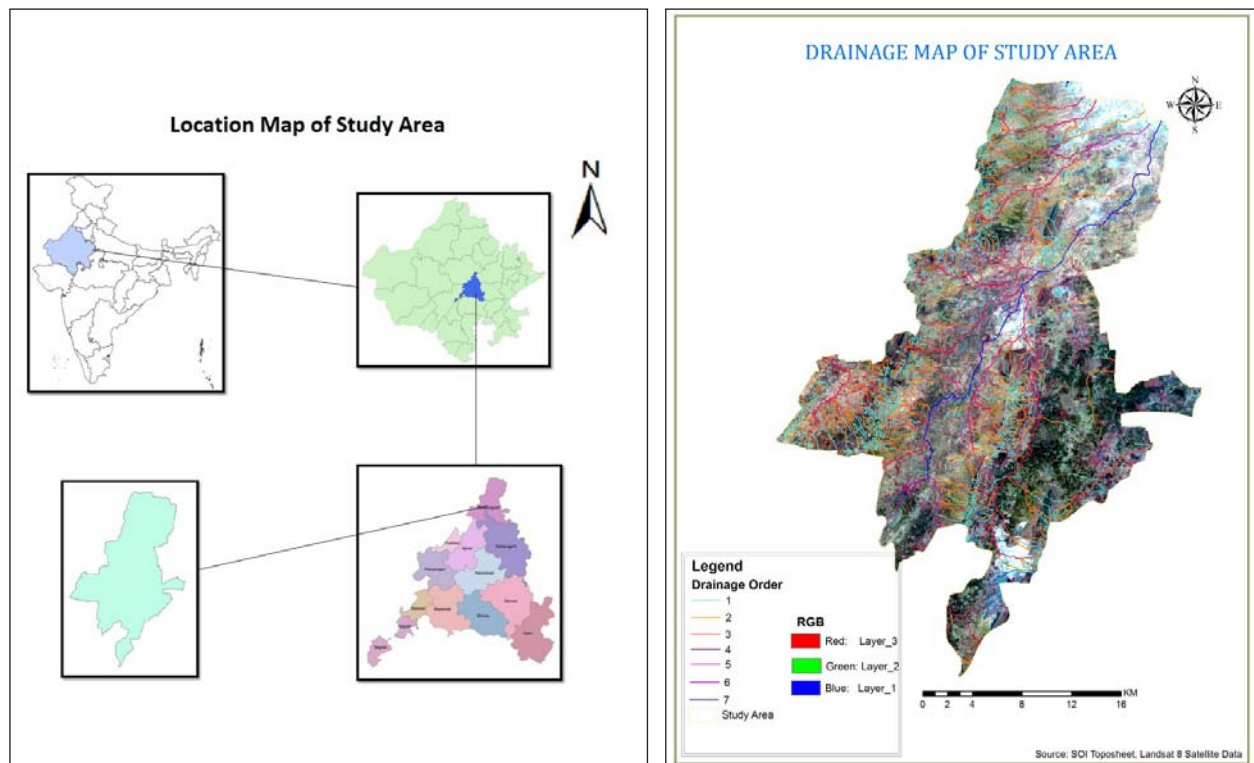


Fig. 1.

Mean annual rainfall (1987-2006) of the Roopangarh is 453.2 mm whereas normal rainfall (1901-70) is lower than average rainfall and placed at 433.8. Roopangarh has a hot semi-arid climate with over 55 centimeters (25.4 in) of rain every year but most of the rain occurs in the Monsoon months, between June and September. During this time temperature drops dramatically and stands at low teens. The low, on the other hand, drops below double digits as January, the coldest month of the year, gets 7°C of average low temperature. Monsoon comes in August and lasts till October. The season offers a moderate level of rainfall with the average contribution of 50 cm. The eastern portion of the Roopangarh is generally flat, broken only by gentle undulations. The western parts, from north-west to south-west, are intersected by the Aravalli Range. Many of the valleys in this region are sandy deserts, part of India's Thar Desert, with an occasional oasis of cultivation., some fertile tracts are also present.

Methodology

In the present study, the maps showing drainage details (Fig. 2) have been prepared from digital data of Landsat 8 PAN merged May 2013 data. These satellite images have

been geo-referenced and merged using Image Processing software ERDAS IMAGINE (9.3) and the thus merged data were used in the

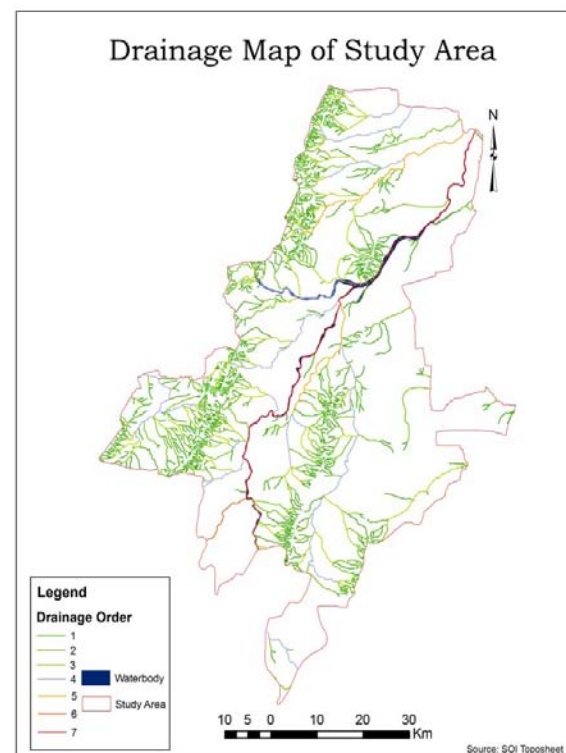


Fig. 2

study. The drainage have been delineated using merged satellite data of Geocoded FCC of bands 2, 3, 4 on the 1:50000 scale and SOI toposheets have been used as a reference. GIS software like Arc Map has been used for digitization

and computational purpose and also for output generation.

In present study the morphometric analysis is carried out using mathematical formulae given in Table 1.

Table 1 Methodology adopted for computation of morphometric parameters

S.No	Morphometric Parameters	Formula	Reference
1	Stream Order	Hierarchical rank	Strahler (1964)
2	Stream Length (Lu)	Length of the stream	Horton (1945)
3	Mean Stream Length (Lsm)	$L_{sm} = L_u / N_u$ Where, L_{sm} = Mean Stream Length L_u = Total stream length of order 'u' N_u = Total no. of stream segments of order 'u'	Strahler (1964)
4	Stream Length Ratio (RL)	$RL = L_u / L_{u-1}$ Where, RL = Stream Length Ratio L_u = Total stream length of order 'u' L_{u-1} = Total stream length of its next lower order	Horton (1945)
5	Bifurcation Ratio (Rb)	$R_b = N_u / N_{u+1}$ Where, R_b = Bifurcation Ratio N_u = Total no. of stream segments of order 'u' N_{u+1} = Number of segments of the next higher order	Schumm (1956)
6	Mean bifurcation ratio (Rbm)	R_{bm} = Average of bifurcation ratios of all orders	Strahler (1957)
7	Relief Ratio (Rh)	$R_h = H / L_b$ Where, R_h = Relief Ratio H = Total relief (Relative relief) of the basin in Kilometer L_b = Basin length	Schumm (1956)
8	Drainage Density (D)	$D = L_u / A$ Where, D = Drainage Density L_u = Total stream length of all orders A = Area of the basin (km ²)	Horton (1932)
9	Stream Frequency (Fs)	$F_s = N_u / A$ Where, F_s = Stream Frequency N_u = Total no. of streams of all orders A = Area of the Basin (km ²)	Horton (1932)
10	Drainage Texture (Rt)	$R_t = N_u / P$ Where, R_t = Drainage Texture N_u = Total no. of streams of all orders P = Perimeter (km)	Horton (1945)
11	Form Factor (Rf)	$R_f = A / L_b^2$ Where, R_f = Form Factor A = Area of Basin (km ²) L_b^2 = Square of Basin length	Horton (1932)
12	Circularity Ratio (Rc)	$R_c = 4 \pi A / P^2$ Where, R_c = Circulatory Ratio π = 'Pi' value i.e. 3.14 A = Area of the Basin (km ²) P = Perimeter (km)	Miller (1953)
13	Elongation Ratio (Re)	$R_e = 2 \sqrt{A / \pi} / L_b$ Where, R_e = Elongation Ratio A = Area of the Basin (km ²) π = 'Pi' value i.e. 3.14 L_b = Basin length	Schumm (1956)
14	Length of overland flow (Lg)	$L_g = 1 / D^2$ Where, L_g = Length of overland flow D = Drainage Density	Horton (1945)
15	Constant Channel Maintenance (C)	$C = 1 / D$	Schumm (1956)

Result and Discussion

The present study emphasizes the use of satellite Remote Sensing for morphometric analysis and the results are discussed below-

Morphometric Analysis

Morphometry is the measurement and mathematical analysis of the configuration of the Earth's surface, shape and dimensions of its landforms (Clarke, 1966). This analysis can be achieved through measurement of linear, aerial and relief aspects of basin and slope contributions (Nag and Chakraborty, 2003). The present study integrated the use of remote sensing in morphometric analysis and the results of morphometric parameters have been determined are discussed and briefly described. The study of basin morphometry attempts to relate basin and stream network geometries to the transmission of water and sediment through the basin. The size of a drainage basin acts upon the amount of water yield, the length,

shape and relief, affect the rate at which water is discharged from the basin and total yield of sediments, the length and character for stream transport and rate at which water and sediments are discharged.

Linear Aspect

Stream order, stream length, mean stream length, stream length ratio and bifurcation ratio are linear aspect that was determined and result has been given in table 2.

Stream Order

The designation of stream orders is the first step in drainage basin analysis and is based on a hierarchic ranking of streams. In the present study, ranking of streams has been carried out based on the method proposed by Strahler (1994). The order wise stream numbers, area and stream lengths of the 10 sub-watersheds. Out of these sub-watersheds, Sursara-II has 2 order, Harmara has 3, Karkeri has 4, Sursara-I

Table 2: Results of Morphometric Analysis of 10 sub-watersheds of Rupangarh watershed Ajmer District.

S No.	SWSD Name	Stream Order	Basin Area (km ²)	Stream Order							Stream Length in km (Lu)							Perimeter (P) (km)	Basin Length (km)
				I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII		
1	Nosal	V	118.76	276	86	19	4	1	—	—	106.04	57.76	30.33	21.39	18.30	—	—	49.73	19.79
2	Sinodiya	VII	104.14	67	24	1	—	1	—	1	34.65	23.74	0.60	—	2.06	—	18.16	83.74	18.36
3	Paner	VII	59.54	93	34	16	3	1	—	1	46.91	33.21	18.36	9.27	1.29	—	3.34	38.10	13.37
4	Kalyanpura	VII	36.27	92	28	9	1	—	—	1	33.00	8.64	11.40	12.82	—	—	2.11	36.84	10.09
5	Karkeri	IV	50.81	187	80	23	16	—	—	—	80.88	40.47	30.45	11.86	—	—	—	31.07	12.22
6	Kuchil	VII	97.53	147	39	10	8	1	2	1	57.39	39.48	19.91	9.78	0.17	10.50	20.35	75.00	17.69
7	Salemabad	VII	46.53	76	46	8	2	1	—	1	41.04	30.57	9.44	6.05	7.25	—	0.51	35.63	11.62
8	Sursara-I	V	119.84	153	53	14	8	1	—	—	73.39	40.37	16.53	29.34	1.54	—	—	73.04	19.89
9	Sursara-II	II	31.58	11	4	—	—	—	—	—	10.29	6.06	—	—	—	—	—	26.22	9.32
10	Harmara	III	38.53	16	4	4	—	—	—	—	10.73	3.27	9.04	—	—	—	—	29.04	10.44

S No.	SWSD Name	Bifurcation Ratio (Rb)						Mean Bifurcation Ratio (Rbm)	Drainage Density (D) (km/km ²)	Stream Frequency (Fs)	Form Factor (Rf)	Circularity Ratio (Rc)	Length of overland Flow (Lg)
		I/II	II/III	III/IV	IV/V	V/VI	VI/VII						
1	Nosal	3.20	4.52	4.75	4	-	-	4.11	1.97	3.25	0.30	0.60	0.25
2	Sinodiya	2.79	24.0	-	-	-	-	13.40	0.76	0.90	0.31	0.19	0.66
3	Paner	2.74	2.13	5.33	3	-	-	3.30	1.89	2.49	0.33	0.52	0.26
4	Kalyanpura	3.29	3.11	9.00	-	-	-	5.13	1.87	3.61	0.36	0.34	0.27
5	Karkeri	2.33	3.47	1.43	-	-	-	2.41	3.22	6.02	0.34	0.66	0.16
6	Kuchil	3.76	3.90	1.25	8	0.5	2	3.24	1.62	2.13	0.31	0.22	0.31
7	Salemabad	1.65	5.75	4.00	2	-	-	3.35	2.04	2.88	0.34	0.46	0.25
8	Sursara-I	2.88	3.78	1.75	8	-	-	4.10	1.34	1.91	0.30	0.28	0.37
9	Sursara-II	2.75	-	-	-	-	-	2.75	0.52	0.47	0.36	0.58	0.97
10	Harmara	4.00	1.00	-	-	-	-	2.50	0.60	0.62	0.35	0.57	0.84

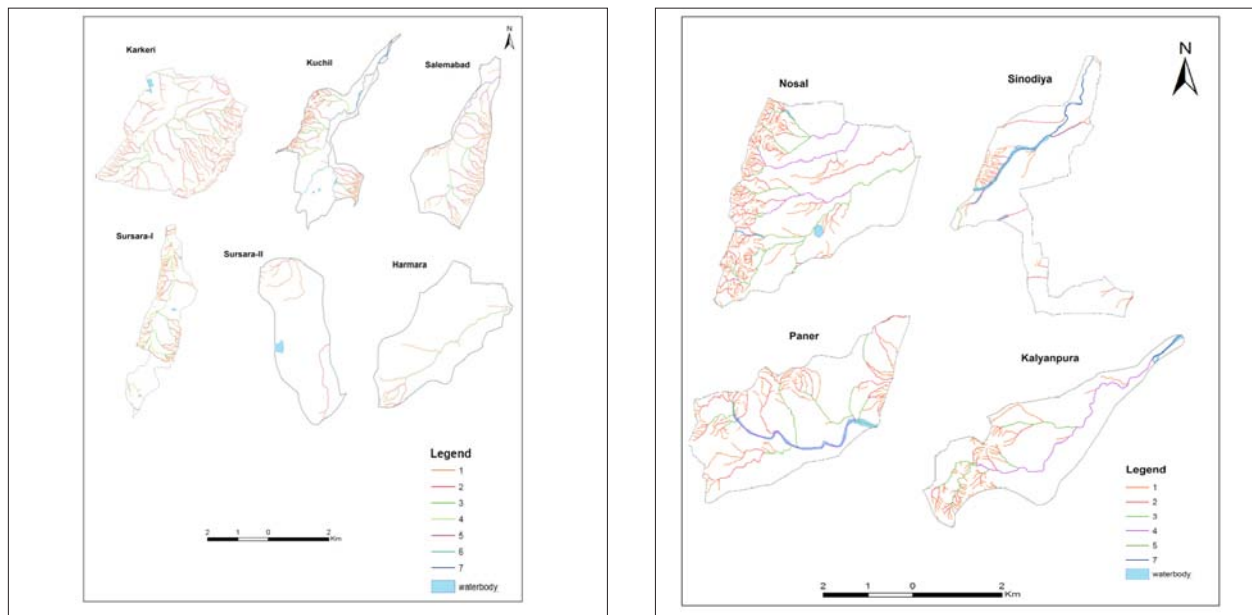


Fig. 3. Stream order in different sub-watersheds.

Nosal have 5, and Sinodiya, Paner, Kalyanpura, Kuchil, Salemabad have 7 order drainage (Fig. 3).

Stream length

The number of stream of various orders in a sub-watershed is counted and their lengths from mouth to drainage divide are measured with the help of GIS software.

The stream length has been computed based on the law proposed by Horton (1945) for all the 10 sub-watersheds. Generally, the total length of stream segments is maximum in first order streams and decreases as the stream order increases.

Mean stream length

According to Strahler (1964), the mean stream length is a characteristics property related to the drainage network and its associated surfaces. The mean stream length has been calculated by dividing the total stream length of order 'u' and number of streams of segment of order 'u' maximum stream length has been observed in Kuchil sub- watershed having 20.35 km in 7th order.

Stream Length Ratio

Stream length ratio may be defined as the ratio of the mean length of the one order to the next lower order of stream segment. Horton's

law (1945) of stream length states that mean stream length segments of each of the successive orders of a basin tends to approximate a direct geometric series with streams length increasing towards higher order of streams. The RL between streams of different order in the study area reveals that there is a variation in RL in each sub-watershed. This variation might be due to changes in slope and topography. Nosal, Kalyanpura, Salemabad sub-watersheds show an increasing trend in the length ratio from lower order to higher order indicating their mature geomorphic stage whereas in remaining sub-watersheds, there is a change from one order to another indicating their late youth stage of geomorphic development.

Bifurcation Ratio

The term bifurcation ratio (Rb) may be defined as the ratio of the number of the stream segments of given order. Horton considered the bifurcation ratio as an index of relief and dissection ratio shows a small range of variation for different regions or for different environment except where the powerful geological control dominates. It is observed from table 2; the Rb is not same from one order to its next order. These irregularities are dependent upon the geological and lithological development of the drainage basin (Strahler, 1964). The lower values of Rb are characteristics of the sub-watersheds which have suffered

less structural disturbance and the drainage patterns has not been distorted because of the structural disturbance. In the present study, the higher values of Rb indicates strong structural control on the drainage pattern while the lower values indicative of sub-watersheds that are not affected by structure disturbances.

The mean bifurcation ratio (Rbm) may be defined as the average of bifurcation ratios of all orders (Table 1). In the present case, Rbm varies from 2.41 to 13.40 and all sub-watersheds fall under normal basin category (Strahler, 1957).

Relief Aspect

The relief measurements like relief ratio, basin length and total relief are tabulated.

Relief Ratio

The elevation difference between the highest and lowest points on the valley floor of a sub-watershed is known as the total relief of that sub-watershed. The relief ratio (Rh) of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principle drainage line is termed as relief ratio (Schumm, 1956) (Table 1). According to him, there is direct relationship between the relief and channel gradient. There is also a correlation between hydrological characteristics and the relief ratio of a drainage basin. The Rh normally increases with decreasing drainage area and size of sub-watersheds of a given drainage basin.

Aerial Aspect

Different morphometric parameters like drainage density, texture ratio, stream frequency, form factor, circularity ratio, elongation ratio and length of overland flow have been discussed in detail and are presented in Table 2.

Drainage Density

Horton (1932) has introduced drainage density into American hydrologic literature as an expression to indicate the closeness of spacing of channels. It is defined as the total length of streams of all orders per drainage area.

Langbein (1947) recognized the significance of D as a factor determining the time of travel

by water and he also suggested a drainage density varying between 0.55 and 2.09 km/km² in humid region with an average density of 1.03 km/km². Density factor is related to climate, type of rocks, relief, infiltration capacity, vegetation cover, surface roughness and run-off intensity index. Of these only surface roughness has no significant correlation with drainage density. The amount and type of precipitation influences directly the quantity and character of surface run-off. An area with high precipitation such as thundershowers loses greater percentage of rainfall as run-off resulting in more surface drainage lines. Amount of vegetation and rainfall absorption capacity of soils, which influences the rate of surface run-off, affects the drainage texture of an area. The similar condition of lithology and geologic structures, semi-arid regions have finer drainage density texture than humid regions. According to Nag (1998), low drainage density generally results in the areas of highly resistant or permeable subsoil material, dense vegetation and low relief. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.

The drainage density varies between 0.52 to 3.22 km/km² indicating low drainage density. In the present case, it is suggested that this low drainage density indicates the region has highly permeable subsoil and dense vegetative cover.

Stream Frequency

Horton (1932) introduced stream frequency (Fs) or channel frequency which is the total number of stream segments of all orders per unit area (Horton, 1932) (Table 1). Hypothetically, it is possible to have the basin of same drainage density differing in the stream frequency and basins of same stream frequency differing in drainage density.

Table 2 shows Fs for all sub-watersheds of the study area. It is noted that study area exhibits positive correlation (R=0.97) with the drainage density values indicating the increase in stream population with respect to increase in drainage density.

Drainage Texture

Drainage texture (R_t) is one of the important concepts of geomorphology which means that the relative spacing of drainage lines. Drainage lines are numerous over impermeable areas than permeable areas. According to Horton (1945), R_t is the total number of stream segments of all orders per perimeter of that area (Table 1). He recognized infiltration capacity as the single important factor which includes drainage density and stream frequency. Smith (1950) has classified drainage density into five different textures. The drainage density less than 2 indicates very coarse, between 2 and 4 is related to coarse, between 4 and 6 is moderate, between 6 and 8 is fine and greater than 8 is very fine drainage texture. In the present study, the drainage density (Table 2) is above 8 indicating very fine drainage texture.

Form Factor

According to Horton (1932), form factor (R_f) may be defined, as the ratio of basin area to square of the basin length (Table 1). The value of form factor would always be more than 0.7854 (for a perfectly circular basin). Smaller the value of form factor, more elongated will be the basin. From Table 2, it is observed that the R_f varies between 0.30 (Nosal sub-watershed) and 0.36 (Sursara-II sub-watershed). Thus indicates all the sub-watersheds are elongated in shape and suggests flatter peak flow for longer duration

Circularity Ratio

It is the ratio of the area of basin to the area of a circle having the same circumference as the perimeter of the basin (Miller, 1953) (Table 1). The circularity ratio is influenced by the length and frequency of streams, geological structures, and land use/land cover, climate, relief and slope of the basin. In the present study, the R_c (Table 2) ranges from 0.19 to 0.66. High R_c 0.66 in Karkeri sub watershed and 0.60 in Nosal sub-watershed indicates that they are more or less circular and are characterized by high to moderate relief and drainage system is structurally controlled.

Elongation Ratio

Schuman (1956) defined elongation ratio (R_e) as the ratio between the diameter of the circle of the same area as the drainage

basin and the maximum length of the basin (Table 1). A circular basin is more efficient in the discharge of run-off than an elongated basin (Singh and Singh, 1997). The values of R_e generally vary from 0.62 to 1.0 over wide variety of climatic and geologic types. Values close to 1.0 are typical of regions of very low relief, whereas values in the range of 0.6-0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped into four categories namely (a) circular (>0.9), (b) oval (0.9 to 0.8), (c) less elongated (<0.7). The R_e of sub-watersheds of the study area varies from 0.62 to 0.68 (Table 2), indicating sub-watersheds to be elongated with high relief and steep slope.

Length of overland flow

It is the length of water over the ground before it gets concentrated into definite stream channels (Horton, 1945) (Table 1). This factor basically relates inversely to the average slope of the channel and is quite synonymous with the length of sheet flow to a large degree. The length of overland flow (L_g) approximately equals to half of the reciprocal of drainage density (Horton, 1945). Table 2 reveals that the L_g is less in Karkeri (0.16) sub-watershed as drainage density is high. The computed value of L_g for all sub-watersheds varies from 0.16 to 0.97.

Conclusion

Remote Sensing and GIS have proved to be efficient tool in drainage delineation and updation in the present study and these updated drainage have been used for the morphometric analysis. The morphometric analysis of the drainage network of all 10 sub-watersheds exhibits the dendritic to sub dendritic drainage pattern and the variation in the stream length ratio might be due to changes in slope and topography. It is also concluded from the study that the study area exhibits positive correlation ($R=0.97$) with the drainage density values indicating the increase in stream population with respect to increase in drainage density.

The variation in values of bifurcation ratio among the sub-watersheds is ascribed to the difference in topography and geometric development. The stream frequencies for all the sub-watersheds of the study area exhibits

positive correlation ($R=0.97$) with the drainage density values indicating the increase in stream population with respect to increase in drainage density.

Drainage density of the region has highly permeable subsoil and dense vegetative cover and has very fine drainage texture. Elongation ratio shows that sub-watersheds are elongated with high relief and steep slope.

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GIS Based Decision Support System of *Spodoptera litura* (Fabricius) (Noctuidae: Lepidoptera) in Soybean

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Abstract: The GIS based decision support system (DSS) enables farmers to follow the proper management practices when the conditions are favorable for pest infestation. Thus the growers can protect their crops by taking action in time in one hand and avoid unnecessary sprays on the other which minimizes the cost of crop protection and protect the environment. A new computerized decision support system has been developed to predict the pest infestation of *Spodoptera litura* (Fabricius) (Noctuidae: Lepidoptera) in soybean using weather based prediction rule. The weather parameters used were maximum temperature (25-28°C), minimum temperature (>19.5), morning relative humidity (>90), evening relative humidity (78-83%) and rainfall (<20 mm). Prediction criteria (severe, moderate or low) were developed based on satisfaction of number of weather parameters mentioned above. The hourly weather data were fetched in real time from the automatic weather stations of IMD. A weather database-driven decision support system was developed using html Image-map (WYSIWYG) technology, server side programming language (PHP), Google map Java Script API and an open-source relational database management system (MySQL) database server. The field trials was validated the DSS during the past kharif season of 2012-13. The infestation of *spodopetra litura* was correctly predicted for soybeans crop in the IARI farm. The web enabled DSS to be implemented for forecasting the pest infestation in field.

Introduction

Soybean (*Glycine max*) is one of the major oilseed crops of India having first rank in both the area and production accounting 37 percent and 40 percent share respectively (Anonymous, 2012). India contributes approximately 51 per cent share to the total area under soybean cultivation in Asia and 10 per cent of the world, while its production share in Asia and the world are estimated as 42 per cent and 5 per cent respectively (FAO, 2012). The major yield loss in soybean crop is due to various insect pests. Out of them tobacco caterpillar, *Spodoptera litura* (Fabricius) is one of the serious defoliators of soybean. It reduces crop value both quantitatively and qualitatively.

The crop pest forewarning system helps agriculturist to identify the severity level of pest population on soybean using weather data in a crop season. It helps planner and grower to protect the crop by taking timely and appropriate management practices in

one hand and avoid unnecessary sprays of pesticides on the other hand. The reduction of sprays of harmful chemicals ultimately leads to economic gain and environment protection. Meteorological factors play an important role in abundance; distribution and population build up of *Spodoptera litura* in soybean crop. It is difficult to find a direct cause and effect relationship between any single factor and pest activity because the impact of meteorological factors on pests is usually compounded (Harinkhree *et al.*, 1998).

Each pest has a threshold temperature such as lower threshold and upper threshold temperature. The development of pest below lower threshold and above the upper threshold is zero. The middle range of lower and upper threshold pest has high development these range of temperature is called congenial (optimal) temperature. In case of *Spodoptera litura* the lower threshold temperature (10.8°C), upper threshold temperature (37°C) and 40°C is lethal for pest (Rao *et.al.*, 1889). In unfavorable

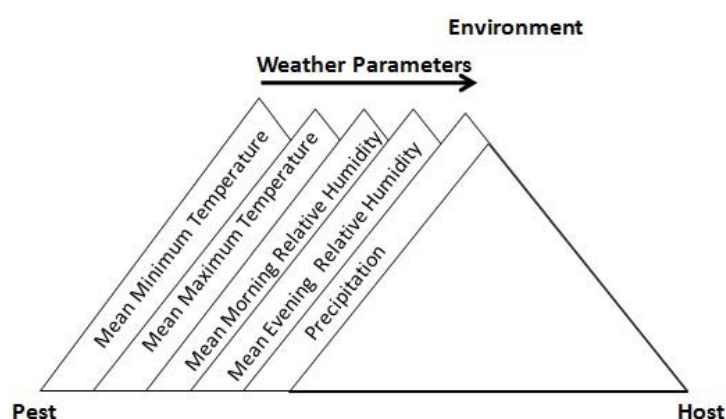


Fig. 1. Pest Infestation Triangle + Weather Parameters + Crop Type.

weather condition the the population of *Spodoptera litura* has been found to be very low whereas in favorable (congenial/optimal) weather condition supports very high pest population in soybean crop.

Decision support systems (DSSs) gather and present data from a wide range of sources to develop a prediction system; DSSs analyzed on the basis of data input to recommend the most appropriate action or action options (Agrios, 2005). The theoretical and practical knowledge of expert, prediction models, and timely data are key elements of decision tools which are used to assist growers with daily forewarning and management (Sonka et al., 1997). The main focus of current research work to develop a web based decision support system using weather and pest criteria to forewarn *S. litura* population on soybean at IARI, Farm New Delhi.

Information Procedure and Methodologies

Weather data: The tool is transformed into reality and is developed with problem solving

approach to benefit our local growers. It is driven by observed and forecasted weather data viz; temperature, relative humidity and precipitation. Observed weather data such as hourly temperature, humidity and rainfall were obtained from the automatic weather station located in the farm of IARI, New Delhi. Forecasted daily weather data were collected from India metrological department (IMD) website (www.imd.gov.in). The hourly and daily weather data were converted to weekly mean weather data and put into database server. The weather database server provides data to the web server.

Pest Infestation data and prediction Model

Weekly pheromone trap catch data (male moth catches) were collected from soybean fields of IARI for *kharif* seasons of 2010, 2011 and 2012. A prediction rule was developed using data of the first and second seasons and data of the third season were use for testing of the rule. On the basis of *Spodoptera litura* data at IARI, farm and its population was categorized

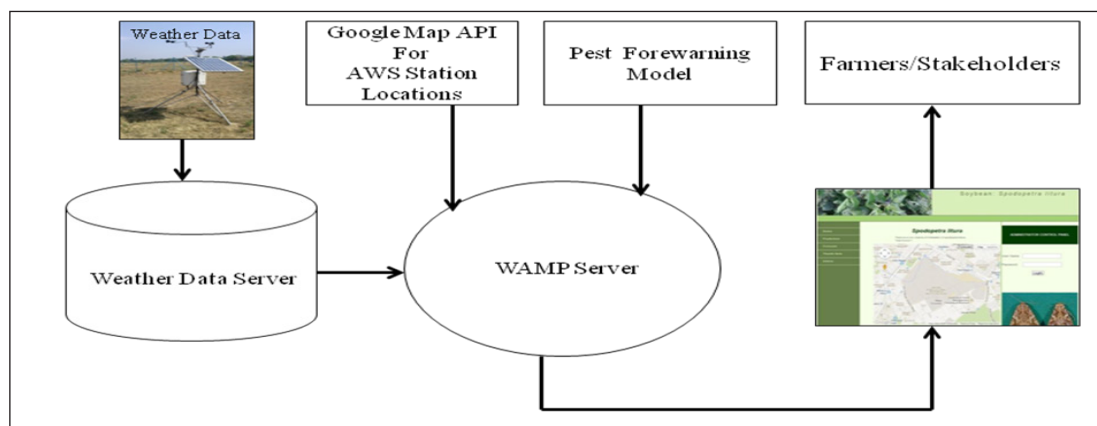


Fig. 2. Forewarning System Architecture.

into three groups (low: < 200, moderate: 200-400 and high: >400 male moth/trap/week.

The most of the research has shown that the study of plant disease begins with a discussion of the plant disease triangle. The three important factors (host, disease and environment) are responsible for any plant disease occurrence (Stevens, 1960). Similar principal also works for insect pest infestation. Environment consists of weather parameters and a modified pest infestation triangle is presented in Fig 1. First, *Spodoptera litura* ((Fabricius) (Noctuidae: Lepidoptera)) must be present in the environment. After that a pest must come in contact with a host (soybean). The most important factor weather condition has a greater impact on pest population.

The pest forewarning model has been developed to describe the conditions that govern the severity level of pest infestation. The weather parameters such as weekly mean maximum temperature (Tmax°C), mean minimum temperature (Tmin°C), mean morning relative humidity RH1 %), mean evening relative humidity (RH2 %) and total rainfall (RF mm) data have been used.

A web enabled pest forewarning systems for soybean crop is developed based on weekly weather data using web based interface. The forewarning system architecture consists of Window, Apache, Mysql and Hypertext Preprocessor (PHP) Language (WAMP) server, weather database server and WYSIWYG HTML web mapping technology with Google Map API (Pavan *et al.*, 2011) (Fig. 2).

Results and Discussion

Pest Weather Model

On the basis of interactive approach between weather parameters and pest severity,

the optimal values/ranges of 5 weather parameters were found to be congenial for high infestation of *S.litura* on Soybean. These weather parameters with their optimal ranges are given below:

1. Weekly mean maximum temperature (25-28°C),
2. Weekly mean minimum temperature (>19.5°C),
3. Weekly mean morning relative humidity (>90%),
4. Weekly mean evening relative humidity (78-83%)
5. Weekly total rainfall (<20 mm)

The weekly population levels of male moths of *S. litura* would be [low: (<200); moderate (200-400) & high (>400)] depending upon satisfying the number of optimal weather ranges. If all five or four ranges are satisfied the population level can be severe: three and two range satisfaction leads to moderate population and one or none satisfied means low population.

Development of DSS

A computerized decision support system (DSS) is developed to predict the severity level of *Spodoptera litura* in soybean (*Glycine max*) using on weather based prediction rule. It is a user friendly weather based pest forewarning tool and has been developed using a free open-source PHP, MySQL databases and pest Model (Fig.3). The Soybean pest forewarning systems was tested during the *kharif* season of 2012 and demonstrated a system for prediction of tobacco caterpillar (*Spodoptera litura*) development in IARI farms. It was observed that the soybean crop was severely infested by *Spodoptera litura* and the pest model forewarned the same.



Fig. 3. Pest Model Based Weather Data.

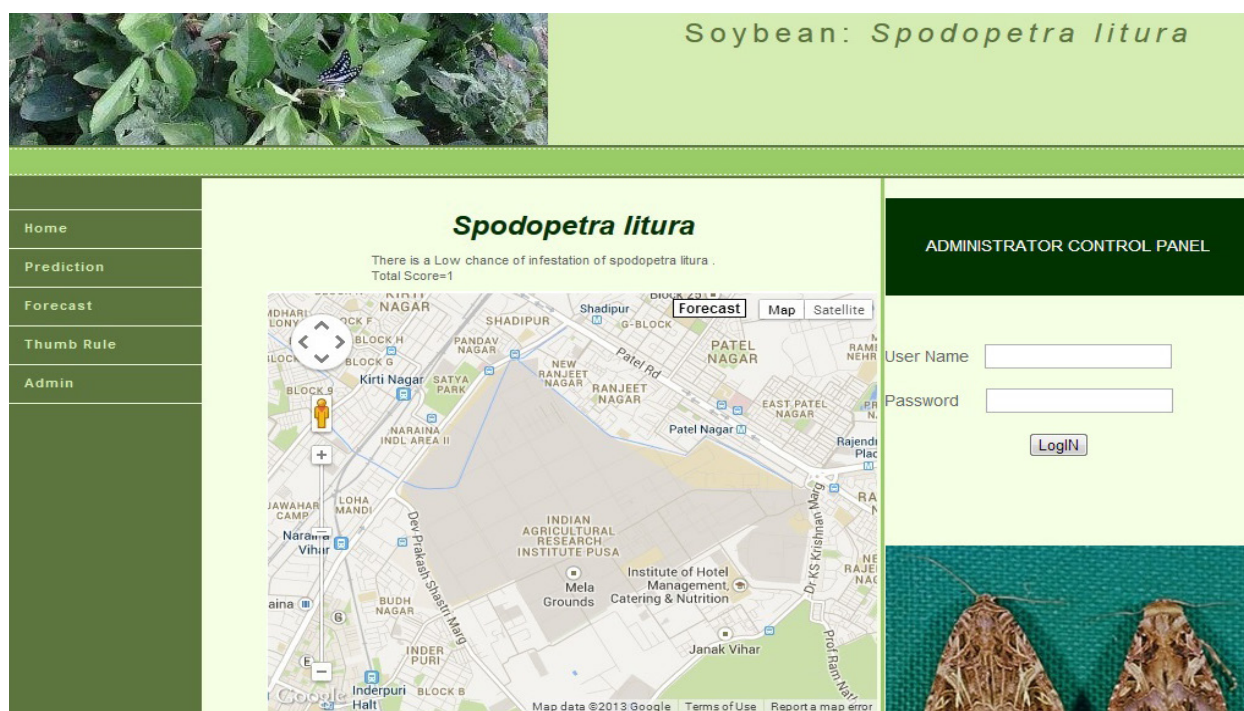


Fig. 4. Forewarning *Spodoptera litura* Infestation in Soybean Crop.

Incorporation to GIS (Google Map API):

The DSS is integrated with an interactive geographic information system (GIS) powered by the Google Maps API. A GIS helps farmers to quickly locate their farms virtually by using tools of Google Maps API and get forewarned Pest infestation severity level in (Fig 4) by clicking on customized Forecast button.

Conclusion

The developed weather and pest criteria with rules of prediction are robust for use in forewarning severity of *S. litura* to the soybean growers. Such a forewarning would help growers to be in preparedness at times of anticipated economic damage by *S. litura*, and to optimize the time of insecticidal application for increased production and profit. This internet-based decision support system will help soybean growers to identify the pest infestation condition on their farms everyday and enable them to take preventive steps when the weather conditions are favorable for pest development. On the other hand, farmers can avoid unnecessary sprays of pesticides, plan pesticides sprays based on pest severity. Stakeholders (farmers and planners) will be benefitted through internet based decision support system.

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Integrated Land-Use Study and Shoreline Changes along Shankarpur - Mandarmoni Coast line, West Bengal Using Remote Sensing and GIS Technique

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Keywords: Land-Use, Shoreline change, Sensitivity mapping, Settlement, RS & GIS

Abstract: The shoreline is under several erosional threats for last few decades by some natural forces and human interference. The land-use study reveals that a vast change in built-up areas along shorelines. In this paper, the relationship between shoreline changes and land-use pattern has been studied on the representation of shoreline in GIS database. The land-use pattern varies with time with a change in sand dunes, sandbar and settlements. Sand dunes in some areas are gradually replaced by mudflat and the area is transformed into intertidal zone. The pattern of shoreline changes along Shankarpur and Mandarmoni coast line was identified using Landsat TM data acquired in 1990 and 2005, Landsat ETM+ data acquired in 2000, SOI Toposheet of 1972 and Google image of 2010 and 2012. This paper shows that a erosional tendency near Shankarpur and coast line sifted maximum 120 meter and minimum 40 meter towards the land. A depositional tendency found on eastern part of Mandarmoni coast.

Introduction

The shoreline changes indicate erosion and accretion of land with time. Various natural causes including sea level rise, coastal erosion, waves, tides, winds, periodic storms, and human interface change the shoreline position with time. The process of erosion and accretion effects human life, cultivation and natural resources along the coast. (Jayson et. al., 2013).

It is therefore necessary to monitor shoreline changes and land use pattern along coastal area. Multi-temporal Remote Sensing data is useful in analyzing, visualizing and mapping of shoreline changes in GIS environment. The aim of the study is to map dynamic change of land-use land-cover and shoreline using SOI toposheet and satellite data.

Objectives

- To calculate rate-of-change statistic of shorelines using time series data from 1969 to 2010.
- To map land-use land-cover change along shoreline using time series data from 1969 to 2010.

Study area

The Sankarpur-Mandarmoni coast is located in the East Medinipur district of West Bengal, the east coast of India facing the Bay of Bengal. It is located between 21°37'26.89"N and 21°38'34.97"N latitude and 87°33'11.90"E and 87°45'26.76"E longitude (Figure 1). The

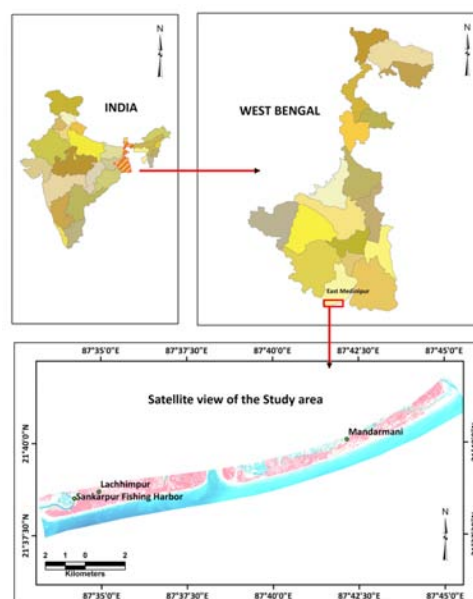


Fig. 1 Location of the study area

study area is falling under Survey of India Topomap no 73O/10. The shoreline is about 22.6 km long from Sankarpur fishing harbor in the west to eastern part of the Mandarmoni in the east. The beach of this area is interrupted by number of tidal channels – Ramnagar khal, Sankarpur khal, Jalda khal etc. The climate of the coast characterized by south-east monsoon prevails between June to October. The monsoon is generally associated with rarely intensifies to a cyclonic storm. During summer days (March-June) normally the temperature does not exceed 30°C and in winter (Nov-Feb) it seldom falls below 20°C (Mandal et al., 2013).

Material and Methods

Dataset

Various time series (Table 1) data were used for analyzing shoreline changes and land-use mapping. Survey of India toposheet (1:5000 scale) of 1969, Landsat data of 2000 and Google Earth Imageries of 2010 are used for land-use land-cover mapping. Same toposheet, Landsat images of 1990, 2005 and Google Earth images of 2010 were used for shoreline extraction.

Data processing

Landsat calibration techniques were used to spectrally enhance all the Landsat TM and ETM+ data. For the ETM+ data the panchromatic band was used to sharpen the multispectral bands to get a new image at 15m. The Survey of India toposheet geometrically projected to maintain real world coordinates. ERDAS IMAGINE 9.2 software was used for all the data processing needs.

Shoreline extraction

Shoreline position can reference several different features such as vegetation line, the high water, the low water line, or the wet/dry line (Himmelstoss et al., 2009). The wet/dry

boundary which approximates the high water line (WHL) extracted using band ratio index method and manual method. Band ratio model between the mid infrared (Band 5) and the green band (Band 2) in ERDAS IMAGINE software used to identify the land-water boundary for the Landsat images. Band 5 exhibits a strong contrast between land and water features due to the high degree of absorption of mid-infrared energy by water (even turbid water) and strong reflectance of mid-infrared by vegetation and natural features in this range (Alesheikh et al., 2006; Binh et al., 2009). The Survey of India (SOI) toposheet and Google Earth images were directly digitized for shoreline extraction.

Shoreline analysis

The shoreline positions were compared and managed in ArcGIS 9.3. The Digital Shoreline Analysis System (DSAS 4.2) developed by the USGS in 2010. DSAS computes rate-of-change statistics for a time series of shoreline vector data (Himmelstoss et al., 2009). The DSAS uses measurement baseline method to calculate change statistics. The baseline is constructed to serve as the starting point for all transects cast by the DSAS application (Jayson-Quashigah, 2013). Each simple transect is cast at a 90-degree angle from the baseline at 500m interval. Historic rates of shoreline change were then calculated at each transect using Net Shoreline Movement (NSM) and End Point Rate (EPR).

The NSM reports a distance, not a rate. The NSM is associated with the dates of only two shorelines. It reports the distance between the oldest and youngest shorelines for each transect.

NSM = distance between oldest and youngest shorelines

The method was used to represent the movements for periods between 1969 and 2010.

Table1. Data characteristic

Data	Date	Path/Row	Bands	Resolution
SOI Topomap	1969	-	-	-
Landsat TM	21-11-1990	139/045	6MS	30m
Landsat ETM+	08-11-2000	139/045	6MS 1Pan	30m 15m
Landsat TM	14-11-2005	139/045	6MS	30m
Google Earth Imageries	2010	-	3MS	0.41m

The EPR is calculated by dividing the distance of shoreline by the time elapsed between the oldest and the youngest shorelines. EPR was employed only two shoreline dates.

$$\text{EPR} = \frac{\text{distance in meters}}{\text{time between oldest and youngest shoreline}}$$

EPR method was used to calculate rate for periods between 1969 and 2010, 1969 and 1990, 1990 and 2005 and between 2005 and 2010.

Land-use land-cover mapping

Landsat TM data of 2000 was classified using unsupervised classification technique. The method was used to classify similar pixel in a group (Chalabi et al., 2004) and give them a name. LULC class of 1969 and 2010 was directly digitized from SOI toposheet and Google Earth Imageries and exported to a GIS environment. ArcGIS 9.3 software was used for final land-use land-cover mapping.

Results and discussion

In all, 4 shoreline positions were extracted for change detection (Fig. 2). The results show that there have been significant changes along the entire coast for the 41 years period under study. Distance between two shoreline 1969

and 2010 was calculated at each transect (Fig. 3). An average value of - 278m have found 75% of the entire coast and 25% of the coast have an average value of 392m, where negative values indicates the shoreline movement towards the land and vice versa. The effected change found especially near the estuary.

Overall rate of change (1969 to 2010) ranges from -10m/year to 20m/year where negative values represent erosion and positive values represent accretion (Fig. 4). A high accretion rate was found near the Pichaboni khal estuary, eastern part of the study area. Remaining the eastern part 75% of the entire shoreline mostly eroded.

The time period between 1969 and 1990 very high rate of accretion found only eastern part of the study area. Erosion rates are significantly high on the other part (Fig. 5). Average erosion and accretion rates were 8.5m/year and 11m/year. The time period 1990 to 2005 shows that the erosion and accretion were continued but the rate are become slow than the past period (Fig. 6). Minimum depositional tendency found near the middle part (Mandarmoni estuary) and Pichaboni khal estuary. Accretion rates range from 0.61m/year to 17m/year with an average 5.71m/year while erosion rates were

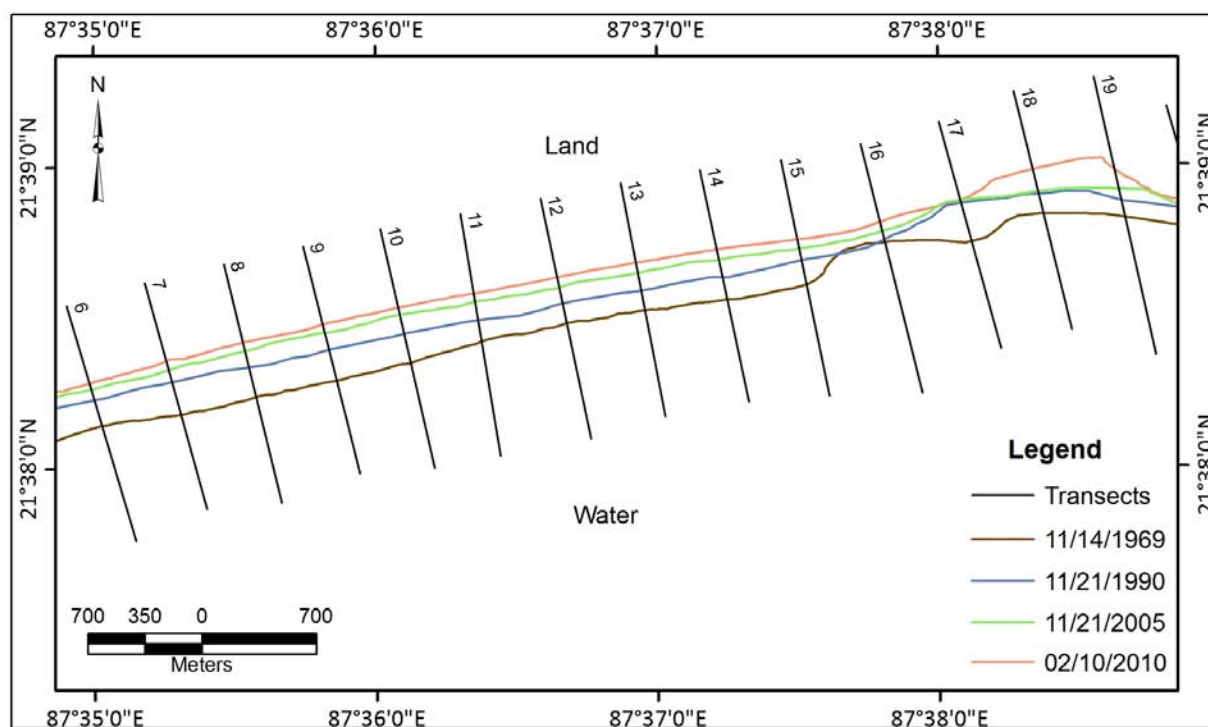


Fig. 2. Extracted Shorelines

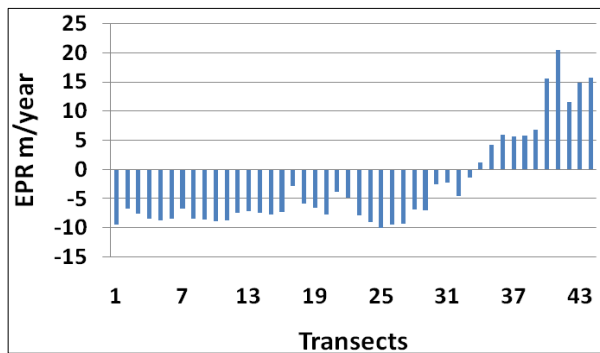


Fig 3. Shoreline movement between 1969 and 2010

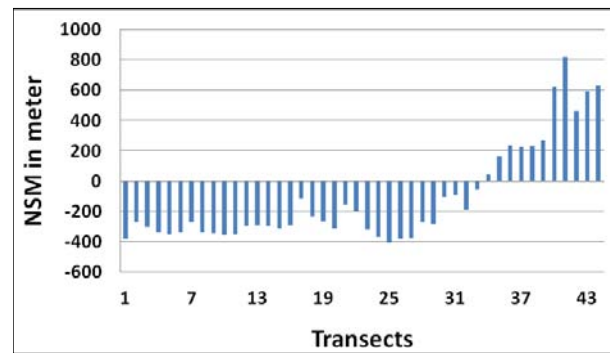


Fig 4. Rate of change between 1969 and 2010

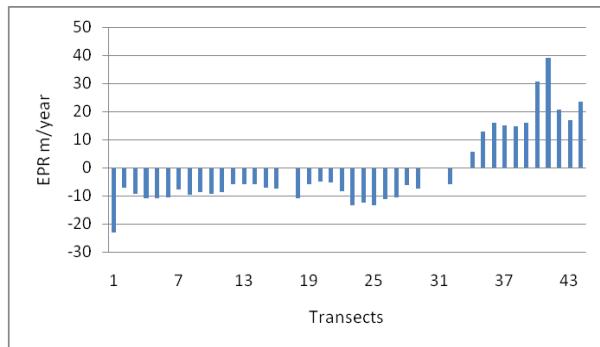


Fig 5. Erosion and Accretion rates between 1969 and 1990 between 0.47 to 7.93m/year with an average of 4.20m/year.

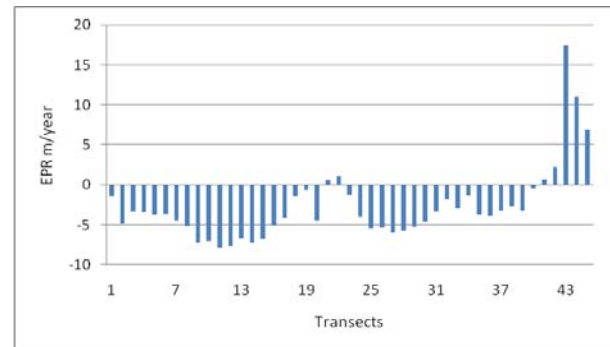


Fig 6. Erosion and Accretion rates between 1990 and 2005

The rates of erosion further increased along the entire coast between 2005 and 2010 (Fig. 7). Average erosion rates were 11.18m/year and accretion with an average of 4.24m/year. The rate of erosion was very high compare to the time period. Very little depositional tendency was found western and middle part of the study area. The average accretion and erosion rates of different time periods have shown in Table 2.

Land-use study integrated with shoreline changes of different years shows that the land-use pattern was changed with shoreline movement. The land-use land cover either eroded or accreted within a time period. The land-use land-cover of 1969 (Fig. 8) integrated with shoreline of 1990 shows that what type of land use were eroded or gone under the ocean

Table 2. Average erosion and accretion rates

Period	Erosion (m/year)	Accretion (m/year)
1969-2010	6.93	9.76
1969-1990	8.5	11
1990-2005	4.20	5.71
2005-2010	11.18	4.24

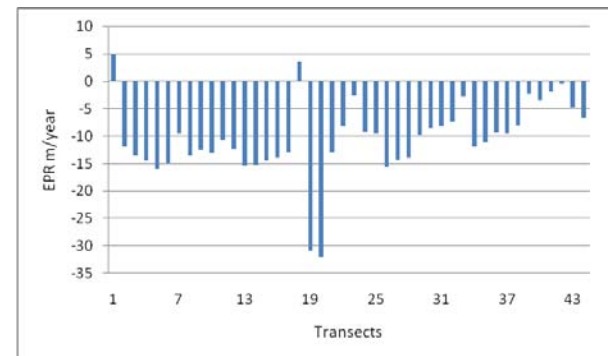


Fig 7. Erosion and Accretion rates between 2005 and 2010

between that time period, means overlaying a shoreline on a land use map (which was earlier dated than the shoreline) were used to identify the changeable area between the time period. During 1969 – 1990 about 2.55 sq km of land was eroded and 1.81 sq km accreted from the area (Fig. 9).

The land use map of 2000 (Fig. 10) and shoreline of 2005 shows that some land feature classes which are fall under the shoreline those are not present in 2005. Those all are eroded. The erosion and accretion of land between 1990 and 2005 (Fig. 11) was 1.19 sq km and 0.25 sq km respectively. The amount of erosion and accretion was decrease between the periods.

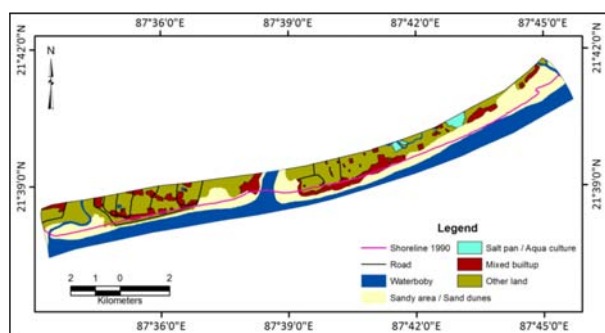


Fig. 8 Land use map of 1969

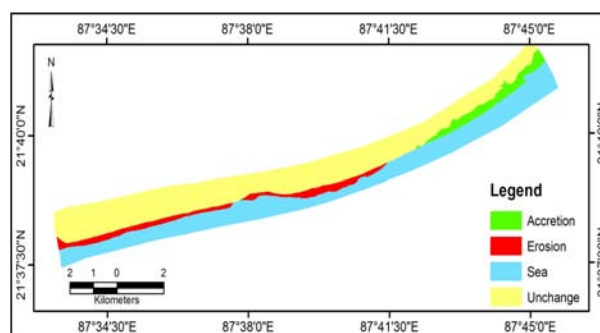


Fig. 9 Erosion and accretion between 1969 and 1990

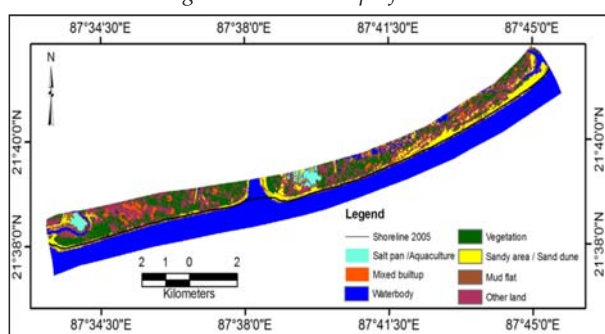


Figure 10 Land use map of 2005

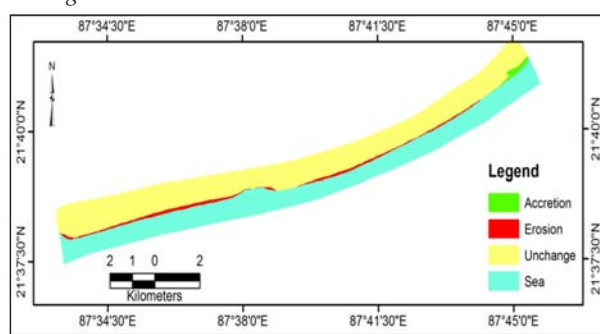


Figure 11 Erosion and accretion between 1990 and 2005

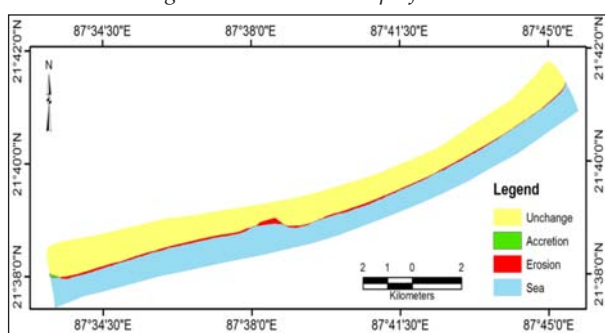


Fig. 12 Erosion and Accretion between 2005 and 2010

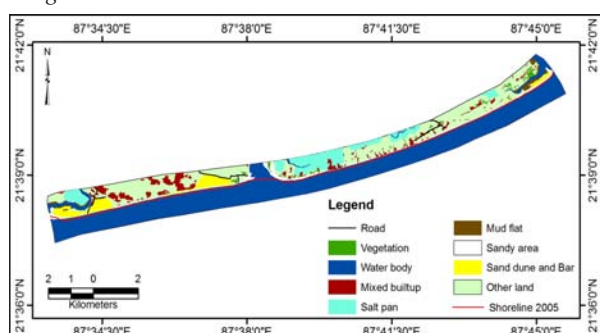


Fig. 13 Land use map of 2010

Between 2005 and 2010 1sq km of land erosion was found from the area (Figure 12). Erosional tendency found all over the coast. Accretion rate was negligible. Land use land cover of 2010 (Fig. 13) and shoreline position of 2005 clearly shows the higher to medium erosion of land all over the coast. The erosion and accretion of different time periods have shows in Table 3.

Table3. Erosion and accretion of different time

Year	Accretion (sq km)	Erosion (sq km)	Total growth (sq km)	Growth rate (sq km/year)
1969-1990	1.819287	2.55587	-0.736	-0.035
1990-2005	0.251179	1.199432	-0.948	-0.063
2005-2010	0.000908	0.99772	-0.89	-0.178

Conclusion

Results of this study shows that Remote Sensing data and GIS technique is useful for shoreline monitoring and change detection

along the Sankarpur and Mandarmoni coast. Although SOI toposheet and high resolution Google Imageries are used for shoreline extraction and land use mapping the study shows that multispectral medium resolution satellite imageries are also useful for mapping and monitoring the historic shoreline change.

The results generally confirm the high rates of erosion all over time period. 75% of the entire coastline has been found an eroded coast. Deposition was found only eastern part

(near Mandarmoni) of the study area between the time period 1990-2005. The average erosion of 6.93m/year found 75% of the coast for the 41 years periods under study. The average rate of accretion 9.76m/year for the entire periods, which was basically higher than erosion but it was found only 25% of the entire study area, near the Pichaboni khal estuary. High erosional rate of 11.18 m/year was found between the time periods of 2005-2010. In this time periods 95% of coast are eroded. The accretion rates are negligible. A land use map and a shoreline of two different years were helps to identify the changeable area in land use land cover. The findings show that growth rate of land gives negative value which indicates the erosion of land for the entire periods.

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Female Work Force in Uttar Pradesh: A Geographical Analysis

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Keywords: *Female population, Work force, Work Participation rate, Economic Sectors Fertility, Mortality, Goods, Services, Development, Planning*

Abstract: Changes in the size of the work force are determined by population growth and work participation rates. Population growth depends upon fertility, mortality and migration. Rapid female population growth in Uttar Pradesh causes problem in the labour market. The growth of female workers has not matched the female population growth resulting in higher dependency ratios and sizeable unemployment or underemployment. Only a part of the entire female population of the Uttar Pradesh is engaged in the production of goods and services. The present paper aims to study the trends in the female work force. These trends have strong implications for economic and social development planning. The study also examines the female population growth and changes in female work participation by economic sectors and how their work participation rates (total, rural and urban) are associated with various socio-economic indicators. The entire study is based upon the district level secondary data obtained from 2001 and 2011 censuses. Carl Pearson co-efficient of correlation and student t-test techniques are used to find out the relationship between work participation rate of female population (Total, Rural and Urban) and various other socio-economic indicators. GIS software - ArcGIS 10.0 version for windows is used for thematic mapping, statistical computation and graphical presentation in relation to selected geographic areas. Statistical analyses are performed on the data which helped to determine trends, and Maps are drawn to show the geographic distributions of the data which helped to locate "problem areas" or areas of potential growth and to visualize situations. From the results it is clear that primary work participation rates of female population is high in the eastern part of the state, whereas, western districts are showing high level of secondary and tertiary work participation rates of female population. It is also clear from the results of co-efficient of correlation that female work force demographic indicators, agricultural indicators and work participation rates (Total, Rural and Urban) have direct bearing on work participation rates of total female population. The study, it is believed, will have distinct practical utility.

Background

The labour force of a country is comprised of persons who can work and choose to do so while the work force consists of only those persons who are employed fully or partially. Changes in the size of the work force are determined by population growth and work participation rates. Work Participation has great subjective significance with growing emphasis on regional planning and regional approach to the population policy and utilization of human resources (Franklin, 1958). It is an important indicator of the economic composition of a region. The degree of employment or unemployment exerts its influence as one of the chief determinants of several socio-

economic and demographic characteristics of the population (Ray, 1978). The socio-economic development of any region is mainly related to degree of work participation and the proportion of workers in different sectors of economy (Chaudhary, 2007). Work participation refers to economic activities in which workers are differentiated (Jaffe and Stewart, 1951).

Sex differential among the number of male and female workers in the total work force is significant. Census of India, 2011 reveals that there are 49.8 million male and 16.0 million female workers in the state of Uttar Pradesh. This would mean that the number of female workers is about three times less than the number of male workers. The female work

force in the state of Uttar Pradesh constitutes about one-sixth (16.7%) of the female population of the state. During 2001-2011, Uttar Pradesh witnessed an increase of 3.0 million female workers, grew by 22.8 percent, against 6.0 million or 86.3 percent in the previous decade of 1991-2001. Between 2001 and 2011, Uttar Pradesh experienced a shortage of female work force as compared to past decade indicative of an approaching structural and demographic shift in employment in India and around the globe. Using employment data from different rounds of the National Sample Survey (NSS), a number of papers/reports have examined the employment situation in India in the post-reform period in comparison with that in the pre-reform period (Sundaram, 2001a, 2001b; Chadha and Sahu, 2002; Government of India, 2002; Sundaram and Tendulkar, 2002; Dev, 2002; Chadha, 2003; Sundaram and Tendulkar, 2004; Sundaram, 2004; and Bhattacharya and Sakthivel, 2005a, 2005b). These studies conclude that there has been a marked slowdown in employment growth in India in the post-reform period compared to the pre-reform period, and that this slowdown has been relatively more marked in the case of female employment. The present study covers only the female work force of the state of Uttar Pradesh and not the labour force. The main objective of the present study is to describe trends in the female work force in Uttar Pradesh. The specific objectives of this paper are to understand the level and sectoral distribution of female work force and to identify and explain various socioeconomic factors responsible for the observed level and changing spatio-temporal patterns of female work participation rate at the district level in Uttar Pradesh. These trends and patterns have strong implications for socioeconomic and regional development planning. The census data of 2001 and 2011 are used for the analysis. The study, it is believed, will have distinct practical utility.

Methods

The terminology such as work, work force, worker, main workers, marginal workers, non-workers, occupational structure and work participation as defined in census 2011; the same has been adopted in this study for analysis and interpretation of results. GIS software - ArcGIS 10.0 version for windows is used for thematic mapping, statistical computation and graphical

presentation in relation to selected geographic areas. Statistical analyses are performed on the data which helped to determine trends, and Maps are drawn to show the geographic distributions of the data which helped to locate "problem areas" or areas of potential growth and to visualize situations. The Karl Pearson's correlation coefficient (r) of variation has been computed to bring about the extent of inter district variation in FWPR.

Karl Pearson's correlation co-efficient

$$r = \frac{\Sigma xy - \Sigma x \Sigma y / n}{\sqrt{\Sigma x^2 - \frac{(\Sigma x)^2}{N}} \sqrt{\Sigma y^2 - \frac{(\Sigma y)^2}{N}}}$$

Where,

r = co-efficient of correlation

x, y = the two given variables

n = Number of observation

The inter-district inequalities in the work status of rural/urban women are shown by the coefficient of equality. In all economic, demographic and socio-cultural variables, which are understood to influence, FWPR are incorporated in the study. Student t-test is applied to test the differentials of female work participation rates (total, rural and urban) with various socio economic determinants.

Student t-test:

$$t = r \sqrt{\frac{(n-2)}{1-r^2}}$$

Where,

t = calculated value of 't' in the test of significance,

n = number of observations,

r = computed value of coefficient correlation

1. Analysis

1.1 Growth of Female Population and Female Workers

Table 1 shows the growth rates (percent) of population, workers, main workers, marginal workers and non-workers by sex and residence. The decadal growth rate of female population of Uttar Pradesh is 21.2 percent (18.9% rural and 30.2% urban). The growth rate of females is higher both in rural and urban areas than males. The growth rate of female workers during 2001-

Table 1. Growth Rates (percent) of Population and Workers by Sex and Residence, 2001-2011, Uttar Pradesh

Residence/Gender	Decadal Growth Rates (%)				
	Population	Workers	Main Workers	Marginal Workers	Non-Workers
Total					
Person	20.2	21.9	13.5	44.6	19.4
Male	19.3	21.6	9.0	87.1	17.3
Female	21.2	22.8	44.3	9.4	20.9
Rural					
Person	18.0	16.3	7.3	37.1	18.8
Male	17.1	17.0	3.1	81.9	17.2
Female	18.9	14.2	34.2	3.1	20.0
Urban					
Person	28.8	48.9	37.1	128.1	21.4
Male	27.6	40.0	30.5	122.5	17.6
Female	30.2	116.0	103.5	141.2	24.0

2011 is 22.8 percent for females. In fact, the growth rate of female workers is significantly higher than that of female population. This may be due to increase in female literacy, the availability of jobs for women, and expansion of service sectors. The table shows that the number of female workers has increased at a higher rate than the male workers. The growth rate of female workers, however, has kept pace with the growth in population. One reason for this may be boundless employment generation and desired changes in the outlook for working females. The growth rates of female workers are invariably higher in urban areas than in rural areas.

The growth rate of female main workers (those who have worked for the major part of the year or worked for at least 183 days or more preceding 12 months to the census taking) during 2001-2011 is 44.3 percent for females. However, the growth rate of female marginal workers (those who did not work for at least 183 days in the preceding 12 months to the census taking) is 9.4 percent for females. The table shows that the number of female main workers has increased at higher rate than the male main workers both for rural and urban areas, while, the growth rate of female marginal workers is much lower than that of male marginal workers in rural areas. The growth rate of female non-workers (who did not work at all during the last year preceding the date of enumeration) during 2001-2011 is 20.9 percent. The table shows that the number of female non-workers has increased at higher

rate than the male non-workers both for rural and urban areas.

1.2 Inter-District Variations in the Growth of Female Population and Female Workers

Growth rates of female population and female workers in the districts of Uttar Pradesh present quite a diversified pattern. The growth rate of female population in the districts of Uttar Pradesh varies between 50.3 percent in Gautam Buddha Nagar and 10.4 percent in Kanpur Nagar. In rural areas, the female growth rate varies between 33.2 percent (Shrawasti) and 2.8 percent (Ghaziabad). In urban areas, the female growth rate varies between 147.0 percent (Siddharthnagar) and 8.1 percent (Kanpur Nagar). The growth rate of female workers in the districts of Uttar Pradesh varies between -29.4 percent in Bulandshahr and 136.4 percent in Etawah. The female work force has declined in a total of 13 out of 71 districts. These districts are Bulandshahr, Faizabad, Muzaffarnagar, Mathura, Balrampur, Baghpat, Sant Kabir Nagar, Shrawasti, Auraiya, Basti, Kushinagar, Mahoba and Kannauj during 2001-2011. The changes that do occur reflect changes in work opportunities, unemployment and underemployment. In rural areas, the growth rate of female workers varies between -32.9 percent (Bulandshahr) and 141.3 percent (Etawah). Figure 1 display the decadal growth of female population and female workers in the districts of Uttar Pradesh during 2001-2011. The female work force in rural areas of the districts has declined in a total of 16

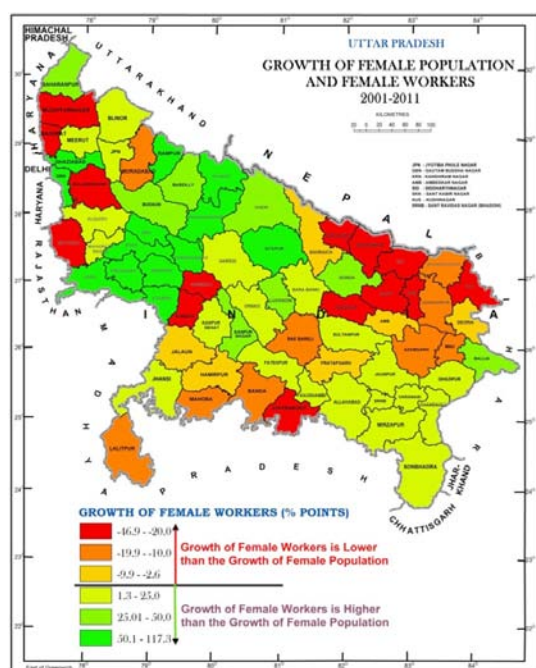


Fig. 1. Decadal Growth of Female Population and Female Workers in the Districts of Uttar Pradesh during 2001-2011.

districts. These districts are Bulandshahr, Muzaffarnagar, Faizabad, Mathura, Baghpat, Auraiya, Balrampur, Moradabad, Sant Kabir Nagar, Meerut, Kannauj, Gorakhpur, Basti, Shrawasti, Mahoba and Kushinagar during 2001-2011. In urban areas, the growth rate of female workers varies between 387.6.0 percent (Siddharthnagar) and 4.1 percent (Shrawasti). The female work force in urban areas of the districts has increased in all 71 districts of the state. The regional patterns in the growth of female population and female work force are displayed in The aggregate female work

force in Uttar Pradesh has been growing at a slightly faster rate than the female population. The analysis of census data reveals that the female work force grew slowly than the female population in a total of 29 out of 71 districts of the state. The aggregate picture, however, masks different trends by residence. The rate of growth of female workers is about 4.7 percentage points lower than the growth rate of the female population in rural areas, while 85.8 percentage points higher in urban areas. As many as 34 districts have witnessed lower growth rate in female work force than the female population in rural areas. However, in urban areas, only six districts namely Bulandshahr, Mau, Shrawasti, Baghpat, Jyotiba Phule Nagar and Kannauj have witnessed lower decadal growth rates of female workers than the female population of these districts. The lower growth rate of female workers in these districts, irrespective of the rural-urban differentials, is partially due to their decreased participation in the cultivation practices due to extensive use of improved agricultural implements.

1.3 Work Participation Rates

Work participation rate is defined as the number of workers per 100 persons. Table 2 gives the work participation rates for marginal, main and total workers by sex and residence as per 2001 and 2011 censuses for the state of Uttar Pradesh.

The female work participation rate has marginally increased from 16.5 percent in 2001 to 16.7 percent in 2011. As a consequence, the proportion of females in total work force rose

Table 2. Work Participation Rates (%) for Marginal, Main and Total Workers, Uttar Pradesh. 2001-2011

Total Rural Urban	Category of Workers	2001			2011			Percentage Change 2001-2011		
		Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
Total	a) Marginal	8.8	7.6	10.2	10.6	11.9	9.2	1.8	4.3	-1.0
	b) Main	23.7	39.2	6.4	22.3	35.8	7.6	-1.3	-3.4	1.2
	c) Total	32.5	46.8	16.5	32.9	47.7	16.7	0.5	0.9	0.2
Rural	a) Marginal	10.2	8.4	12.2	11.9	13.0	10.6	1.7	4.6	-1.6
	b) Main	23.7	39.0	6.8	21.6	34.3	7.7	-2.1	-4.7	0.9
	c) Total	33.9	47.4	19.0	33.4	47.4	18.3	-0.5	0.0	-0.8
Urban	a) Marginal	3.5	4.6	2.3	6.2	8.0	4.2	2.7	3.4	1.9
	b) Main	23.4	40.0	4.5	24.9	40.9	7.1	1.5	0.9	2.6
	c) Total	26.9	44.6	6.8	31.2	48.9	11.3	4.2	4.3	4.5

Source: Author's calculation based on data of 2001 and 2011 census.

from 24.1 to 24.3 percent. The female work participation rate is lower in urban areas than in rural areas. The work participation rate for female main workers displayed an increasing trend both in rural and urban areas of Uttar Pradesh. Contrary to the general trend, the work participation rates for female marginal workers showed a decreasing trend in rural area and increasing trend in urban area.

1.4 Inter-district variations in the Female Work participation rates

Among the districts there are sharp differences in female work participation rate, as the percentage varies from a maximum of 31.1 percent in Kaushambi to a minimum of 7.7 percent in Saharanpur during 2011. The overall female work participation rate for the state as a whole has marginally increased during 2001-2011. The female work participation rate has noticeably decreased in a total of 29 out of 71 districts, whereas in other districts it has increased. The highest decline is observed in Bulandshahr (-11.1%) and is in Hamirpur (-0.6%). However, the highest increase in the female work participation rate during 2001-2011 is found in Etawah (6.2%) and lowest in Sultanpur (0.4%). Figure 2 displays the decadal change in female work participation

rates in the districts of Uttar Pradesh during 2001-2011. In rural areas, the female work participation rates vary from the maximum of 34.9 percent in Jhansi to the minimum of 7.8 percent in Saharanpur across the districts of Uttar Pradesh during 2011. The female work participation rate in the rural areas of the state has marginally decreased from 19.0 percent in 2001 to 18.3 percent in 2011. The female work participation rate in rural areas has conspicuously decreased in a majority of the districts (34). The highest decline is noticed in Bulandshahr (-13.6%) and lowest is found in Lucknow (-0.3%). The female work participation rate in rural areas has evidently increased in a total of 37 out of 71 districts of the state. The highest increase is noticed in Etawah (7.0%) and lowest increase is noticed in Aligarh (0.1%). Among the districts, there are sharp differences in female participation in urban areas during 2011, as the percentage varies between 4.9 percent in Shrawasti and 20.1 percent in Mau. Contrary to the rural areas, the female work participation rate in the urban areas of the state has substantially increased from 6.8 percent in 2001 to 11.3 percent in 2011. In a total of 65 out of 71 districts have returned higher female work participation rates in 2011 as compared to 2001. However, six districts namely Mau, Bulandshahr, Baghpat, Jyotiba Phule Nagar, Shrawasti and Kannauj have returned lower female work participation rates in 2011 as compared to 2001. There are a number of possible causes for this variation in female work participation rates across districts. Economic opportunities for women vary. In general, the districts having high female participation rates are either comparatively more developed industrially like Kanpur Nagar, Lucknow, and Varanasi or are observing more females in Azamgarh, Deoria and Jaunpur or having higher concentration of Scheduled Castes in Sitapur, Hardoi and Allahabad having higher concentration of Scheduled Tribes in Sonbhadra, Ballia and Kushinagar.

1.5 Distribution of workers by sector

The classification of workers into various sectors can give an indication of the level of economic development. In other words the shift of workers from the primary sector in the economy to secondary and tertiary follows the industrialisation and development of the economy. Primary sector relates to the

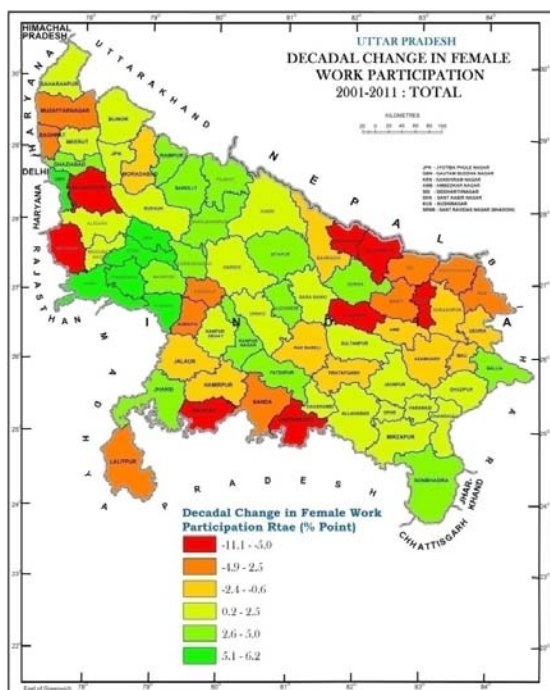


Fig. 2. Decadal Change in Female Work Participation Rates in the Districts of Uttar Pradesh during 2001-2011.

production of primary goods in agriculture and in allied pursuits. Workers engaged in this sector include persons engaged as cultivators; as agricultural labourers; in livestock, forestry, fishing, etc.; and in mining and quarrying. Secondary sector includes all persons engaged in manufacturing, processing, servicing and repairs in household industry and other than household industry and constructions. Tertiary sector includes trade and commerce; transport, storage and communications; and other services. Census gives the broad classification of workers as cultivators, agricultural labourers, household industry workers and other workers. In this analysis, cultivators and agricultural labourers are included in the primary sector; household industry workers are included in secondary sector; and other workers are considered in tertiary sector.

Workers move from the primary to the secondary and tertiary sectors as economy develops. Large proportions of working population of Uttar Pradesh are still engaged

in the primary sector despite the massive investments being made under the Five Year Plans. However, this proportion continues to decline with every increase in the industrialisation of the state. With regard to females, the primary sector share has decreased from 75.7 percent to 60.6 percent in 2011. The share of female cultivators has decreased from 36.1 percent in 2001 to 22.2 percent in 2011. The share of female agricultural labourers has also marginally decreased from 39.6 percent in 2001 to 38.4 percent in 2011. The share of female workers in secondary sector has also increased from 8.3 percent in 2001 to 9.7 percent in 2011. The share of female workers in the tertiary sector has substantially increased from 16.0 percent in 2001 to 29.7 percent in 2011 (Table 3). The primary sector remains the dominant source of employment generation for female population in Uttar Pradesh. Analysis of census data reveals that approximately 3.0 million new female workers are observed into the female work force from 2001 to 2011. Of

Table 3. Distribution (%) of Workers by Primary, Secondary and Tertiary Sectors, India 2001 and 2011

Sector/ Workers	2001			2011			% Change during 2001-2011		
	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
1. Primary Sector (Cultivators + Agricultural Labourers)									
Total	65.9	62.8	75.7	59.3	58.8	60.6	-6.6	-4.0	-15.1
Rural	77.6	76.3	81.4	72.0	73.0	69.3	-5.6	-3.3	-12.1
Urban	9.5	8.9	13.5	11.4	11.5	10.9	2.0	2.6	-2.6
1.1 Cultivators									
Total	41.1	42.7	36.1	29.0	31.1	22.2	-12.1	-11.5	-13.8
Rural	48.7	52.2	38.9	35.6	39.2	25.5	-13.1	-13.1	-13.4
Urban	4.4	4.4	5.0	4.0	4.2	3.2	-0.4	-0.2	-1.9
1.2 Agricultural Labourers									
Total	24.8	20.1	39.6	30.3	27.7	38.4	5.5	7.6	-1.2
Rural	28.9	24.0	42.5	36.4	33.8	43.8	7.5	9.8	1.3
Urban	5.0	4.6	8.5	7.4	7.4	7.7	2.4	2.8	-0.8
2. Secondary Sector (Household Industry Workers)									
Total	5.6	4.7	8.3	5.9	4.7	9.7	0.3	0.0	1.3
Rural	4.8	4.1	6.9	5.2	3.9	8.8	0.3	-0.2	1.9
Urban	9.3	7.4	23.8	8.7	7.5	14.8	-0.6	0.1	-9.0
3. Tertiary Sector (Other Workers)									
Total	28.5	32.5	16.0	34.8	36.5	29.7	6.3	4.0	13.7
Rural	17.5	19.6	11.7	22.8	23.1	21.9	5.3	3.5	10.3
Urban	81.2	83.7	62.7	79.8	81.0	74.3	-1.4	-2.7	11.6

Source: Author's calculation based on data of 2001 and 2011 censuses.

these new female workers, 23.9 percent are found to be engaged in primary sector, 11.2 percent in secondary sector, and 64.9 percent in the tertiary sector. Primary sector employment generation is important for both sexes, but especially so for women. Thus, there is a clear-cut shift of women workers from primary sector to tertiary sector in the state of Uttar Pradesh.

1.6 Inter-District Variations in the Sectoral Distribution of Female Workers

In 2001, 75.7 percent of the female workers were engaged in primary sector for the state as a whole, 8.3 percent in the secondary sector and 16.0 percent in the tertiary sector. The corresponding figures for 2011 are 60.6, 9.7 and 29.7. The transfer of women out of the primary sector has occurred in all districts except Kanshiram Nagar district.

i. Primary Sector- The decline in the share of female workers in the primary sector ranges from 27.0 percentage points in Gorakhpur to 3.1 percentage points in Farrukhabad. The increase in the share of female workers in the primary sector is reported only in Kanshiram Nagar district. The proportion of female workers engaged in primary sector in 2011 varies among districts from 85.1 percent in Lalitpur to as low as 18.9 percent in Ghaziabad. The other districts with lower share of female workers in primary sector are Gautam Buddha Nagar (21.6%), Lucknow (26.6%), Bareilly (28.2%) and Firozabad (28.7%). The lower proportion of such female workers is reported in all those districts with higher concentration of urban population. Figure 3 shows the percentage change in the share of female workers in primary sector in the districts of Uttar Pradesh during 2001-2011.

ii. Secondary Sector –the proportion female workers in the secondary sector or female workers engaged in household industry has declined in 2011 as compared to 2001 in 24 districts, no change is reported in five districts namely Mahamaya Nagar, Jhansi, Lalitpur and Sultanpur, while increase is reported in as many as forty-two districts during this period. The increase is highest in Bareilly (10.9 percentage points) and lowest in Banda and Mau (each 0.1 percentage point), while decrease is highest in Farrukhabad (10.4 percentage points) and lowest in Aligarh (0.3 percentage point). The proportion of female household industry workers in 2011 varies among districts from

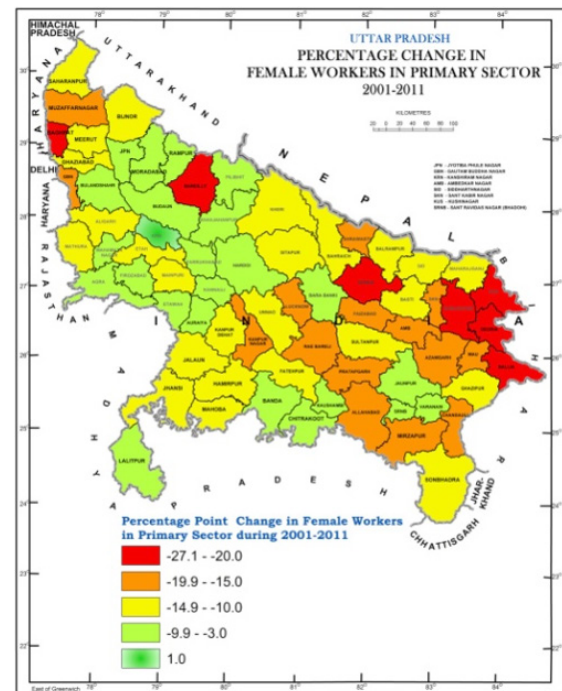


Fig. 3. Percentage Change in the share of Female Workers in Primary Sector in the Districts of Uttar Pradesh during 2001-2011.

35.6 percent in Kannauj to 3.2 percent in Banda. Figure 4 shows the percentage change in the share of female workers in secondary sector in the districts of Uttar Pradesh during 2001-2011.

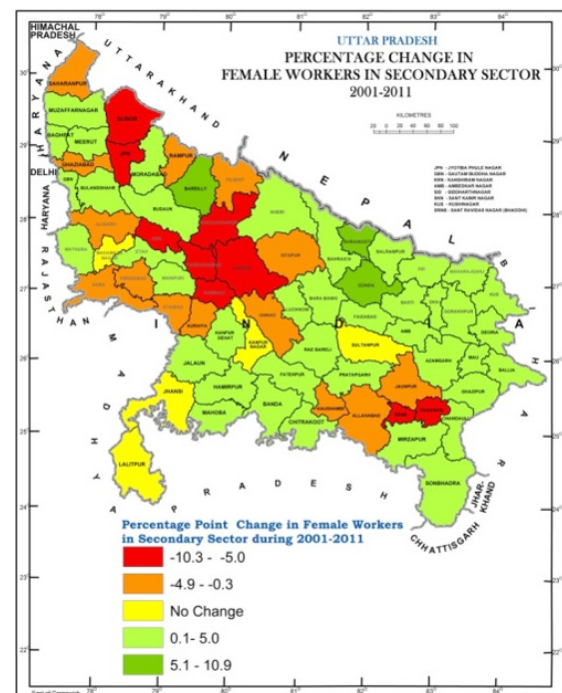


Fig. 4. Percentage Change in the share of Female Workers in Secondary Sector in the Districts of Uttar Pradesh during 2001-2011.

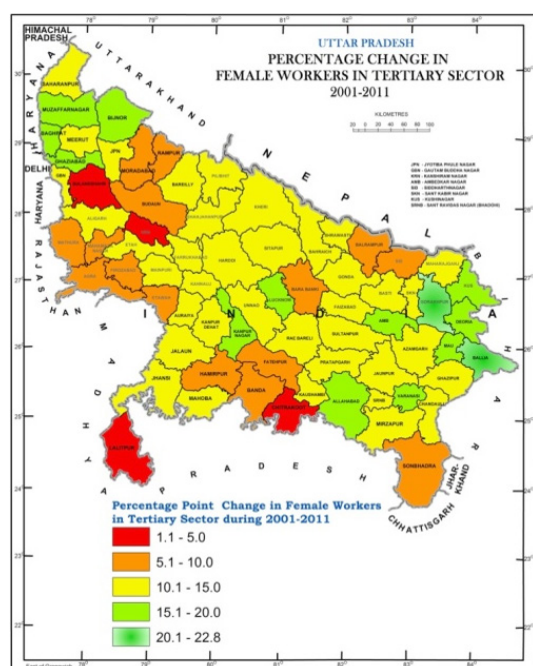


Fig. 5. Percentage Change in the share of Female Workers in Tertiary Sector in the Districts of Uttar Pradesh during 2001-2011.

iii. Tertiary Sector – The proportion of females workers in the tertiary sector have increased substantially by 13.7 percentage points to 29.7 percent in 2011 as compared to 2001 for the state as a whole. Among the districts, the proportion of female workers in

tertiary sector has increased in all the districts of Uttar Pradesh. The percentage point increase varies from 1.0 percent in Bulandshahr to 22.8 percent in Gorakhpur. The proportion of female workers in tertiary sector as per 2011 census varies among districts from 71.8 percent in Ghaziabad to 11.1 percent in Lalitpur and Chitrakoot. Figure 5 shows the percentage change in the share of female workers in tertiary sector in the districts of Uttar Pradesh during 2001-2011.

2. Results

2.1 Female Work Participation Rates and Other Selected Indicators

For correlation analysis of the female work participation rate of the female population, linear correlation based on table 4 has been prepared for fourteen variables measured for total rural and urban female population of all the seventy-one districts of Uttar Pradesh. All variables are assumed to be random variables. The correlation examines whether an association exists between the female work participation rate and random variables selected for the study, and if it does, to what extent. To examine the patterns between variables that indicate whether the variables are related scatter diagrams are plotted. Pearson's formula

Table 4. Results of Pearson's product moment correlation coefficient (r)

Variables	Definition	Female Work Participation Rate (Total) (Y_1)	Female Work Participation Rate (Rural) (Y_2)	Female Work Participation Rate (Urban) (Y_3)
X_1	Growth Rate of Female Population	-0.03	-0.06	0.06
X_2	Density of Female Population	-0.27	-0.27	0.20
X_3	Percentage of Female Population to the Total Population	0.28	0.21	0.22
X_4	Sex Ratio (Total)	0.28	0.21	0.22
X_5	Sex Ratio (Rural)	0.30	0.23	0.26
X_6	Sex Ratio (Urban)	0.08	-0.004	0.01
X_7	Literacy Rate of Female Population (Total)	-0.17	-0.12	0.31
X_8	Literacy Rate of Female Population (Rural)	-0.16	-0.14	0.26
X_9	Literacy Rate of Female Population (Urban)	0.28	0.29	0.32
X_{10}	Percentage of Urban Female Population to the Total Female Population	-0.35	-0.26	0.16
X_{11}	Percentage of Female Non-Workers to Total Female Population	-1.0	-0.98	-0.43
X_{12}	Percentage of Child Population (0-6 years) to total population	0.09	0.03	-0.28
X_{13}	Percentage of Female Scheduled Caste Population to total Female Population	0.33	0.33	0.23
X_{14}	Percentage of Female Scheduled Tribe Population to total Female Population	0.32	0.34	-0.04

is used to calculate the correlation coefficients. The correlation coefficient measures the degree of association between two variables X and Y.

Table 4 reveals that the positive values of r indicate positive or direct correlation the two variables X and Y i.e. X increases Y also increases or as X decreases Y also decreases. Negative values of r indicate negative or inverse correlation, thereby meaning that an increase in one variable results in a decrease in the value of the other variable. In a total of 6 out of 14 selected random variables are negatively correlated. Growth rate of female population (X1), density of female population (X2), female literacy rate (X7), rural female literacy rate ((X8), percentage of urban female population to total female population (X10) and percentage of female non-workers to total female population (X11) are negatively correlated with female work participation rate (Y1). Similarly, X1, X2, X6, X7, X8, X10 and X11 are negatively correlated with rural female work participation rate and only three variables i.e. X11, X12 and

X14 are negatively correlated with urban female work participation rate. The values of r ranging between 0.28 and 0.33 indicate a medium degree of association between the variables X3, X4, X5, X9, X13 and X14 and Y1 (female work participation rate). For this, it indicates that an increase in the percentage of female population, sex ratio (total), sex ratio (rural), urban female literacy rate, percentage of female SC and percentage of female ST is likely to increase female work participation rate.

2.2 Testing for the Significance of the Correlation Coefficient (r)

Student t-test is applied for testing the significance of r of the random variables (X1, X2.....X14) selected for the study with reference to Y (Y1, Y2 and Y3). From table 5 it is observed that the coefficient of correlation of fourteen indicators of female work participation rates (Y1, Y2 and Y3) with 98 degree of freedom are statistically significant at 95 per cent level of confidence. They are X1, X2, X3, X4, X5,

Table 5. T Testing of different variables for significance of the correlation coefficient

Variables	Definition	Female Work Participation Rate (Total) (Y ₁)	Female Work Participation Rate (Rural) (Y ₂)	Female Work Participation Rate (Urban) (Y ₃)
X ₁	Growth Rate of Female Population	-0.249*	-0.499*	0.499*
X ₂	Density of Female Population	-2.329*	-2.329*	1.696*
X ₃	Percentage of Female Population to the Total Population	2.423*	1.784*	1.873*
X ₄	Sex Ratio (Total)	2.423*	1.784*	1.873*
X ₅	Sex Ratio (Rural)	2.612*	1.963*	2.237*
X ₆	Sex Ratio (Urban)	0.667*	-0.033*	0.083*
X ₇	Literacy Rate of Female Population (Total)	-1.433*	-1.004*	2.708*
X ₈	Literacy Rate of Female Population (Rural)	-1.346*	-1.174*	2.237*
X ₉	Literacy Rate of Female Population (Urban)	2.423*	2.517*	2.806*
X ₁₀	Percentage of Urban Female Population to the Total Female Population	-3.104**	-2.237*	1.346*
X ₁₁	Percentage of Female Non-Workers to Total Female Population		-40.908	-3.956**
X ₁₂	Percentage of Child Population (0-6 years) to total population	0.751*	0.249*	-2.423*
X ₁₃	Percentage of Female Scheduled Caste Population to total Female Population	2.904**	2.904**	1.963*
X ₁₄	Percentage of Female Scheduled Tribe Population to total Female Population	2.806**	3.003**	-0.333*

**Significance at 1% Level; * Significance at 5% Level

X6, X7, X8, X9, X11, X12, and X14. Leaving two indicators namely, X10 and X13 with 98 degree of freedom are statistically significant at 99% level of confidence. Thus from the results of co-efficient of correlation it can be inferred that percentage of females to total population, sex ratio, female literacy rate, proportion of children (0-6 years), proportion of SC and ST females in total female population have direct bearing on female work participation rates. Contrary to it growth rate of female population, density of female population, literacy rates, percentage of urban females to total females show inverse relationship with female work participation rate.

Conclusions

In absolute terms, there is a net addition of about 33.0 million females in the population of Uttar Pradesh and female workers increased by 3.0 million during 2001-2011, against 6.0 million or 86.3 percent in the previous decade of 1991-2001. The size of female work force has reduced by 3.0 million from the previous decade of 1991-2001 in the 2001-2011. In fact, the growth rate of female workers is significantly higher than that of female population as greater proportions of women are observed into the work force. The female work force grew slowly than the female population in a total of 29 out of 71 districts of the state. The overall female work participation rate for the state as a whole has marginally increased during 2001-2011. The female work participation rate has noticeably decreased in a total of 13 out of 71 districts. The female work participation rate in the rural areas of the state as a whole has marginally decreased while considerably increased in urban areas during 2001- 2011. The female work force in rural areas of the districts has conspicuously decreased in a total of 16 out of 71 districts. The female work force in urban areas of the districts has invariably all 71 districts. Among the districts there are sharp differences in female participation. The primary sector remains the dominant source of female employment generation in Uttar Pradesh. A shift from the primary to the secondary and tertiary sectors is visible in all the districts, but in the case of females the shift to the tertiary sector is quite substantial. The female employment in the primary sector is decreasing at the faster rate, while female employment in the secondary and tertiary sector is increasing at faster

rate. The state remains heavily agricultural with the primary sector. The proportion of female workers in the primary sector is seen vary dramatically across the districts. As an economy develops, labour is transferred out of the primary sector. Therefore, it is the districts which have lower per capita incomes that have greater proportions of female workers in the primary sector. The correlation between district per capita income and the proportion of female workers in the primary sector is negative.

From the results it is clear that female work participation rate is high in the eastern part of the state and more particularly in Bundelkhand region, whereas, western districts are showing low level of female work participation rates. It is also clear from the results of correlation co-efficient and student t-test that percentage of females to total population, sex ratio, female literacy rate, proportion of children (0-6 years), the proportion of SC and ST females in total female population have direct bearing on female work participation rates. Contrary to it growth rate of female population, density of female population, literacy rates, percentage of urban females to total females show inverse relationship with female work participation rate.

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Geospatial Mapping of Fisheries Profile of Chhattisgarh state through GIS

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Abstract: Geospatial technology is fast growing segment of information technology that combines multiple applications like GIS, remote sensing, cad, and imaging tools. The geospatial technology capabilities in combination like other technologies can be decision making tools for planning. In the present times fisheries and aquatic science professionals are using GIS as a resource management tools. In this context, a study was performed where mapping of fisheries profile of Chhattisgarh state was performed through GIS tools having critical geographic dimensions. The mapped information can be used for the purpose of planning and decision making as each aspect of the map has different components involved. For this purpose, at the core of the system the data was assessed at an integrated level from disparate sources mainly level statistical hand book of Chhattisgarh state at district level. Data was brought in tabular form through Microsoft Excel and then joined to Arc info version 9.3.1 GIS Software with digitized map of Chhattisgarh state to enable mapping. This was further synchronized and integrated to generate four thematic maps searchable on several criteria.

Map 1 Contains fish production growth rate over the period 2001-04 fish import and fish export. With this mapping, planners and various stakeholders have accessible information as regards the various components of fisheries in the state of Chhattisgarh.

Map 2 Contains the searchable criteria as regards the fisher populations as well as their classified categories as per the computation in the state of Chhattisgarh. It also contains the searchable credible water resources of fishery, district wise private and public which are (Govt.) owned.

Introduction

Chhattisgarh one of the thirty five constituents of the country, occupies 135194 square km which is 4.14% of the geographical area of India. Uttar Pradesh in North, Jharkhand in North East Orissa in East, Andhra Pradesh in South, Maharashtra in South West and M.P. and Maharashtra in West form its borders. 43% land is covered by forests. There are 3 agro climatic zones comprising northern hills central plateau zone and Bastar plateau zone.

Northern Hills: The area of this agro climate zone accounts for 21% of the total geographical area. Koriya, Surguja, Jaspur, Raigarh, and Korba are districts situated in this zone.

Central plain Region: This agro climate zone covers 50% of the geographical area of the state. Raipur, Bilaspur, Champa, Janjgir, Kabirdham, Rajnandgaon, Durg, Dhamtar, and Mahasamund are the districts included in this plain zone.

Bastar Plateau Zone: It accounts for 29% of the total geographical area of the state. Kanker (North Bastar), Bijapur and Naragampur are districts included in this zone.

Objective:

- (i) To digitize the Chhattisgarh State on district level.
- (ii) To feed secondary data in Microsoft Excel and find out the fish production growth rate since 2000-2012.
- (iii) Join the different Excel sheets with the digitized map of Chhattisgarh state in Arc GIS 9.3.1 and create different thematic maps.
- (iv) On the basis of data analysis and results finding give the suitable suggestion for more fish production.

Sources of Data and Methodology

- Fish production data at districts level has been taken from Chhattisgarh Matsy Udog Sankhiki

- Bas map has been taken from Census Map of India.
- After scanning the Map of Chhattisgarh state (district wise) is reregistered in Arch GIS software (9.3.1)
- Excels table of Chhattisgarh states are Joined with the digitize map of Chhattisgarh state in Arc GIS software are (9.3.1)
- After Joining the Excel table with digitize map of Chhattisgarh, different thematic maps relating to fish growth production, fishermen population, Inland water area maps have been prepared.
- This study has been done with an objective of developing a GES tool for Indian fisheries growth rate based on state level Indian fisheries data collected from secondary sources viz.; hand-book of fisheries statistics 2003 published by Ministry of Agriculture, Government of India. Here, marine, inland and total fish production data of all the states of the period 1990-91 to 2003-04 have been brought in tabular form through Microsoft Excel and their rate has been calculated by using the following growth-rate mode in Microsoft excel sheet.

Growth in fish production (y) has been analyzed by using the exponential growth function of the form

$$Y = ab^t \quad \dots(1)$$

Where a = intercept, b = Regression Co-efficient, t = Time

The above mentioned equation has been used to obtain the growth-rate (r) of marine, inland and total fish production of all the states of India separately for the period [1990-91 to 2003-04]. Linear form of the equation is obtained by taking logarithms of both sides which is given by

$$\log_e Y = \log_e a + t \log_e b \quad \dots(2)$$

The exponential growth rate (r) can be computed by using the relationship

$$r = [\text{Anti log } e \text{ of } b - 1] \times 100 \quad \dots(3)$$

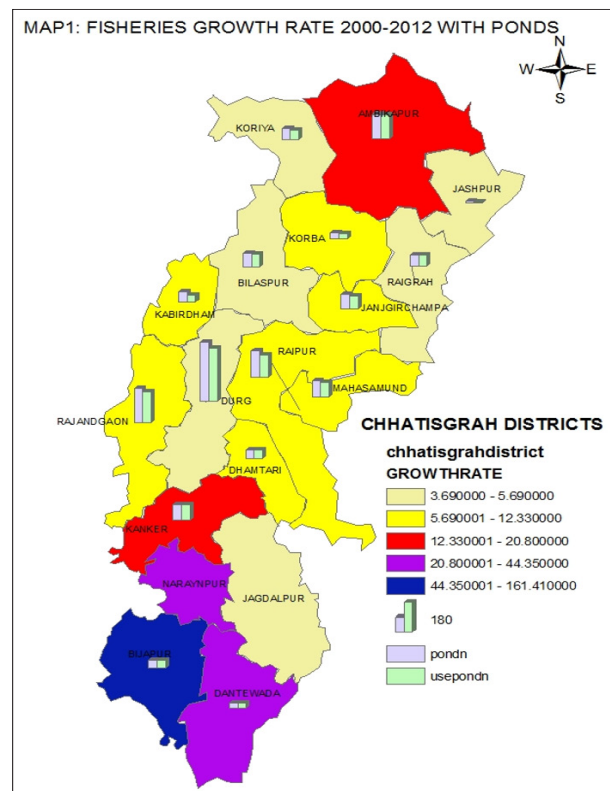
Growth rate have been calculated in Micro Soft Excel. The excel sheet is joined to digitized map of India by allotting a location code (LC) number to each state. After joining of the excel

sheet, geocoding process is adopting customized layering system in the GIS-Software Map Info, first layer in thematic map was created for fisheries profiles of India, the second layer in thematic map represents fish consumption for the year 2003.

Results and Discussion

1. Map 1 Fisheries growth rate with utilization of Ponds resources: According to Map 1 there are five categories of growth rates. The lowest growth rate is below 6.0 5% found in five districts namely Durg, Bilaspur Koriya Jaspurand Raigrath.

The second category of growth rate (5.69% to 12.33%) belong seven districts namely Rajandgan, Kabirdhan, Korba, Jamjir Chanpa, Raipur, Mahasmund and Dhamtami. The third growth 20.85%-44.35% belong to only two districts namely Ambikapur and Kanker, Forth category (20.80-44.35) Contain only two districts Narayanpur and Dantewada. The highest growth rate 74.4 to observed only Bijapur.



(ii) Layer Utilization of Ponds (Water Resources): The biggest (100%) water resources utilized by following districts Raigarh, Baster,, Naraynpura, Kanker, and Dandewada (Fig. 1).

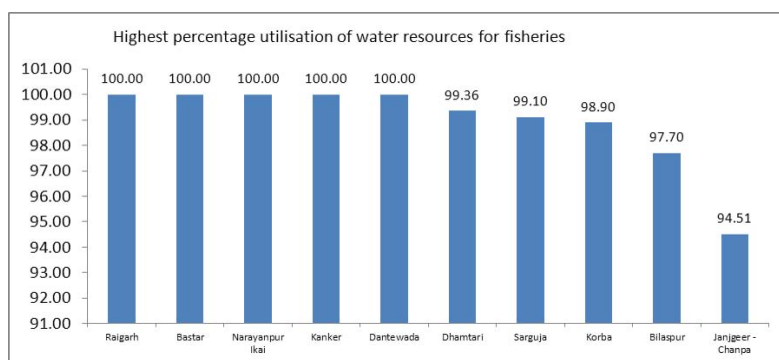


Fig. 1 Highest percentage utilization of water resources for fisheries

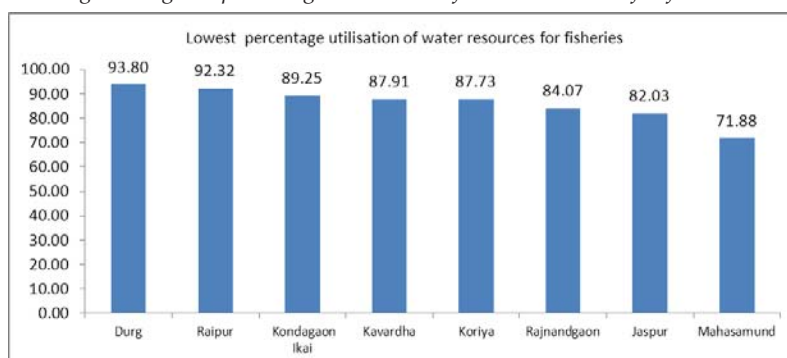


Fig. 2 Lowest percentage utilization of water resources for fisheries In Chhattisgarh

In the said district the growth rate is highest except Raipur where the fishers growth rate is 9.20 where Birapur (Baster) 161.41, Kanker 20.66, Narayanpura 44.35

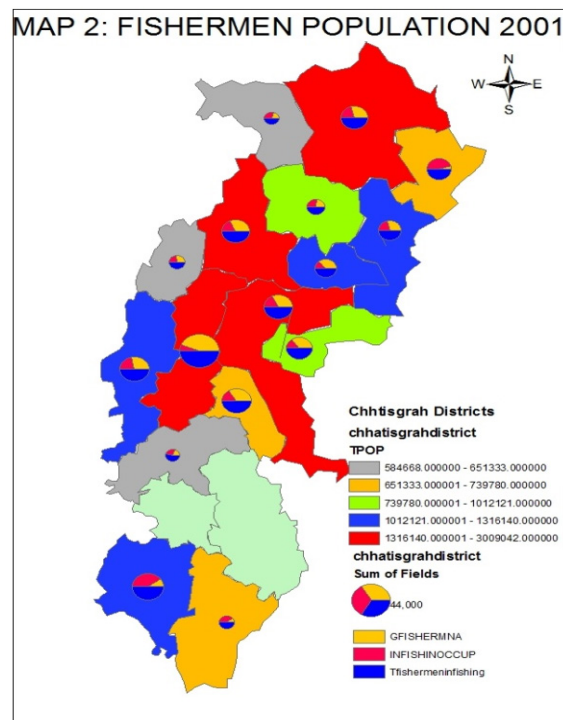
The lowest percentage of use of water resources has been identified Mahasamund (71.88 %) Jaspur (8.03%), Rajandgon (84.07 %) Koriya (87.73%) and Kavardha (87.91%) (Fig. 2).

2. Map 2 Fishermen population (2001): According to Map 2 and figure 3 Highest fishermen population is found in Durg, Baster, Raipur, state Rajandgoen, Dhamaturi belong to maximum fishermen population. Where in Durg general fishermen (by caste) is more and in Baster professional fishermen population become more. Likely Raipur, Rajandgaen, Dhamtaur and Bilaspur contain more general (Fig. 3).

Lowest fishermen population in the State: Koriya, Dantewada, Kavaradha, and Korba containg less fishermen population across the state. In these districts by professional fishermen population become more. In Korba, Kavardha and Kanker by professional fishermen population become more (Fig. 4).

3. Imports and Export fish status in Chhattisgarh state (2002-03): It has been

observed that some districts where population is more and fish consumption is also high they imports fish from their surrounding states. Their districts are Raipur, Kanker, Koriya, Baster and Sarguja (Fig. 5).



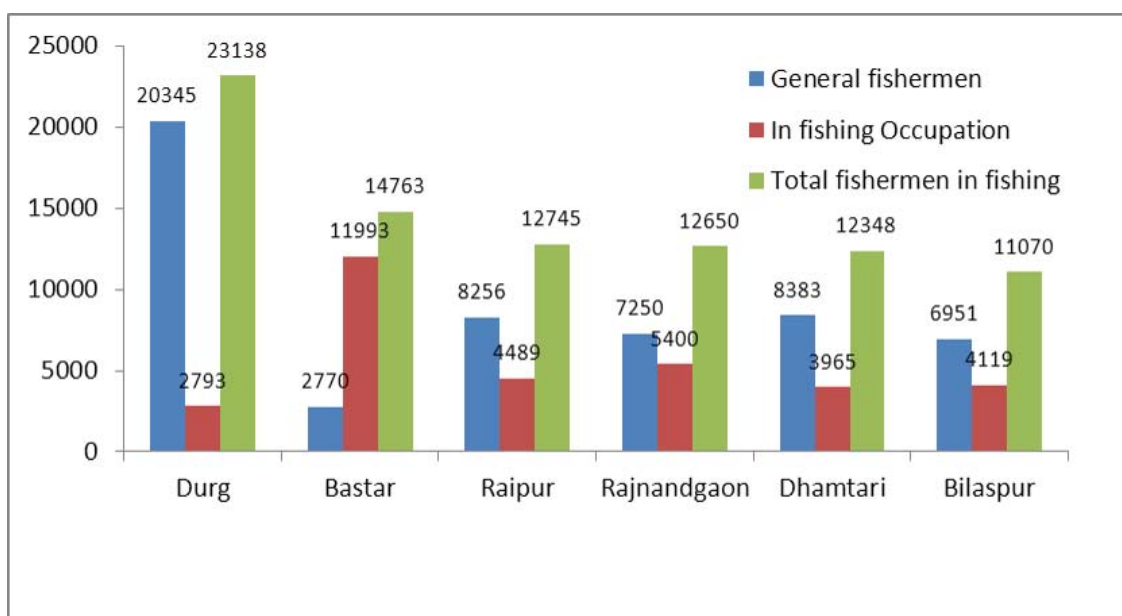


Fig. 3. Fishermen population across districts (Highest)

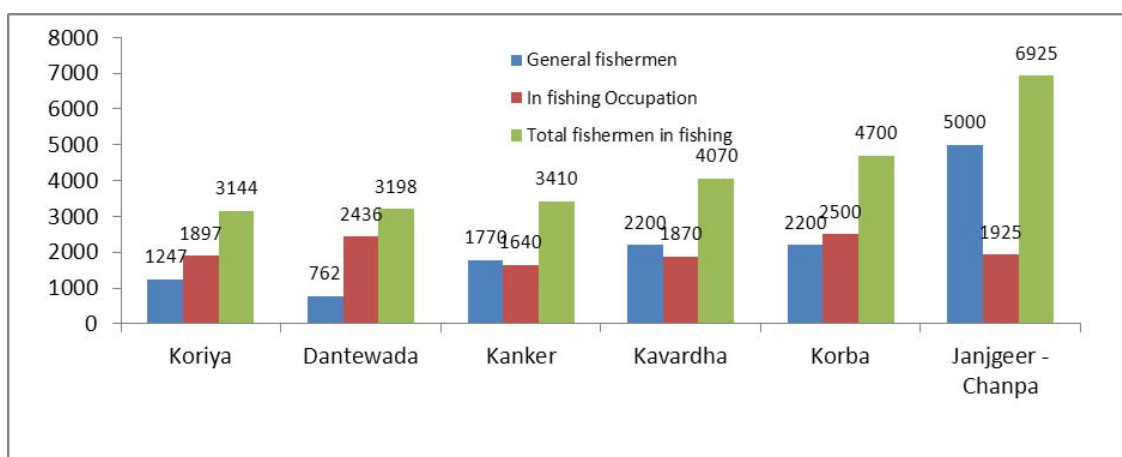


Fig. 4 Fishermen population across districts (Lowest)

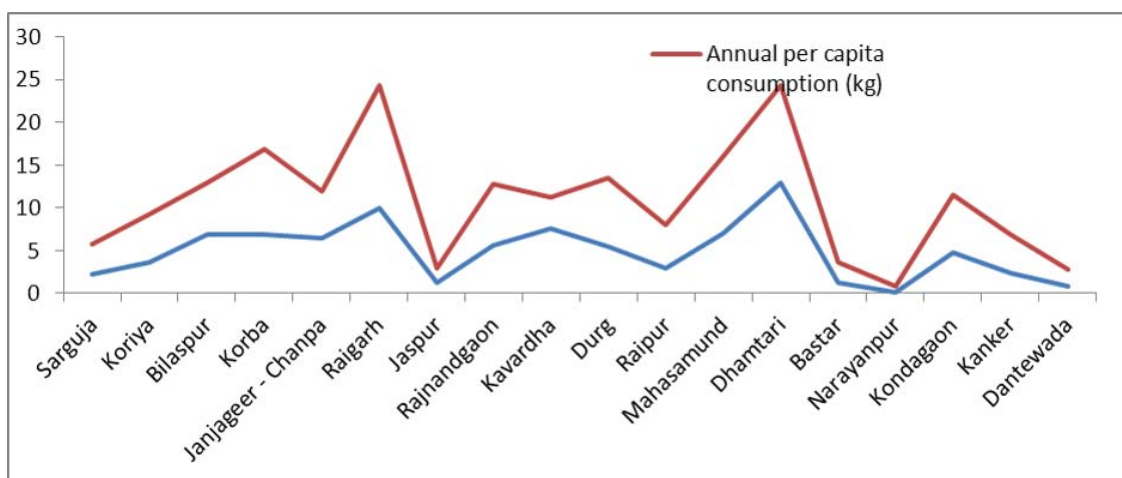


Fig. 5: Percapita production-consumption across coastal districts in Chattisgarh (kg)

Some districts where important fishespecieses are available they exports to U.P, West Bengal and Mumbai (Maharashtra). These districts are Bilaspur, Dhamtari, Janjnageera, Mahasmunda and Durg.

Fish production (per person production in kg./ Year) Fish consumption (consumption in Kg. per person in a Year) 2002-2003 According to data at state level production is less them consumption. According to data per person production per year is 501 kg where consumption per person per year is 6.4 kg. at state level. 70% population of Chhattisgarh states habituate of fish eating. Raigrah, Korba, Mahasmunda, Koriya Raipur ad Durg, there are the districts where consumption is more than production. Dhamtari, Sangirchapa, Bilaspur

there are the districts where production is more than consumption.

Conclusion and Suggestion

Chhattisgarh is situated in the middle part of the country. There are enormous potential for fisheries development. It is climate & meteorological condition is favorable for fisheries. Suggestions for more production of fishes in the state are following.

- Production and distribution of fish seed.
- Supply of quality seed for stocking.
- Development of Reservoir & Reverine fisheries.
- Training to farmers and out of the state study tour to learn new techniques.

Political Economy of Under Development in Mewat, Haryana

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Keywords: *Anatomy of Underdevelopment, Levels of Development, Socio-Economic indicators, Non-Workers, Marginal and Small Landholdings, Subsistence Agriculture, Land Mortgages, Low educational level, Mewat region, Ethnicity*

Abstract: This paper tries to capture the anatomy of underdevelopment in Mewat region, Haryana. Development and underdevelopment both are related. The paper proceeds by selecting some indicators of socio-economic development and finds that Mewat is at the lower end in levels of development in all districts of Haryana. A further analysis of the disaggregated data at the tehsil level reveals structural underdevelopment. Non-workers outnumber total work force participation. Agriculture is the main occupation of the people. The nature of the economy is generally subsistence in nature. Area leased-in for share of produce declined from 1995 to 2005. Usufructuary mortgages also declined from 1995 to 2005. Usufructuary mortgages had higher incidence for semi medium, small and medium landholdings in 2000-01. There is higher preponderance of marginal and small farmers in Taoru, Nuh, Hathin and large farmers in Ferozepur Jhirka and Punhana. The level of urbanization is abysmally low and most of the people continue to live in the rural areas. The average gender gap in literacy rate is relatively higher in three out of five tehsils. Most of the villages are in the low and very low levels of development and less than one percent in very high levels of development which demonstrates that underdevelopment is highly entrenched at the micro local level in Mewat region.

Introduction

Twentieth century has been a watershed in the development discourse especially for countries like India. While many regions in India attained significant development levels, some are still lagging behind. In due course, some special assistance programmes were undertaken for these regions with an emphasis on the decentralization of power and the participation of people in decision-making but the results have been disappointing (Mewat Completion Report Digest 2008). Development and underdevelopment both are related. Underdevelopment does not mean the absence of development (Frank 1975). It means dependent, distorted and truncated development and the economy generally lacks dynamism, which ultimately leads to disarticulation of the economy (Amin 1974). Mewat region in Haryana presents all these characteristics of an underdeveloped economy. This paper tries to capture the anatomy of underdevelopment in Mewat region, Haryana.

Study area

Mewat is one of the most backward regions of the state. It has a distinct ethnic and cultural identity. The district is predominantly rural (89.05 %) and lies between 26 degree and 30 degree North latitude and 76 degree and 78 degree East longitude (Fig.1). It is a part of the indo-Gangetic plain and touches National capital region in the southwest and Rajasthan in the northeast. The region falls under sub tropical semi arid zone II of agro climatic zones of Haryana (Comprehensive District Agricultural Plan, 2012). To improve the standard of living of the people in Mewat, Mewat Development Agency was constituted under the aegis of the Mewat Development Board in 1980. However, the region continues to lag behind in socio-economic development as compared to the rest of Haryana (Amir Ali 1970; Ahmed 1994 as cited in Maheshwari 2003). Historically, the region has been discriminated and neglected a lot (Mayaram 2004). Belu Maheshwari sums up the situation:

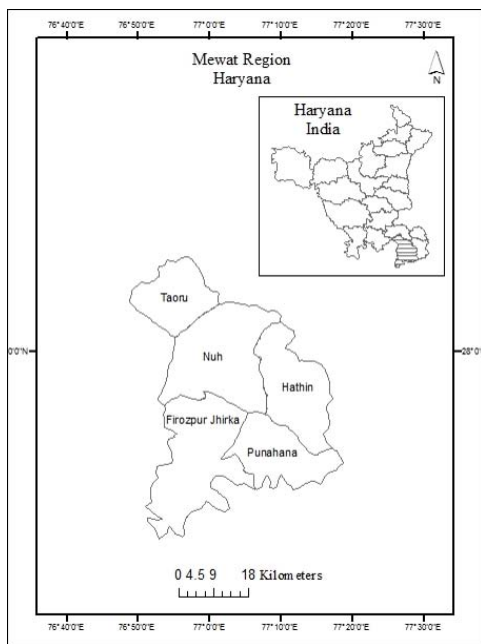


Fig. 1

"The reason for the neglect is that politically the area is not much of relevance. The Mewatis comprise a mere 3 percent of the Haryana population and do not count much in terms of votes. The district administration, taking its cue from the political bosses, shows total antipathy to the region. This can be seen from two facts; firstly, only 60 percent of posts are normally manned. Absentism among employees is endemic, most employees think of Mewat as punishment posting (Kalapani) and their residences are outside the area. 'Even the Chief Administrator, Mewat Development Board, stays in Gurgaon and no incumbent has continuously stayed for two years on the post'".

Mewat development area project was launched in 1995 but the project suffered on several counts. The implementation was tardy. The role of the bureaucracy was not satisfactory and the overall project performance was poor.

Data Sources and Methodology

The secondary data sources are taken from Census of India 2001 and 2011, Office of Registrar General and Agricultural Census 2000-2001 to 2005-06, Department of Agriculture & Cooperation of Govt. of India. Village directory Census data 2011 and agricultural Census data 2010-11 is still not in the public domain. Only Primary Census Abstract village level data is available which gives only selected demographic indicators. Therefore the researcher has

relied on 2001 Census and Agricultural data 2000-01 for constructing indices of levels of development at the district and village level. This paper attempts to locate Mewat in terms of levels of development vis-à-vis other districts in Haryana. The study proceeds by selecting some indicators of development first at the districts level, then at the tehsil level and at the village level. Z scores are used to make the variables scale free and then the indicators are added horizontally for composite index score. The formula of Z scores is:

$$Z_i = (X_i - \bar{X}) / S_x$$

Z_i = Z scores for observation ith

X_i = The value of X variable for its ith observation

$\bar{X}$ = Mean of the values of X

S_x = Standard deviation of the X values

District wise Levels of Development

The composite index of Z scores (Fig. 2) shows that Panchkula, Kurukshetra, Karnal and Panipat are the most developed districts. In the second class, Ambala, Yamunanagr, Hissar and Sonipat are the most developed districts. Kaithal, Fatehabad, Sirsa, Rohtak, Faridabad and Palwal are in the category of third class. In the fourth category, there are

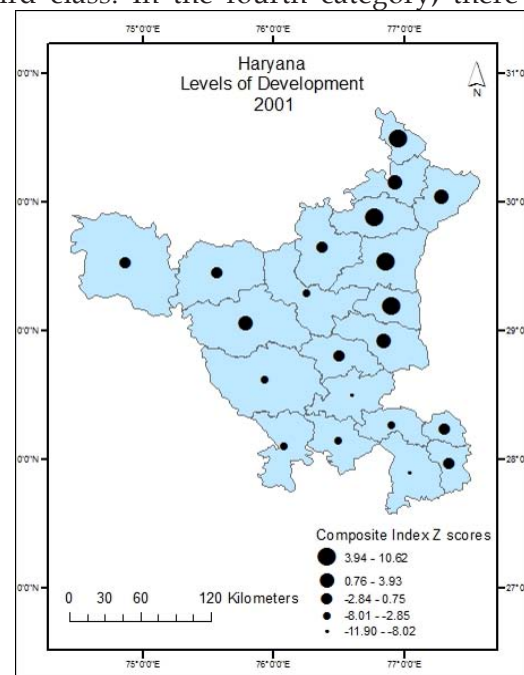


Fig. 2

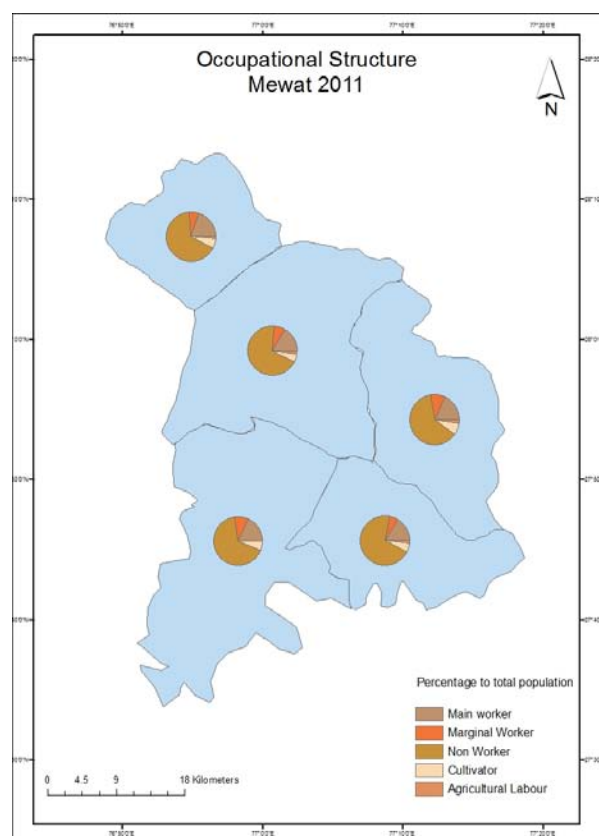


Fig. 3 Occupational Structure

Jind, Bhiwani, Mahendragarh, Rewari and Gurgaon districts. Jhajjar and Mewat are in the last category of levels of development. Mewat is a part of the southern Haryana plain and at the lowest levels of development. This area lacks of irrigation facilities. Therefore, agricultural potential is limited here. Almost on all indicators, it shows the extreme level of backwardness. The backwardness in the primary sector further pushes behind the revival of the secondary sector. As a result, Southern Haryana faces development deficit as compared to northern Haryana. This region also has a distinct cultural and ethnic character from the rest of Haryana.

Occupational structure (Fig.3) is indicative of the distribution of workers in the economy. This distribution reflects the nature of the economy and its orientation. Workforce participation is highest for Hathin (30.54 %) and lowest for Punhana (23.70 %). Males have more workforce participation than females. Main workers constitute of the highest % in Taoru (21.34 %) and least in Punhana (17.6 %). Hathin has the highest % of cultivators (8.18 %) and Nuh has the least (6.06 %). Hathin has highest % of agricultural labourers (2.89) while Ferozpur Jhirka the least (0.60 %).

Non-workers constitute a significant proportion of the workforce participation. Punhana comprises relatively more non-workers than other tehsils and Hathin the least. Punhana, Ferozpur Jhirka and Nuh have more non-workers while Taoru and Hathin have fewer workers than the district average. Higher % of non-workers indicates their dependence on the working population and is a burden on the scarce resources.

The Natural Resource Base

Net sown area classified by the size class of the land holdings (Table 1) indicates the technological base of the economy. It indicates one significant aspect of the level of agricultural development. In Taoru, Semi-medium and medium has the highest net sown area than small and marginal land holdings.

Terms of Leasing

Leasing-in area (Table 2) is a significant temporary land resource over a period of time. It points to the direction of relations of agricultural production. Terms of leasing are significant only for Ferozpur Jhirka and insignificant in the case of other tehsils. Share of produce is a significant mode of leasing of land in Ferozpur Jhirka. It is more significant in the

Table 1: Distribution of Net Sown Area in Mewat by size class (area in %)

Size class	Taoru	Nuh	Ferozpur Jhirka	Punhana	Hathin
Marginal	15.82	10.71	8.83	8.34	15.61
Small	17.73	14.46	18.64	12.34	14.29
Semi medium	30.20	24.96	25.59	24.89	27.55
Medium	26.60	30.75	36.96	36.06	32.15
Large	9.65	19.12	9.99	18.38	10.40

Source: Agricultural Census, Ministry of Agricultural and Cooperation of India, 2005-006.

Table 2. Distribution of Leased-in area in Ferozepur Jhirka for Partly Leased-Landholdings for all Social Groups (area in hectares)

Size class	Fixed Money			Area leased-in for Share of produce			Usufructuary mortgage			Other terms		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Marginal	0	0	0	0	29	0	10	0	0	0	0	0
Small	0	0	0	4	94	0	10	26	0	13	0	0
Semi Medium	0	0	0	5	183	0	19	0	0	13	0	0
Medium	0	0	4	0	52	0	1	51	0	1	0	0
Large	0	0	0	0	13	0	0	15	0	0	0	0

Source: Agricultural Census, Ministry of Agricultural and Cooperation of Govt. of India

Note:* Usufructuary mortgage occurs when the mortgagee is unable to pay the loan amount to the mortgager. In this situation, the ownership of land is with the mortgager unless and until the whole amount is paid.

case of semi medium and small landholdings followed by medium and large landholdings. From the data it seems that area leased-in for fixed money is zero except in the case of medium landholdings in 2005.

Usufructuary mortgage is more significant in 2000-01 in the case of medium, small and large landholdings over 1995-96 in case of semi medium, small and marginal landholdings. Area under mortgage increased in the case of medium, small and large landholdings and decreased for semi medium and marginal landholdings. Other terms were significant in 1995-96 for semi medium and small landholdings and insignificant in the case of 2000-01 and 2005-06 for all size classes.

Subsistence farming

Pulses and cereals still constitute a larger % of the net sown area in Mewat. In rural areas, consumption of cereals and pulses is very high. Higher consumption result in less production for the market. Less production for the market implies less profitability of agricultural production. Subsistence agriculture is the chief characteristic feature of agricultural in Mewat. Semi medium and medium landholdings have the highest area in all tehsils except Nuh where large landholdings have the highest area under cereals. In Taoru and Nuh, semi medium have the highest area under pulses while medium landholdings in Ferozepur Jhirka and Hathin. Large landholdings have the highest area under pulses.

Distribution of Landholdings by Size class

Taoru has the highest % of marginal landholdings (9.34%) followed by Hathin

(8.61%). Punhana has the least % of marginal farmers (5.04%). Small landholdings have the highest % in Ferozepur Jhirka (18.33%), Taoru (17.74%) and least in Punhana (12.34%). Semi medium landholdings have the highest % in Taoru (30.20%) and Hathin (25.93%). Medium size landholdings are highest in Ferozepur Jhirka (37.39%) and Punhana (36.05%). large landholdings is highest in Punhana 14.92%) and Nuh (12.71%).

Socio-economic Development

Literacy is a good indicator of development. Selected Socio-economic Indicators are given in table 3. It reflects the level of modernization of the people that enables them to utilize the potentialities and resources of the region more efficiently. General educational attainment by literacy rate is highest in Taoru and Hathin and lowest in Ferozepur Jhirka and Punhana. There are also significant differences in male and female literacy, which translates into gender gap. Gender gap is highest in Hathin and Punhana and lowest in Taoru and Nuh. Sex ratio is highest for Punhana and Ferozepur Jhirka and lowest for Nuh and Hathin. Urban population is highest in Taoru and Punhana and lowest in Nuh and Punhana. About 89.05 % of the population stays in the villages. A large rural belt is still untouched by the process of urbanization. Urbanization greatly aids the structural change in the economy.

Table 4 indicates that Hathin has recorded the highest change in literate persons followed by Punhana and Ferozepur Jhirka. Taoru and Hathin are the net gainers in female per one thousand males. While Ferozepur Jhirka and Punhana are gainers in 0-6 sex ratio, Taoru

Table 3. Selected Socio-economic Indicators (in %)

Name	Literate Persons	Male Literacy	Female Literacy	Gender Gap	SC population	Sex Ratio	Sex ratio 0-6	Urban _ population
Taoru	51.36	62.23	39.29	22.94	14.09	901	871	17.15
Nuh	42.69	54.85	29.14	25.71	6.19	898	897	7.66
FPJ*	39.70	52.20	26.00	26.20	5.50	913	916	11.77
Punhana	37.80	50.50	23.82	26.68	5.17	913	921	12.79
Hathin	46.50	59.36	32.08	27.28	8.82	892	889	5.36
Mewat								

Source: Primary Census Abstract, Office of the Registrar General, Census of India, 2011

Note: FPJ* implies Ferozepur Jhirka

Table 4. Changes in Selected Socio-economic Indicators 2001-2011 (in %)

Name	Literate persons	Male Literacy	Female Literacy	Sex Ratio	Sex Ratio 0-6	SC population	Urban population
Taoru	+(7.11)	+(5.91)	+(8.74)	+(20)	-(5)	-(0.29)	+(3.42)
Nuh	+(9.06)	+(7.92)	+(10.44)	+(7)	+(7)	-(0.65)	+(2.47)
FPJ*.	+(9.95)	+(8.98)	+(11.14)	+(9)	+(21)	-(0.89)	+(4.49)
Punhana	+(10.04)	+(9.42)	+(10.69)	+(2)	+(17)	-(0.19)	+(6.79)
Hathin	+(11.45)	+(10.91)	+(12.42)	+(20)	+(7)	-(0.67)	-(0.64)
Mewat							

Source: Computed from District Census Handbook, Census of India 2001 and Primary Census Abstract, Office of the Registrar General, Census of India, 2011

Note: FPJ* implies Ferozepur Jhirka

is the net loser in 0-6 sex ratio. Punhana and Ferozepur Jhirka are the highest net gainers in urban population. Hathin has added the least urban population.

Village Levels of Development

As the tehsil level, indicators show a varied nature of structural underdevelopment in Mewat (Table 5). About 92.38% of the population of Mewat stays in the villages. The cultural landscape of Mewat is predominantly rural. Without exaggeration, Mewat is a land of villages. Therefore, any study on Mewat has to look at the village levels of development. Figure 4 shows certain clusters. As the map

clearly shows there is clustering of development close to the Bhiwadi industrial area touching Taoru. This area has certain advantages that it

Table 5: Village Levels of Development (2001)

Classification	Number of villages	Levels of development
First category	3	Very High
Second category	22	High
Third category	68	Medium
Fourth category	218	Low
Fifth category	203	Very Low

Source: Author calculations

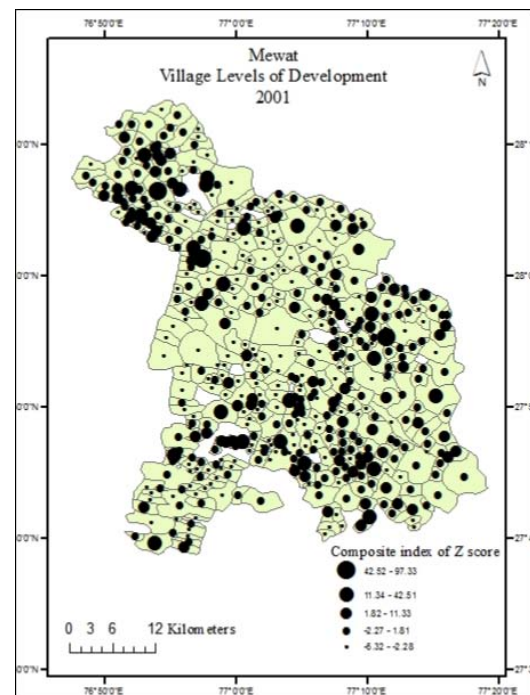


Fig. 4.

enjoys certain economies of scale in terms of concentration of industries and in the remaining area various ancillary units gets established to cater to the needs of those industries. Only three villages come in this category.

The second belt of concentration is found in the Hathin tehsil. Third belt of concentration lies in the borderlands of Punhana and Ferozpur Jhirka and is very much scattered. It is close to the Faridabad industrial area where large number of small-scale industries is located and due to this, several ancillary units have come up in the area. In the second category of high levels of development, there are twenty-two villages. In the third category of medium levels of development, there are 68 villages. In the fourth category of low levels of development, there are 218 villages and in the fifth category, there are 203 villages. Taken together both the fourth and fifth category of low level and very low levels of development, these add up to 421 villages as compared to only 3 villages in the very high and 22 villages in the high levels of development. Out of 514 villages, 421 villages translate to eighty percent of the villages and twenty-five villages (very high and high) less than five percent.

Conclusion

The analysis reveals that at the district level, Mewat shows relatively lowest levels of development among all the districts of Haryana. Being an ethnic tract puts it at double disadvantage vis-a-vis the other districts of Haryana. Despite situated in the national capital region, it continues to lag behind in all spheres of development. The development indices have improved over a period of time but the change has been very slow. Non-workers outnumber total work force participation. It indicates higher dependence of non workers on the productive workers. Pulses and cereals still constitute a larger % of the net sown area in Mewat. There is preponderance of marginal and small farmers. There is higher incidence of usufructuary mortgage for marginal, semi -medium and small landholdings. The potential of the agriculture sector is limited. Small and medium landholdings have higher incidence of usufructuary mortgages. There is higher gender gap in literacy rate between males and

females. It shows higher female deprivation in educational attainment. Average sex ratio is higher in two tehsils and lower in three tehsils. Average level of urbanization is higher in one tehsil and lower in the four tehsils.

About 89.05% of the population lives in the rural areas. Although mortgages declined from 1995 to 2000 and became almost nil in 2005, yet from 1995-2000, mortgages was highest for marginal, small and semi medium size landholdings in 1995. The poor resource base combined with low agricultural potential has resulted in structural underdevelopment. There is a historical aspect to the relative underdevelopment in Mewat also (Mayaram 2004).

The village levels of development shows some interesting patterns. Out of 514 villages, 421 villages are in the low and very low levels of development while three villages are in the very high and 25 villages in the high levels of development, which show that most of the villages are in the low levels of development. Therefore, the process of underdevelopment is operating on a much wider horizon in Mewat. In fact, one can say that there is a development of underdevelopment. It has been nearly 32 years since the Mewat Development Board was constituted in 1980s that there has been no noticeable increase in the level of development and the progress is so slow that one hardly notices any change in the life of the people. Summing up, Underdevelopment in Mewat represents a major challenge for policymakers in general and regional planners in particular.

[The author expresses gratitude to Prof. B.S. Butola for his guidance.]

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Cartographic Appraisal of Historical Development of Land Use System in Erstwhile Marwar State with Special Reference to Jodhpur Pargana

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Keywords: Marwar State, Jodhpur Pargana, Khalsa land, Jagir, Sasan, Land use

Abstract: Marwar the largest kingdom in Rajputana and the 3rd largest of the Indian kingdoms after Kashmir and Hyderabad was established in 6th century. The state spread over 91124 km² has 22 Parganas. Based on available old records from 1657 AD onwards, administrative and census reports and maps, the tenancy system, land use and agriculture of erstwhile Marwar State has been assessed. Abolition of Jagirs and development of land tenure and land reforms are highlighted. Marwar State map of 1939 was digitized and Jodhpur Pargana map showing villages of different legal status has been prepared. Historical development in irrigation and cropping system are worked out and mapped. Trend in land use in Jodhpur Pargana from 1901 to 1951 has been worked out. Results reveal 8 times increase in land put to non-agricultural uses, net area sown 33%, double cropped area 60 times and net irrigated area 10 times respectively. On the other hand the area under culturable waste has declined by 81% and fallow lands by 59%. Increase in mining and decline of common pastures is very much evident. Assessment of land use changes in Jodhpur district from 1957-58 to 2011-12 has been done. Besides, spatial land use changes are highlighted by comparing recent RS&GIS based land use map of Jodhpur district with land use maps of 1976-77 and 1989-90.

Introduction

Marwar, the largest kingdom in Rajputana and the 3rd largest of the Indian kingdoms after Kashmir and Hyderabad, was established in 6th century. The state spread over 91124 km² had 22 Parganas. Marwar was governed by feudal jagirdari system under aristocratic setup. There were no land tenancy laws and entire land was vested either to state (*Khalsa*) or *jairdars* (*Jagir*) who collected revenue from farmers in cash (*hasil*) or in form of produce. Farmers had no rights and as such land use and agriculture was in very poor stage. Farming was totally traditional and subsistence. Irrigation from dug wells with traditional water lifting devices was confined in limited villages along the younger alluvial plains and valley fill regions. No land records data was available except for *khalsa* villages on few aspects only. After independence and merger of Marwar state into Rajasthan, the *jagirs* were abolished and farmers were made owner of the lands they were cultivating. Survey, classification and preparation of land records and settlement of

land was undertaken; land revenue fixed for different category of land; ownership and use of land documented; various land reformation and agricultural development processes started.

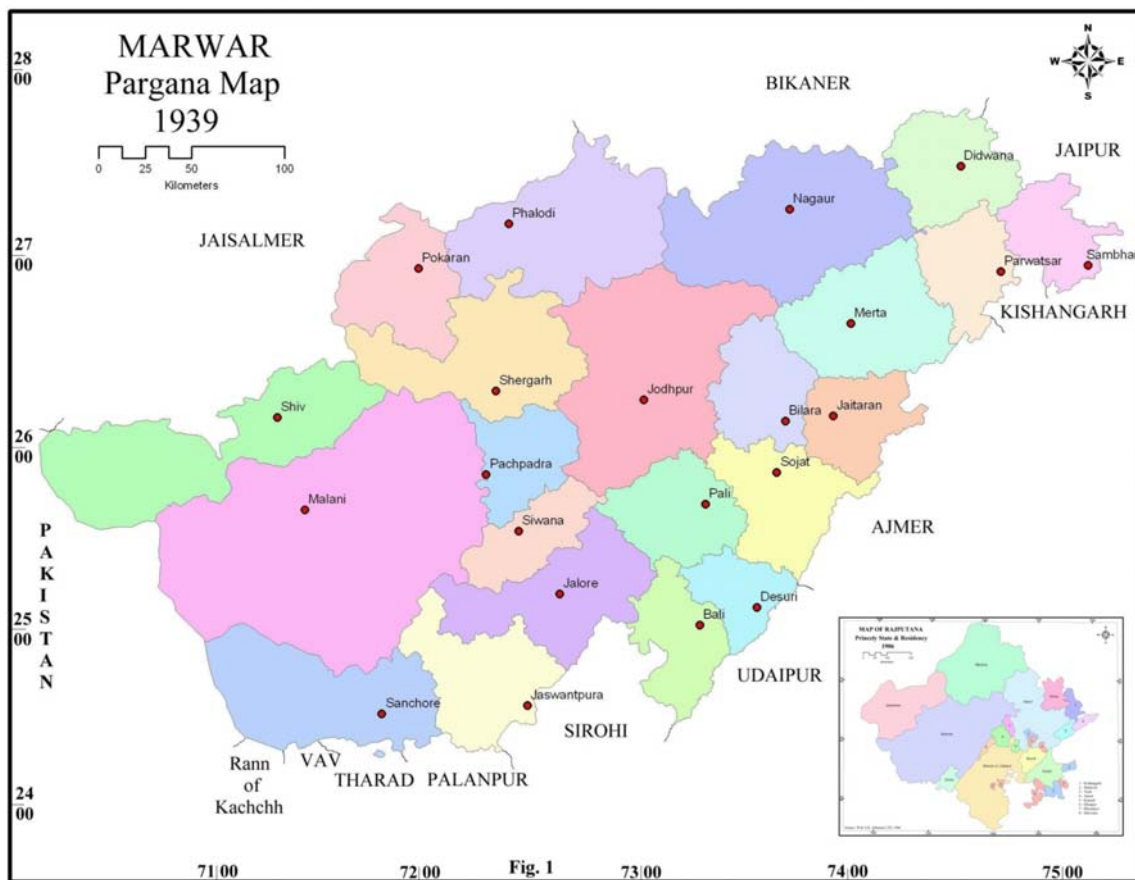
With the above background the present study aims to trace out the historical account of erstwhile Marwar State on tenancy system, land use and agriculture from the available records, maps etc.; digitize old maps, analyze dataset and prepare thematic maps using RS&GIS technologies. Based on available old records of 1657-58 AD, major land use systems of Jodhpur Pargana have been mapped. Analysis of limited land use data of Jodhpur pargana from census reports from 1901 to 1951 is highlighted. Trend in land use and cropping pattern in Jodhpur district has been worked out by analyzing data from 1957-58 to 2011-12 and updating land use map through digital interpretation of IRS P6 LISS-III data. The major issues of the region are brought out and measures are suggested for appropriate use of lands, sustainable management of natural resources and ecological improvement.

Location and Extent

The erstwhile Marwar State which extends from Girab in the west to Shamgarh on the Aravallis was bounded in north by Bikaner state; on the north east by Sekhawati districts of Jaipur state; towards east by Jaipur and Kishangarh state, south-east by Mewar (Udaipur) and British province of Ajmer, south by Sirohi and Palanpur state; towards west by Rann of Kutch and Thar and Parker district of Sind and on northwest by the State of Jaisalmer. It extended between $24^{\circ} 36'$ and $27^{\circ} 42'$ north latitudes and between $70^{\circ} 06'$ to $75^{\circ} 34'$ east longitudes. With a total geographical area of 35061 sq. miles or 91124 km², it occupies maximum NE-SW length of 467 km with a maximum width of 211 km. It had 22 parganas (Fig. 1), 4500 villages and 17 Top Thikana (Siyasat). Each pargana was presided over by a 'Hakim'. When Maharaja Jaswant Singh ji occupied thrown in 1650 AD, there were only Jodhpur, Sojat, Phalodi, Merta and Siwana parganas under Marwar. Soon after Jaitaran and Pokaran paragana were included.

Historical Background

Rajputana was having 19 princely states and three chiefships. Marwar, the largest kingdom in Rajputana and the 3rd largest of the Indian kingdoms after Kashmir and Hyderabad, was established in 6th century by Gurjara Pratihara with a capital at Mandore. The historical account of Marwar State is given by various authors viz. Adams (1899), Bhati (1968a, 1968b, 1974), Tod (1978a, 1978b), Sharma (1993) and Kumar (2008). In 13th century Jodhpur State was founded by Rathore clan of Rajputs who claim descent from Gahadvala king of Kannauj. Rao Siyaji, grandson of Jaichand came to Marwar after sacking of Kannauj by Mohammad Ghori in 1194. His 10th successor Rao Chanda finally wrested control of Marwar in 1226 from the Gurjara Pratihara. The city of Jodhpur, capital of the Rathore state was founded in 1459 by Rao Chanda's successor, Rao Jodha. There had been 13 rulers of Marwar state from 1250 to 1459 from Rao Shiya to Rao Rid Mal and 28 rulers from 1459 to 1947 from Rao Jodha to Maharaja Hanwant Singh. In 1581 Marwar was brought under



direct control of Mughal administration and remained so till 1583. In 1818 Jodhpur was brought under British control and become a princely state of Rajasthan. In 1891 there were 4225 villages in Marwar. In 1931 the numbers of inhabited villages were 4158.5 while total villages were 4346 (Anon.1931). In 1941 there were 4185 inhabited villages and 26.5 towns with a total population of 2555904. Bali, Parvatsar and Sambhar were most thickly populated parganas (> 50 person/km²) while Phalodi and Sheo were having lowest density of population. Pargana wise details of area, number of villages, population and density are given in table 1. After independence on 7th April 1949, Maharaja Hanwant Singh acceded to the Govt. of India and it was merged into newly created state of Rajasthan and was divided into five districts viz. Jodhpur, Nagaur, Pali, Jalor and Barmer.

Method and Materials

Marwar State Map on 1: 253,440 scale (SOI, 1939) has been digitized and map showing village (of different legal status) boundary has been prepared. Village boundaries and names were verified from District Census Handbook, 1971 of Barmer (1972a), Jalor (1972b), Jodhpur (1972c), Nagaur (1972d) and Pali (1972e). Based on this map and Census of Marwar, 1931 (Anon.1931), the pargana map of Marwar and village map of Jodhpur pargana prepared. Land use and cropping pattern data from agricultural statistics of 1900-01, administrative reports of Marwar State from 1917-18 to 1930-31 and Marwar Census of 1941, were analyzed to workout land use development. Based on available old records of 1657-58 to 1663-64 AD from *Marwar Pargana -ri- Vigat* by Muhta Nainsi (Bhati 1968a,

Table 1. Area, Number of villages and Population of different Parganas of Marwar State, 1941

Pargana	Area (Km ²)	No. of inhabited village	No. of towns	Total Population	Density of Population
Marwar State	91196.31	4185	26.5	2555904	28
Jodhpur City	67.57	00	1	126842	1877
Bali	2167.6	157	1	132522	61
Bilara	2058.4	116	2	89721	44
Desuri	1845.3	144	1	92404	50
Didwana	2952.5	240	2	125006	42
Jaitaran	2235.1	156	2	108171	48
Jalor	4033.6	229	1	175285	43
Jaswantpura	3534.6	225	1	132809	38
Jodhpur	7459.1	371	0	171996	23
Mallani	14736.3	477	1	234190	16
Merta	4200.0	325	1	149474	36
Nagaur	6778.2	310	2	172634	25
Pachpadra	2224.7	96	2	44165	20
Pali	2661.4	142	1	71395	27
Parvatsar	2183.2	202	1	121801	56
Phalodi	9239.4	139	3	102351	11
Sambhar (Marwar)	1455.4	118	2	84540	58
Sambhar (Samlat)	415.8	6	0.5	9978	24
Sanchoe	4725.0	233	0	91811	19
Sankra	189.7	22	0	10371	55
Sheo	6362.3	72	0	29168	5
Shergarh	4649.6	103	0	82773	18
Siwana	1975.2	84	0	55774	28
Sojat	3046.0	218	2	140723	46

Source: Census of Marwar State, 1941

1968b, 1974), major land use and agriculture systems of Jodhpur *Pargana* are find out and mapped. Land use mapping of Jodhpur district was carried out on 1:50,000 scale through interpretation of toposheets and IRS P6 LISS-III data supported with field survey and results were compared with earlier prepared land use map of the district for 1976-77 and 2005-06. Land use data of Jodhpur district from 1957-58 to 2011-12 are analyzed to assess long term changes. Various reports on natural resource assessment and management are consulted to find out potential and problematic areas and major issues.

Results and Discussion

Land tenure system:

Out of total 36120 sq miles or 93876 km² area of Jodhpur state, khalsa lands constitute 17% and jagir lands 83%. Forest were 457 sq miles or 1.3% (Banerjee, 1952). These were regulated by Marwar Forest Act 1934. 831.7 sq km khalsa area was under forest department. Total khalsa area was 14411.5 sq km. Culturable wasteland constitute 1359.3 sq km. Jagirdars were having 80569 sq km area under their control. Extensive forest areas in the vicinity of villages were earmarked in 1906 in Jodhpur state for supporting the requirements and meeting the rights of villagers and their grazing need. These 'Gujara' forests were already degraded. The position of farmers in what were Khalsa was better than kisans of the jagir areas. He was only a little above a beast of burden. The bigger jagirdars has judicial powers including magisterial powers. Further they had their own police force besides the revenue staff. This enabled them to keep their stronghold on the farmer. Jagirdar would in first instance be taking 50% of produce. 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 important farming community. Among them the important categories of peasants were: *Karsa* (resident cultivators), *Pohis* (non-resident cultivators) and *Basi* (subordinate peasants). Following were the village category.

1. *Khalsa* or fiscal land: Ultimate ownership rest with state (paid by revenue).

2. Non-Khalsa land including *bhumichara*, *jagir* and *sasan* (paid by *rekh*)
3. *Charnot* land was used for grazing
4. Land given in lieu of services called *pasayat*.
5. Villages given as gift to Brahmin, *charan*, *bhat*, *jogi* etc called *sasan*
6. *Mustarka* (Owned jointly by Darwar and Jagirdaran)
7. '*Dhani*' is a small conglomerate of huts. *Dhanis* are ancillaries of village. Those who wants to live in proximity to their fields make their huts in the field and can able to take care of their crops in a better way.

Abolition of Jagirs and Land Reforms:

Before independence there was no tenancy law and one could be thrown away from the land, one could cultivate at the pleasure of *jadirdar*. Marwar Kisan Sabha led by Baldev Ram Mirdha and Marwar Lok Parishad led by Jai Narain Vyas jointly staged agitation for settlement of *jagirs*. 'Dabra Kand' of 13 March, 1947 compelled the national leaders to resolve this issue. Thus after passing of Marwar Tenancy Act 1949 and Marwar Land Revenue Act 1949 by Rajasthan Assembly in 1955, the jagirs were abolished and farmers became proprietors of all their fields, wells etc without paying any premium or compensation and further were relieved from paying any '*lag bag*' (cesses) etc.

Land use:

Information on categories of villages, land use, cropping pattern, revenue and population of Marwar State has been given in report on the Administration of Marwar State (Anon. 1918, 1930, 1931a, 1931b, 1932) and Census of Marwar State (Mathur, 1942). As per agricultural statistics 1900-01 (Anon. 1906) out of total 11187.57 km² reporting area of Marwar, forest constitute 2.48%, area not available for cultivation 15.76%, culturable waste 10.78%, fallow land 42.12%, net cropped area 28.86% and area sown more than once 0.16% respectively. Irrigated area from all sources was 4.12%. Out of total cropped area (324697 ha) *bajra* constitute 38.29%, *jowar* 17.0%, *wheat* 7.07%, *barley* 3.75%, *maize* 1.1%, *gram* 1.9% and other food crops 20.61%. *Sesamum* constitute 3.05%,

cotton 1.47%, tobacco and opium 0.05%, fodder crops 0.15% and misc. food and non food crops 0.98%. In 1926-27 khalsa land in Marwar was 14522 km² or 16%. Of this total cropped area was 21.3%. There were about 10100 irrigation wells (Anon, 1930). Bajra, jowar, moth and sesamum were produced on the fertile portion of Luni while wheat and barley are produced in Godwar, Sojat, Jaitaran, and Maroth parganas. During 1926-27 out of the total 35322 ha cropped area of *khalsa* villages, bajra constitutes 54%, jowar 17.7%, wheat 5.7%, barley 0.5%, maize 0.8%, moth 5.6%, gram 1.2%, sesamum 2.3%, cotton 0.2%, maize 0.8% and others 7.3% respectively.

Demographic Situation:

The total population of Marwar during 1891 was 2528178. There were 504115 occupied residential houses and villages and town together 4225. The rural and urban population ratio was 89.4% and 10.61% respectively. Hindus were occupying 86.27% of the total population. This was followed by Muslims 7.07% and Jains 6.64%. Regarding occupational pattern, agricultural class constitute 38.7%,

professional class 23.8%, commercial 4.0%, artisans and village menials 28.7%, vagrants, minor artisans and performers 2.9% and others 1.5% respectively. The population of Jodhpur city was 61849 (31706 males and 30143 females). Suburb population was 18646. Hindus were 42990, Muslims 13676, jain 5040 and others 143. During Maharaja Abhay Singh's regime there were 4370 villages in Marwar State out of which 650 were khalsa. In 1941 the population of Jodhpur state was 2555904. The livestock population during 1900-01 was 466821. Of this bull & bullock constitute 10.6%, cow 14.9%, buffaloes 3.4%, young stock 7.7%, sheep 33.6%, goat 27.1%, horse and pony 0.4%, mules 0.6% and camel 1.7% respectively.

Administrative setup of erstwhile Jodhpur Pargana:

In 1658 A.D. Jodhpur pargana was having 1167 villages which include 802 inhabited, 221 uninhabited and 144 *sasan* villages. These villages were administered with 20 sub-centres located in present Jodhpur, Pali, Barmer and Nagaur districts (Fig. 2). After Jodhpur become princely state and brought under British rule,

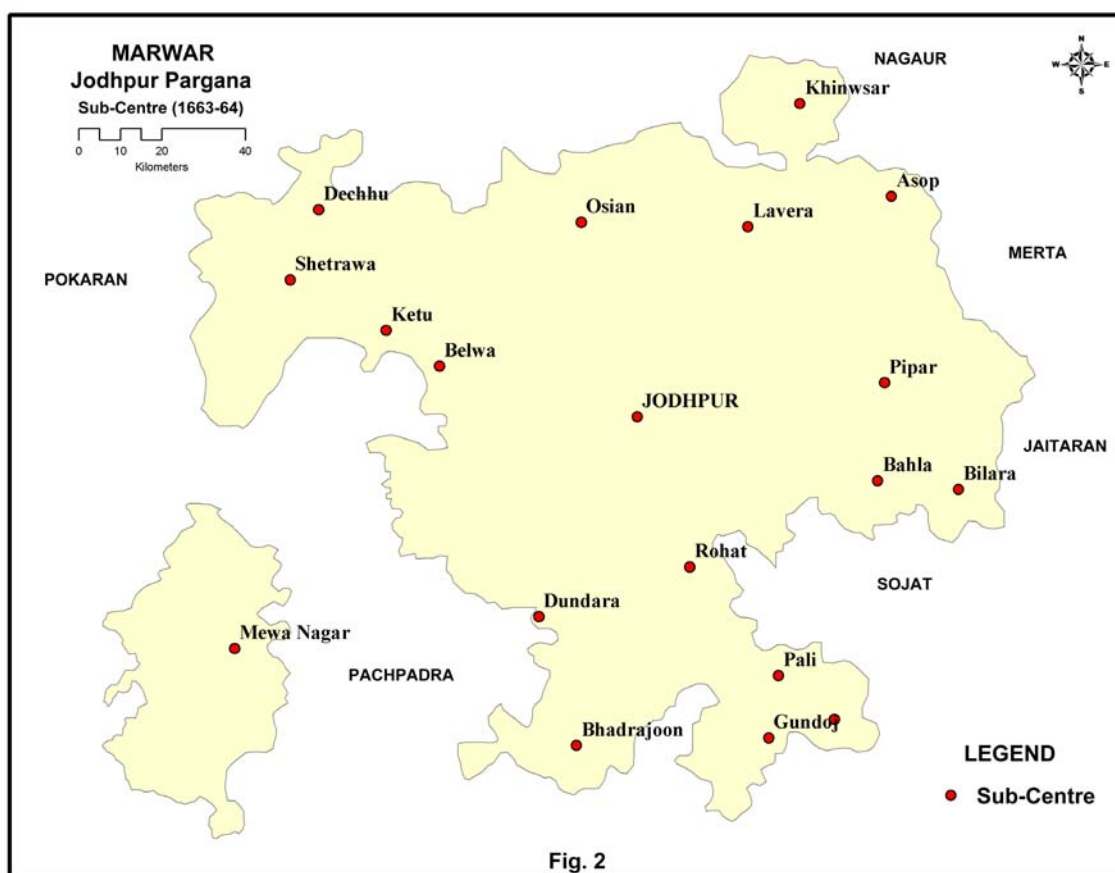
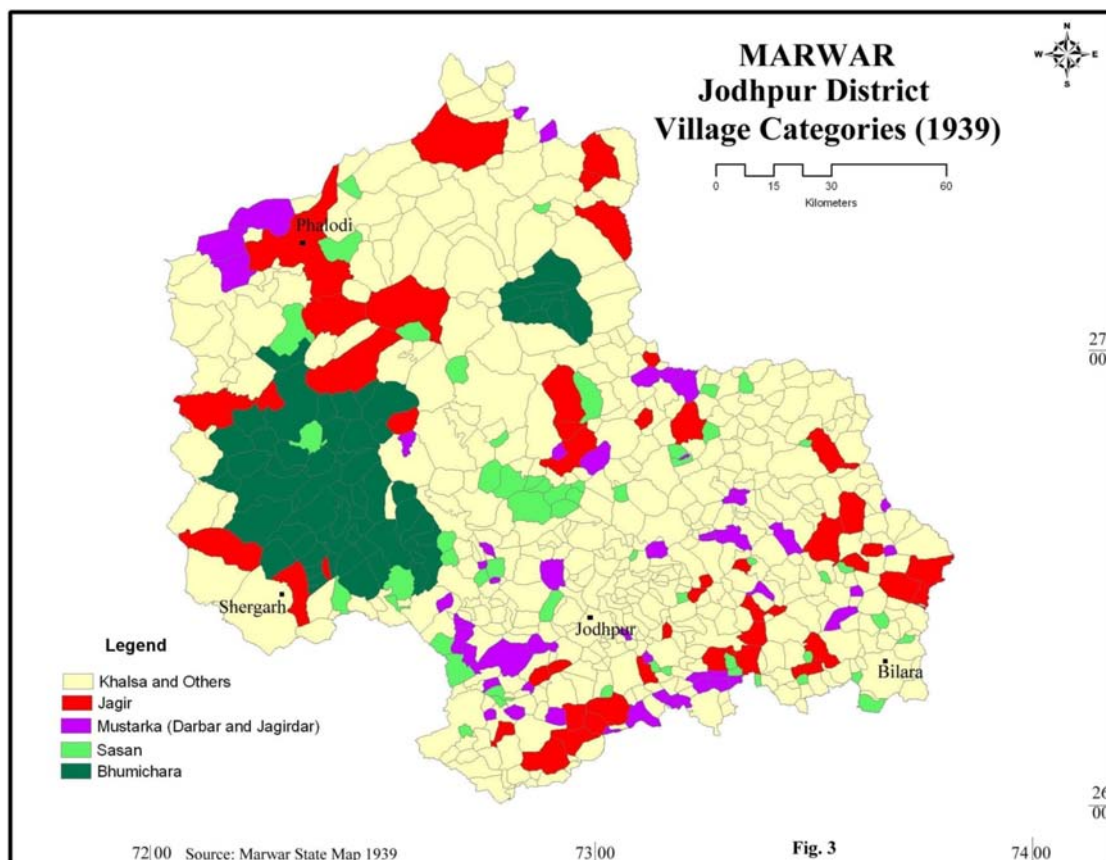


Fig. 2

the parganas were reorganized. After formation of Rajasthan, former Jodhpur pargana become a district by retaining four tehsils viz. Phalodi, Shergarh, Jodhpur and Bilara. At this time there were 730 villages (458 khalsa and 272 non-khalsa villages) with a total area of 9006 sq. miles or 23407 km² (Dool Singh, 1964). Details are shown in fig. 3. During 1951-61 Osian tehsil was constituted by transferring 118 villages from Jodhpur tehsil and 18 villages from Phalodi tehsil. At the same time 33 villages from Bap tehsil of Jaisalmer were transferred to Phalodi tehsil. Pokaran town with 47 villages from Phalodi tehsil and 17 villages of Shergarh tehsil were combined to form Pokaran tehsil of Jaisalmer district. As such from 1951 to 2011 the population of the district has increased by 448% (from 6.7 lakh to 36.9 lakh) with an average decennial growth rate of 32.9%. Similarly the numbers of villages are increased from 730 to 1862. The present Jodhpur district with an area of 22564 Km² has a population of 3687165 (2011) and 3328143 livestock (2007), ten panchayat samiti, 11 tehsils and 339 gram panchayats.

Land use in Jodhpur Pargana/district:

As per agricultural statistics of 1900-01 (Anon. 1906) out of total 339462 ha reporting area of khalsa villages of Jodhpur district (Jodhpur, Bilara, Phalodi and Shergarh parganas) forest constitute 0.09%, area not available for cultivation 15.33%, culturable waste 5.87%, fallow land 59.4% and net cropped area 19.31% respectively. Out of total cropped area (66543 ha) bajra constitutes 40.62%, jowar 18.28%, wheat 9.46%, barley 4.04%, gram 1.55%, sesamum 3.32%, cotton 0.63% and pulses 18.74% respectively. Present Land use map of Jodhpur district based on digital analysis of LISS-III data reveals 8.3 % area under irrigated farming, 61.4% rainfed farming, 24.0% wasteland, 4.8% pastures, forest 0.2% and built-up land and water bodies 1.3% respectively. In 1663 irrigated was only about 9585 ha confined in about 80 out of 1167 village with *arat* (513), *kosita* (2065) and *chanch* (650) etc. (Bhati, 1968). Average figures of 1917-18, 1926-27, 1929-30 and 1930-31 reveal 92.7% area under kharif crops and 7.3% under rabi crops. Out of total cropped area the percentage of bajra comes to



57.8, jowar 13.0, moth 9.2, guar 5.8, sesamum 2.7, wheat 4.8, moong 0.7, gram 0.6, cotton 0.4, barley 0.3, maize 0.2 and others 4.5 (Anon. 1918, 1930, 1931, 1932). Land use figures of 2011-12 reveal 0.32% area under forest, barren and uncultivable land 6.44%, permanent pastures 5.42%, culturable waste 0.73%, current fallow 10.19%, other fallow land 14.02% and net sown area 59.44% respectively. Net irrigated area is 12.69%. Out of total cropped area during 2009-10 (Anon. 2012), bajra constitutes 41%, moth 12.2%, guar 9.5%, moong 7%, mustard 5.3%, joar 4.4%, wheat 3.8%, groundnut 3.1%, sesamum 2.6% and cumin 2.7 percent respectively. Other crops are cotton, castor, onion, chillies, garlic, methi and menhdi.

Land use changes:

During the period from 1901 to 1951 net sown area has increased by 33%, double cropped area 60 times, net irrigated area 10 times and land put to non-agricultural uses 8 times respectively. On the other hand the area under culturable waste has declined by 81% and fallow lands by 59% respectively. Statistical data of Jodhpur district from 1957-58 to 2011-12 reveal 8 times increase in land put to non-agricultural uses, net area sown 33%, double

cropped area 60 times and net irrigated area 10 times respectively. On the other hand the area under culturable waste has declined by 81% and fallow lands by 59% respectively (Table 2). Irrigated area has sharply increased from 1977-78 onward. Area under culturable waste started decline after 1990. The intensification of agriculture took significant momentum from 1889-90 onward. Comparison of land use maps of 1976-77 and 2005-06 and interpretation of LISS-III data of 2011-12 the trend in major land use category are assessed. The area under irrigated cropped land has increased by 858% and rainfed cropland by 3.4%. On the other hand the area of pastures has declined by 18.4% and wastelands by 15.9% respectively. Virtually no development of common lands viz. *gochar*, *oran*, *agor* and forest has been taken place and slowly 64% government land had gone into private hands. Trend in cropping pattern from 1900-01 to 2010-11 is shown in table 3. Agricultural developments mainly taken place in Bilara, Jodhpur and Osian region while Phalodi and Shergarh region remained neglected. More emphasis was given to mining of sandstone and limestone. Nearly 29% land of district is still not being properly utilized and economic return from them is very low.

Table 2. Trend in Land use in Jodhpur District (Area in ha)

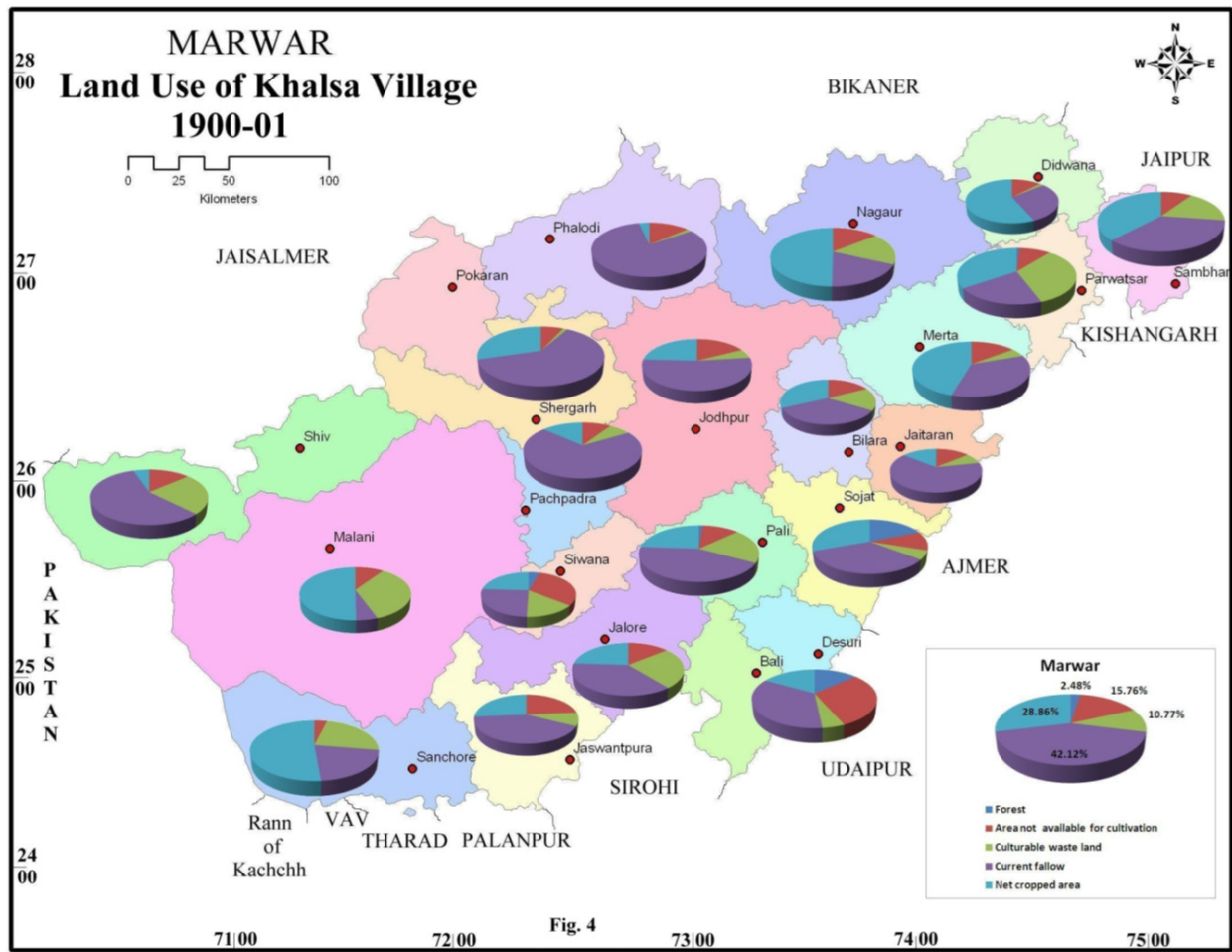
Land Use Category	1900-01*	1957-58	1975-76	1992-93	2011-12
Area not available for cultivation	52047	240000	142000	222289	156418
Permanent pastures and other grazing lands		61000	106000	124277	122215
Culturable waste land	19911	72000	92000	50676	14840
Fallow lands	201663	912000	713000	536564	493012
Net sown area	65540	947000	1105000	1316140	1341096
Area sown more than once	1003	2000	19000	45690	175233
Gross irrigated area	9585	22032	34435	111655	434912

*For Khalsa area only

Table 3. Trend in Cropping Pattern in Jodhpur District (Area in ha)

Crop	1900-01*	1926-27*	1957-58	1975-76	1992-93	2010-11
Bajra	27027	36803	526000	47000	684810	635173
Jowar	12165	11070	67000	13000	26168	57240
Wheat	6296	5215	21000	50000	27395	59285
Kharif Pulses	61819	2035	143000	262000	228978	290494
Sesamum	2210	1878	62000	42000	68424	20577
Mustard	00	00	Neg.	5000	49675	78487
Cotton	417	507	1000	1000	2568	11611
Guar	NA	3711	NA	196316	81904	134019

*For Khalsa area only



Conclusions

Under the feudal and *Jamindari* system in Marwar State, there were no tenancy rights and farmers were over burdened with many taxes and 'begars'. The condition of farmers of *jagir* land was much worse than those of *khalsa* land. The boundaries of *parganas* and status of *khalsa*, *jagir* and other category of villages were frequently changing on the wish of rulers. Only a little bit data was available for *khalsa* villages while for non-*khalsa* village no details were available. Bajra, jowar, moth, guar and til were major rainfed crops while wheat was dominant irrigated crop. Irrigated fields with traditional water lifting devices were mainly located along the younger alluvial plains. No attention was paid for development of agriculture and the conditions of peasants. Agriculture and other developments taken place only after independence and merger of Marwar State in to newly created Rajasthan State in 1949. The *jamindari* system was

abolished; tenancy rights were granted to the farmers; survey and settlements taken place; and the region was put into mainstream of national development. In Jodhpur district, from 1957-58 to 2011-12 irrigated and double cropped area has tremendously increased. On the other the area under culturable waste and fallow land has declined. Acreage of wheat and mustard has significantly increased while cumin and castor become new promising crops. Mining of sandstone and limestone came up in big way. Increased productivity of rainfed cropland; efficient use of ground water and increasing water use efficiency; and development of pastures and degraded lands are major thrust areas for development priority.

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Maps Internet and Geovisualization

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Abstract: Map Represents spatial information and relationship of geographic space. Mapped data has become an important part of understanding and managing geographic space. This new movement brings a change in the field of cartography. Use of maps are simultaneously descriptive ("where is what) and prescriptive ("what and why") in manner. This new dimension introduced almost new geospatial concepts and tools which is Geographic information system (GIS). The Internet is usually a simple information search rather than a geographic analysis. But the internet is also an excellent medium for collecting spatial data. Geovisualization is a interactive visualization. It refers a tools and techniques which helps to analysis geospatial data. There are two parts of geovisualization i) knowledge storage or information transmission and ii) data exploration or decision making process. Geovisualization should help the map user interpret, validate and explore data. It has ability to query spatial databases and geographic analysis.

Application of Geovisualization

- (i) Natural calamities such as Tsunamis (India), Katrina (USA), Cloud burst in Kedarnath (India)etc.
- (ii) Archaeology: It provides accessing and exploring unearthed archaeological data.
- (iii) Environmental planning and analysis: It provides georeference model to explore complete set of environmental data for analysis, query and decision making purpose.
- (iv) Urban Planning: Planners and general public both use geovisualization to explore the real world environment and model. Geovisualization will be very popular in the near future because of widespread use of internet in the general public of the world.

Aims and objectives

The aims and objectives of the paper are to give support to decision maker when facing problems which require rapid solutions in spite of the complexity of scenarios under investigation.

Methodology

The direct depiction method is the prime methodology of Geovisualisation. This approach has involves the direct depiction of each record in a dataset. It also can allow the analyst to extract geographical pattern by

looking at the displays and interacting with them. There are three methods use in collecting data in Geovisualization.

1. Direct depiction method
2. Summarise: this method involves in data aggregation (can join the vast amount of data), generalization and sampling.
3. Patterns: this method involves in applying sophisticated computational techniques (patterns). Computationally extracted patterns are presented to the user for interpretation, evolution and synthesis.

Introduction

Map represents spatial relationship between information and geographic space. Recently mapped data has become an important part of understanding and managing geographic space. This new movement brings a turning point, use of maps from descriptive as well as prescriptive. It has introduced almost new geospatial concept and tool. Geovisealization is the name of this new concept and tool.

Recently Internet becomes more universal. Anyone can easily use internet. So there is a close connection between internet and map. Through internet map can be easily accessecible. Internet mapping is the boon of geospatial technology. Internet mapping or network mapping is the study of physical connectivity of the internet. Recently the Internet has been improved by more sophisticated method. It allows making faster and sensible map.

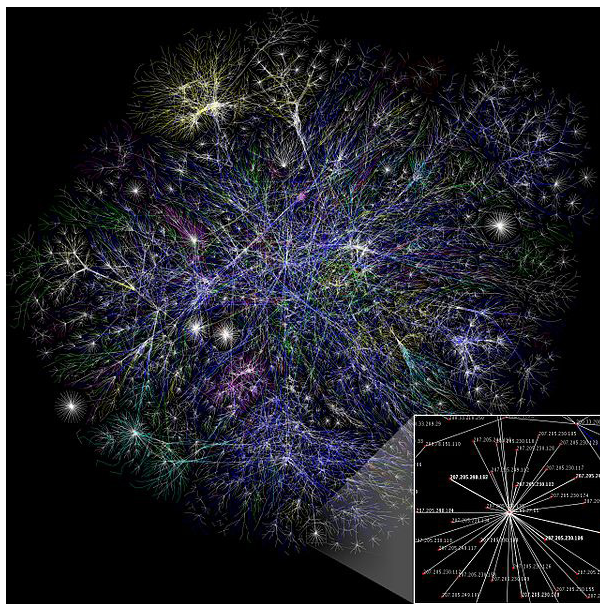


Fig. 1. Galaxy type work of Internet mapping

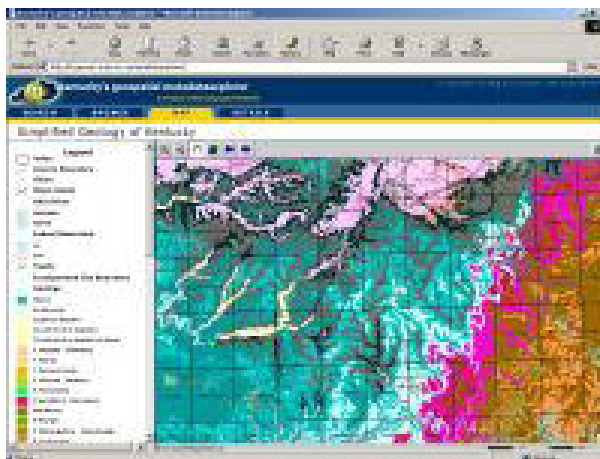


Fig. 2. Kentucky, USA geography network

A variety of geospatial data (like Fig. 1, 2 and 3) can be located, accessed, downloaded and act as a new metadata explorer.

The internet is an excellent medium for providing information derived from spatial data.

Geovisualization

It refers to a set of tools and techniques supporting geospatial data analysis through the use of interactive visualization. Traditional static maps have limited exploratory capability but geovisualization has vast exploratory capabilities for example to explore different layers of the map, to zoom in or out and to change the visual appearance of the map. It allows interactive



Fig. 3.

mapping through cartography (map) and internet. Without GIS Internet mapping can not be possible i.e. explorative analysis over internet. Geovisualization is a new method of decision making technique. According to International Cartographic association (2001) " Geovisualization integrates approaches from visualization in scientific computing (ViSC), cartography, image analysis, information visualization, exploratory data analysis (EDA), and geographic information systems (GISystems) to provide theory, methods and tools for visual exploration, analysis, synthesis, and presentation of geospatial data". Geovisualization should help the map user interpret, validate and explore data.

There are two methods of geovisualization:

"Dasymetric mapping" is the technique of intersecting two datasets to improve the estimated distribution of spatial objects in one of them.

"Multivariate mapping" is the representation of two or more attributes of spatial objects in the same map. It serves mainly two purposes i) to show a relationship between the attributes ii) it helps decision making purpose.

There are three steps of data analysis in geovisualization :

a) Data collection-Direct depiction and visualization

b) Data compilation- Derivation, depiction, aggregates, generalization and samples.



Fig. 4.

c) Presentation or knowledge formation by interpreting patterns, comparing patterns, building composite patterns and developing arguments, ideas and conclusion.

Geovisualization has taken an important role for the analysis of spatial data. A good map not only represents data properly but also serves as an instrument of generalization and summarization. It should be user friendly and helping a user comprehensively.

Figure 4 is the best example of geovisualization of global connectivity pattern (rail, road and underwater cable network of Africa).

There are three approaches to data transformation in geovisualization.

Data→Direct depiction (interacting with visual representations)→Patterns→Knowledge.

Data→Summarization (the users identifies patterns from data summaries of original measurement)→Patterns→Knowledge.

Data→Pattern extraction (the computer identifies pattern from the data or summaries of the data

→Patterns→Knowledge.

This is the best example of geovisualization of global connectivity pattern (rail, road and underwater cable network of Africa)

Some basic Factors which influences the Development of Geovisualization:

- (i) There is rapid advancement in the field of graphics, animation and display technology in recent time.
- (ii) The availability of low cost 3D graphics hardware and the development of highly immersive 3d virtual environments.
- (iii) Maps filter out unnecessary details of the environment in order to highlight interesting information. For example road map based on satellite imagery would be extremely hard to use,
- (iv) To analyze and explore huge amount of geospatial data is almost impossible for computer aided technology. For example a mobile phone call is recorded by computer. So geovisualization is the only technique to store, analyze and explore galaxy amount of geospatial data (routinely collected by Government and private agencies). Computers are well equipped for data processing, exploring and finding pattern of voluminous data but they perform very poorly in detecting and interpreting these types of noise data.
- (v) Easily available internet and its development into the prominent medium to disseminate geospatial data and maps. Reaching the user or public is an important criteria of government and private agencies because they provide and sell services of geospatial information. Nowadays human centered or user oriented approaches are very popular and profitable. Best fitted method, approaches and models are not only depends on its highly accessible technological part but also on the user's background. User centered approaches are applied in Geovisualization. It enhances human visual thinking and act as a problem solving tool.

Visual thinking does not follow a logical pattern so it has not been accepted in science for a long time. In 1990, Maceachren and ganter introduced a new concept (geovisualization) which based on human vision and act as a tool of new advancing science. Famous example of visual thinking is wegner's theory of continental drift. So geovisualization can make powerful

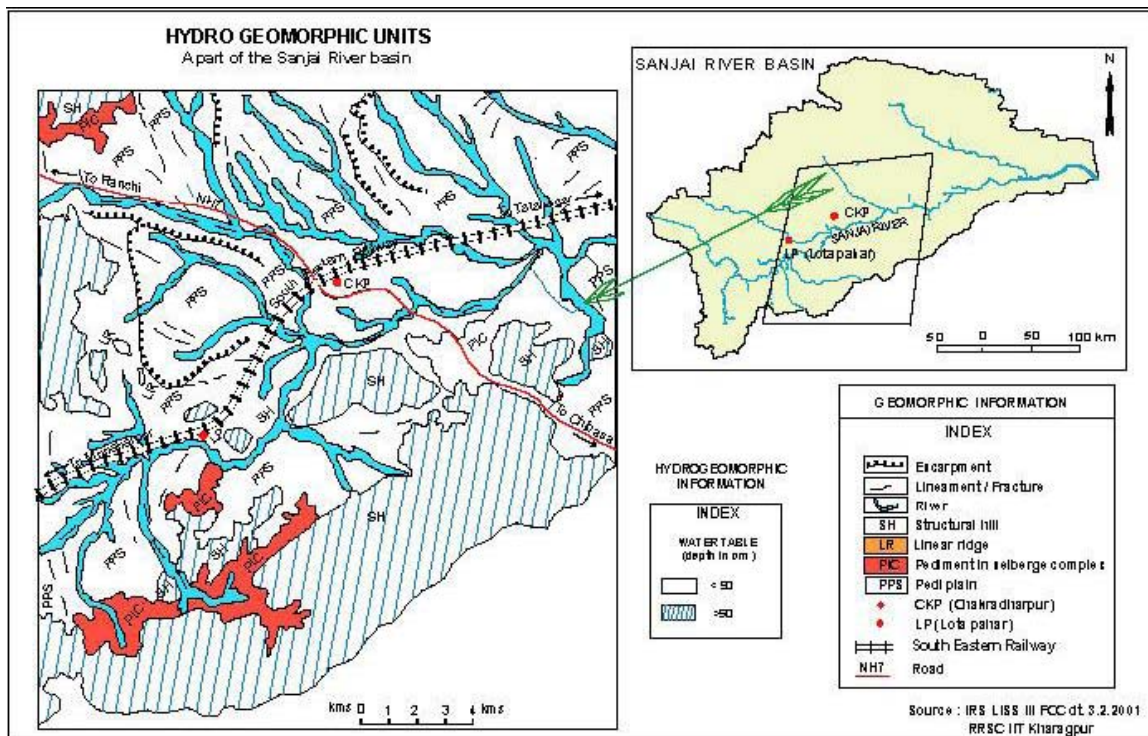


Fig. 5.

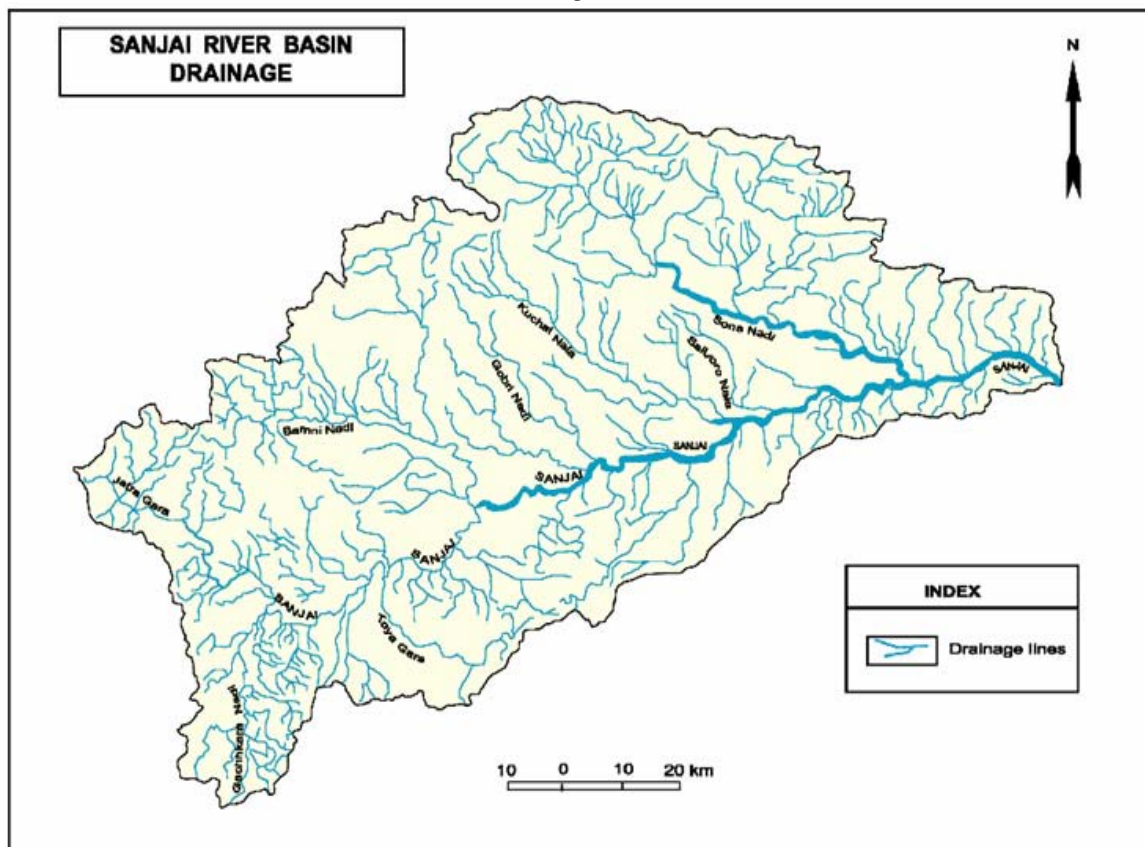


Fig. 6.

Example of 2D geovisualization. It is a drainage net work map of Sanja river basin located in Singhbhum district in Jharkhand state in India.

contribution to decision making and can be used stimulate changes to reality.

Figure 5 Hydro Geomorphic units, a part of the Sanjai river basin, in Singhbhum district, Jharkhand. It depicts geomorphic information (escarpment, lineament, ridge, prdipplain etc.) as well as hydrogeomorphic information (depth of water table).

Conclusion

Maps, Internet and Geovisualization are interdependent on each other. Geovisualization is the new process of knowledge (geo spatial) making. Internet act as a modern tool (medium) and map is the end product. Ever changing Geospatial technological sphere and emergence of a wide range in the past few years are the main causes of development of new concept (Geovisualization). In the last few years different new concept has developed i.e. neo-geography by Turner (2006), web mapping (Plewe, 2007), volunteered geographic information (Good child, 2007), Ubiquitous cartography (Gartner, 20007), wiki mapping (Guptill, 2007), wikimapia, google maps etc. are the turning point of development of new concept. But this concept is not flawless. It ignores social implications. So there is vigorous research needed to solve the key dimension of the concept. Geovisualization is not only the

new concept of geospatial information but it is a new tool for understanding, interpretation and assessment of environmental data (shows on fig no 5 and 6).

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Cartographic Exercises for Assessment of Forest Resources in North East India

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Introduction

In India, the estimated forest cover is 76 million hectares, which is about 23 percent of the total geographical area. This percentage is far below the standard requirement, which is 30 percent of the total geographical area. But the scenario is different in case of North Eastern part of the country. According to the estimate made by Forest Survey of India, it appears that the forest cover in the north-east region is 42.24% of the total geographical area. Fifty one forest types are found in this region. Out of the nine important vegetation types of India, six are found in the North Eastern region. These forests accommodate 80,000 out of 150,000 species of flowering plants. So far as North Eastern States are concerned, in terms of floral species richness the highest diversity is reported from the states of Arunachal Pradesh (5000 species) and Sikkim (4500 species). According to the Indian Red Data Book published by the Botanical Survey of India, 10 per cent of the total flowering plants in the country are endangered. Of the 1500 endangered floral species, 800 are reported from North East India.

Mapping Forest Resources by National Atlas & Thematic Mapping Organisation

National Atlas and Thematic Mapping Organisation (NATMO), a subordinate office of Department of Science & Technology, Government of India, is responsible for preparation of different types of thematic maps. In addition to preparation of National Atlas of India, the Organisation prepared Forest Resources Atlas, Land Resource Atlas, Agriculture Resource Atlas, Water Resource Atlas, etc. where country's resource conditions have been thoroughly depicted. To visualise nation's forest resources, NATMO has published Atlas of Forest Resources of India, in which, apart from some general maps at a scale of 1:6 million, country's forest types and

also wet land and wild life have been mapped in detailed (*at a scale of 1:2 million*). However, at present there is a growing awareness regarding environment and ecology. Hence to visualise the environmental condition of the country, NATMO has prepared maps on Environmentally Sensitive Zones at a scale of 1:1,000,000. Now a days *Eco Tourism* has gained importance and NATMO is also conscious about that issue. As a result the Organisation has prepared two maps on bio-sphere reserves in North Eastern India, viz. *Kaziranga National Park* and *Namdapha Tiger Reserve*.

Bio-sphere reserves in North Eastern India

It has already been mentioned that forest cover in the north-east region of India is 42.24% of the total geographical area. There are some states where the forest coverage is more than 50%. Important wild life sanctuaries within this region are Namdapha National Park, Manas National Park, Kaziranga National Park, Orang National Park, Pobitora Wildlife Sanctuary, Sipahijola Wildlife Sanctuary, Keibul Lamjoa National Park, etc. However, NATMO has undertaken mapping exercises for two such reserves, viz. Kaziranga National Park and Namdapha Tiger Reserve.

Kaziranga National Park

It was Lady Curzon who first became concerned about the rhino of Kaziranga after hearing from British tea planter friends and came to Assam in 1904-05. Kaziranga was then a sportsman's and poacher's paradise with rapidly declining population of rhino. Lady Curzon persuaded Lord Curzon, the then Governor General of India, to protect the animal. However, there was a long journey before Kaziranga became a World Heritage Site. The important mile stones in this regard are:

- 1st June, 1905 : Preliminary notification was issued informing Government's intension to declare 56,273.60 acres of land as reserve forest
- 3rd January 1908 : Kaziranga was declared as Reserve Forest prohibited for shooting
- 1913 : Expanded by another 13,506 acres
- 10 November, 1916 : Declared a game sanctuary
- 1938 : A.J.W. Milroy, the then Conservator of Forest, prohibited all poaching and opened Kaziranga to visitors
- 1950: The name game sanctuary was changed to Wild Life Sanctuary
- 11 February, 1974 : Designated as Kaziranga National Park and was listed in world heritage site by UNESCO.

Actually Kaziranga National Park has unique environment of its own. It has been designated as National Park by Assam National Park Act of 1968. It is situated on the bank of Brahmaputra River covering parts of Golaghat and Nagaon Districts of Assam. The Park hosts two thirds of the world's Great one horned rhinoceroses. Moreover, it has the highest density of tiger population among protected areas of the world. The Park has been recognized as a Tiger Reserve in the year 2006. Kaziranga is the home of wild animals like elephants, wild water buffaloes, swamp deer, hog deer, wild boar, sambar, leopard, sloth bear, pangolin, hoolock gibbon, python, etc. It has also been designated as an Important Bird Area for conservation of avifaunal species. The park is rich with about 300 different species of avifauna. They include cormorants, herons, egrets, storks, pelicans, hornbills, eagles, teals, terns, ducks, pheasants, partridges, pigeons, parakeets, kites, wood peckers, bulbuls, etc. There are many small water bodies within Kaziranga National Park. The Park is crisscrossed by four rivers including mighty Brahmaputra. The flora is characterized by elephant grass and dense tropical moist broadleaf forests.

The Park has faced severe threats from natural calamities, and illegal poaching. Floods caused by overflowing of river Brahmaputra have caused significant losses of animal life. Poaching activities, particularly of the rhinoceroses for its horn, has been a major

concern for the authorities. Rhinoceroses amounting to 567 were hunted by poachers between 1980 and 2005. In a single year, 18 one-horned rhinoceroses were killed by poachers in 2007. To overcome these threats, preventive measures such as construction of anti-poaching camps and maintenance of existing ones, patrolling, intelligence gathering, and control over the use of firearms around the park have been initiated. As a result a number of casualties are reduced.

Namdapha Tiger Reserve

The other forest area of north east India which has been mapped by NATMO is Namdapha Tiger Reserve, a true wilderness and enchanting beauty of lush green vegetation, impenetrable pristine and virgin forest is located within Changlang district of Arunachal Pradesh bordering Myanmar. It covers an area of about 2000 sq km having diverse flora and fauna. Namdapha extends from an elevation of 200 metres and rises as high as 4500 metres in the snow capped mountain of the Himalaya. Within this wide altitudinal range is a diversity of terrain and life, unparalleled elsewhere in the Indian subcontinent, perhaps also in the world. The entire area of the reserve is mountainous and form the catchment area of Noa-Dehing (Diyun) river, a tributary of Brahmaputra, flows from east to west. It is also drained by Deban and Namdapha rivers, from which it acquired its name, originating from Daphabeun (4598 m), the highest mountain peak in the reserve. In addition, there are some natural lakes (locally called *beels*) in the high hills and a few small pools such as Moti *Jheel*, Rani *Jheel*, Raja *Jheel*.

Bounded by east-west stretching Daphabum Ridge in the north and Patkai ranges on the Indo-Myanmar border in the south, the Diyun, valley of Namdapha opens out to the upper Brahmaputra valley. The north eastern hills along Nagaland enclose the south eastern side of the upper Brahmaputra valley while the greater Himalaya and its foothills are positioned such that the monsoon clouds get trapped in Upper Assam causing extremely heavy rainfall. In all the valleys of Arunachal Pradesh opening to the west, particularly in the southern segment in which the Diyun valley lies, rain occurs most heavily for almost 8 months of the year with a short winter (October to January) being comparatively dry.

In the lower levels grows a tangled profusion of tropical rainforests with huge Hollock, Hollong and Mekai trees intermixed with giant creepers, tall cane and dense bamboo stands. Higher up are the deciduous forests with temperate and alpine forests higher still where oak, magnolia, pine, betula, rhododendrons grow in profusion. Namdapha is a botanical heaven, with over 150 tree species and many flowers and orchids. The *Penus Meerkusi* and *Abies Dalavavi* are not found elsewhere in India. One of the rarest endangered orchids, the Blue Vanda is found here. The most famous local medicinal plant *Mishuni Teeta* (Copti Teeta), which is used by the tribal population for all kinds of diseases, is available here but its export has been banned.

Cartographic Exercises

So far as the source materials to initiate these exercises are concerned, obviously Survey of India topographical sheets at a scale of 1:50,000 was used as base maps. Maps, literature, statistical information, etc. were also collected from local authorities. The base map / guide maps were compiled with the help of such available materials. To incorporate latest scenario these maps were updated with the help of data available in the form of satellite images (IRS IC LISS III).

Apart from the main map, a series of maps have been inserted at appropriate space. Air routes from different parts of India to the destinations have been mapped at a scale of 1:15, 000,000. The other route map presents detail information regarding rail and road communication for entire North Eastern India, which has been prepared at a scale of 1:6,000,000. The detail map of Kaziranga National Park at a scale of 1:100,000 shows the environment in which the wild life roams around. It also depicts information regarding administrative boundary, National Park boundary, six phases of added areas, drainage system, communication network, tourist route, different types of landscape like forest, grass, scrub, bill, etc., tourist zone,

elephant ride zone, location of watch tower, forest camp, lodge, hotel, inspection bungalow, forest office, etc. Moreover, Tourist Zone I and II have been mapped at a larger scale of 1:50, 000. In addition to such information in graphical format, salient features have been presented in textual form. They include wild life population, geographical condition of the region, visiting season and also visiting hours, available accommodation with tariff rates, places of tourist interest and also 'Do's & Don'ts' within the Park. For Kaziranga National Park, Tourist Zone I and II have been mapped at a larger scale of 1:50, 000. On the other hand, for Namdapha Tiger Reserve, core area and also buffer zone of the reserve has been mapped in detail at a scale of 1:50,000.

Base maps thus prepared, were scanned with the help of AO scanners and converted into appropriate format so that digitization work may be conducted in Arc Info environment. Attribute information were also attached as and where necessary. Ultimately Adobe Illustrator along with Map Publisher Plug-in was used for preparation of final lay out. Check plots were printed from A0 colour plotters. For final printing purpose CYMK colour separates were generated where from pre sensitized (PS) plates were prepared. Lastly final maps were printed from off set printing machine.

Conclusion

These two maps have depicted detail scenario of respective areas. They contain information like tourist route, tourist zone, elephant riding zone, location of forest camp, watch tower, lodge, hotel, IB, forest office, etc. Spatial distribution pattern of forests, scrubs and grasses, bills and swamps have also been precisely depicted. Thus these maps are considered as self help guides for visitors entering these forest areas. Moreover, such maps need to be prepared for other biosphere reserves in India, either by state agencies or by private entrepreneurs so that resources condition in respective areas may be available for tourists and other users.

State of Female Headed Households in India: An Analysis Based on Census 2011 Data

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Abstract: Present paper analyses the state FHH in India using Census 2011 data on "Houses, Household Amenities & Assets" among Female Headed Households (FHH). The findings of this paper are based on secondary source of data which mainly derived from Census of India. State is considered as basic unit of the study. This paper examines that there are about 27 million female headed households in the country. They constitute 10.9% of the total households in the country. There are about 49 Lakh single member FHHs in the country. The paper also shows that larger proportion of FHH either do not have 'Any exclusive Room' or have only 'One dwelling room'. The household size in case of FHH tends to be smaller than Male Headed Households. 28.7% FHH do not have any of the specified assets. In order to uplift the female status in the society, female of the society needs, to be made more aware about various developmental programmes and financial schemes offered by the government for women, to raise literacy level among women so that they become independent. Apart from all, the overall society needs to change the mindset and give equal opportunities to females in all the sectors of life.

Introduction

India has come a long way forward in providing the education to its residents and has achieved the Literacy Rate of 73.0% (as per Census 2011). It is believed that the education broadens the mindset of the society and creates equal opportunities for all the components of the society. But the Indian Society has ever been male dominating and experienced the discrimination towards female gender. This discrimination in the society starts before the birth of the child itself i.e. the preference for the girl child, which continues in imparting education, imparting technical trainings, in work participation, share in parental property and so on and is evident from the Census 2011 data results like Child Sex Ratio (919), Gender Gap in Literacy Rate (16.3) and Gender Gap in Work Participation Rate (27.8) [Census of India: Primary Census Abstract (2013)]. In order to give more support to the argument, analysis of Census 2011 data on "Houses, Household Amenities & Assets" among Female Headed Households (FHH) can be very useful.

Office of the Registrar General & Census Commissioner, India has a long practice of releasing data on "Houses, Household Amenities & Assets" since long but it is for the first time in the history of Census that this organisation has released the data on "Houses,

Household Amenities & Assets" classified by sex which may help to provide an insight into the living conditions of Female Headed Households (FHH).

Objective

In the present study, authors have tried to put forward the state of Female Headed Households (FHH) in India. The analysis in the paper is based on the hypothesis that the living conditions in these households are poor and in some cases very pathetic too. Basic amenities of life are inadequately available to them.

Database and Methodology

The study is based on the Census of India data for the year 2011. State is taken as a unit of study for analysis and mapping purpose. Data on "Houses, Household Amenities & Assets" among Female Headed Households collected was interpreted and represented cartographically by using the Choropleth technique. First of all, choropleth maps for each amenity were prepared. Then, these maps were overlaid on each other. Application of this cartographic technique revealed some interesting. The spatial patterns thus emerged were analysed and interpreted.

To represent the living conditions of the FHHs, Living Conditions Index (LCI) of all the

indicators for all the States/UTs was calculated by deploying the following famous formula suggested by Harper [1977, Pp. 211]:

$$I_{ij} = \frac{X_{ij} \times 100}{NA_i} \quad i = 1, 2, 3 \dots n \text{ and } j = 1, 2, 3 \dots n$$

Where:

I_{ij} = Index of the j th State/UT of the i th indicator.

X_{ij} = Value of the i th indicator of j th State/UT.

NA_i = National Average of the i th indicator.

For comparison between the Index value of j th State/UT of i th indicator national average of the i th indicator has been taken as the base i.e. 100. Thus, the greater the variability of the j th region, the poorer is its performance in the i th component and vice versa. Having calculated the LCI for all considered indicators, a Composite LCI has been calculated as a simple average (i.e., assigning equal weights to all the indicators) of the LCIs representing all the considered indicators. All maps are prepared by using ArcGIS 10 software.

Female Headed Households

As per Census 2011, there are 26,884,345 female headed households in the country. They constitute only 10.9% of the total households. Among the States/UTs Lakshadweep (40.2%), Kerala (22.7%), Meghalaya (21.7%), and Goa (20.3%) are the only states which have more than 20% FHHs (Census of India). Tables on Houses, Household Amenities & Assets among Female Headed Household (2012)]. Amongst all the States/UTs, 13 of them have the representation of FHH less than National Average (10.9%). From the map (Figure-1) it can easily be visualized that all these States/UTs form a contiguous belt in the northern part of India with the exceptions of Himachal Pradesh, Uttarakhand and Punjab which explains that as we move towards the south, a better representation of FHHs can be observed.

As per NFHS data proportion of female headed households has increased in India from 9.2% (1992-93) to 10.3% (1998-99) and to 14.4% (2005-06) [NFHS I (1992-93), II (1998-99) and III (2005-06)]. Similarly, as per

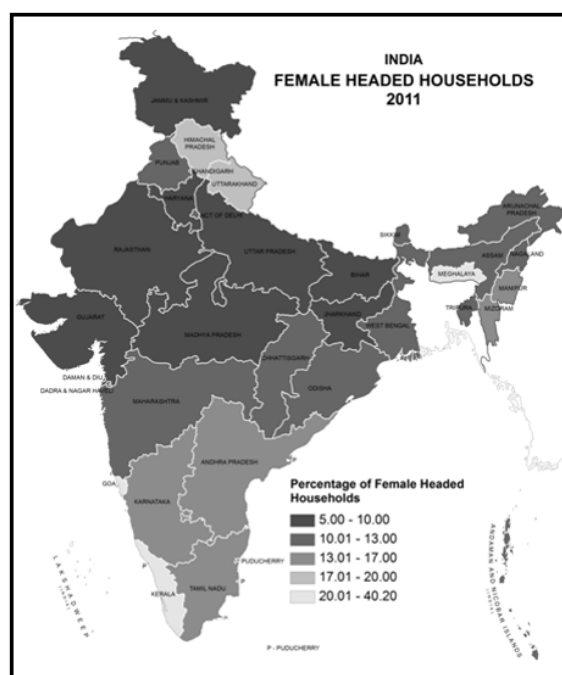


Fig. 1.

Census data the same has increased from 10.4% in 2001 (The Census 2001 data relates to Population Enumeration phase as similar data from Houselisting phase is not available) to 10.9% in 2011. The reasons of emergence of more FHHs could be attributed to more "widowhood, divorce, separation, desertion, migration of male members for long periods, loss of economic function by resident males due to severe unemployment, disability, illness etc.

Amenities and Assets

a) Type of Census Houses

As per census, a 'Census House' is a building or part of a building used or recognized as a separate unit because of having a separate main entrance from the road or common courtyard or staircase etc. It may be occupied or vacant. It may be used for a residential or

Table 1.

Type of Census Houses	Female Headed HH%	Male Headed HH%
Permanent	60.5	62.1
Semi permanent	26.2	25.0
Temporary	12.4	12.0
Serviceable	7.6	7.2
Non serviceable	4.8	4.8
Any other	0.9	1.0

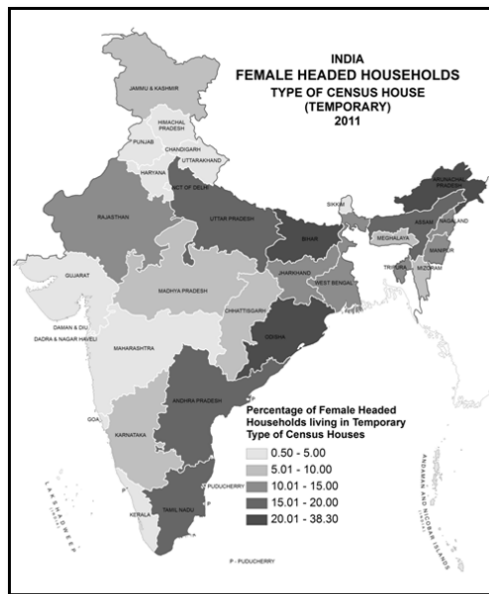


Fig. 2.

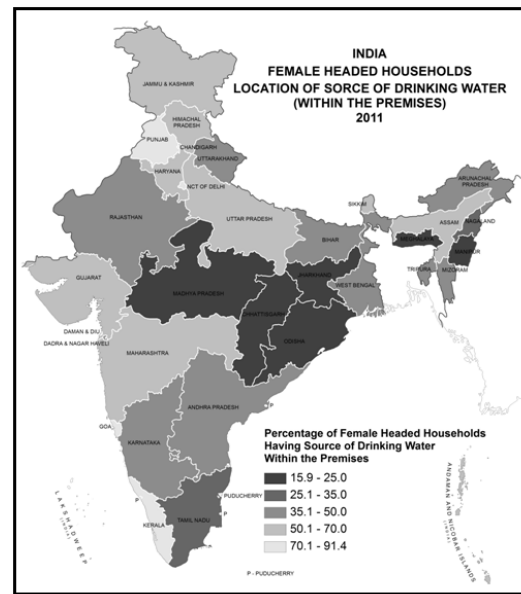


Fig. 3.

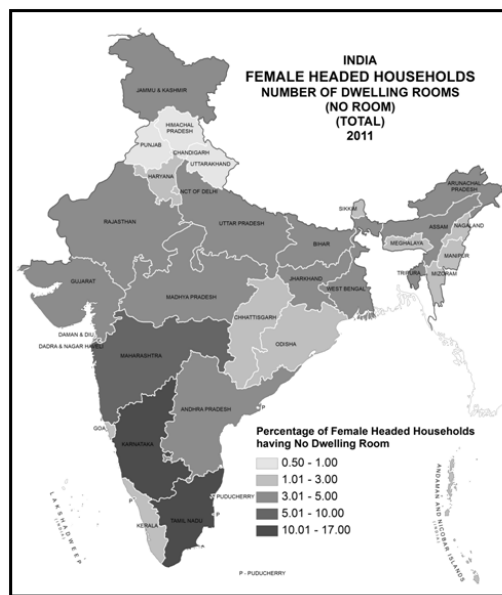


Fig. 4.

non-residential purpose or both [Census of India: Tables on Houses, Household Amenities & Assets (2012)]. As per Census 2011 data, in the country, 60.5% of FHHs have been residing in Permanent, 26.2% in Semi-permanent and 12.4% in Temporary type of structure of Census Houses in comparison to MHHs residing in 62.1%, 25.0% and 12.0% respectively (Table-1).

Temporary Census Houses are with wall and roof made of temporary material. For example, Wall can be made of Grass, Thatch, Bamboo etc., Plastic, Unburnt brick or Wood and Roof

can be made of Grass, Thatch, Bamboo, Wood, Mud, Plastic or Polythene [Census of India: Tables on Houses, Household Amenities & Assets (2012)].

Contiguous patches of States/Uts are seen, starting from Uttar Pradesh up to North-East (except Mizoram, Meghalaya and Sikkim) and from Odisha in the north till Tamil Nadu in the South along the eastern coast of the country, where more than 15% of FHHs reside in Temporary type of Census Houses structures (Figure-2).

b) Availability of Drinking Water

In General, it is the duty of female members of the household to arrange the Drinking Water for the family. Location of the source of Drinking Water for the Household plays a significant role in terms of efforts made in fetching the water which becomes one of the major tasks for the female among other housing activities. As per Census, the Location of the source of Drinking Water has broadly been categorized in three categories:

1. Within the premises: If the drinking water source is located within the premises where household lived.
2. Near the premises: If the drinking water source of water is located within a range of 100 metres from the premises in urban areas and within a distance of 500 metres in case of rural areas.
3. Away from the premises: If the drinking water source is located beyond 100 metres from the premises in urban areas and beyond 500 metres in rural areas [Census of India: Tables on Houses, Household Amenities & Assets (2012)].

As per Census 2011, 45.0% of the FHHs have the source of Drinking Water Within the Premises, 37.2% have Near the Premises whereas 17.8% of them have to travel more than 100 meters in urban areas and 500 meters in rural areas to fetch the water in comparison to 46.8%, 35.7% and 17.5% respectively in case of MHHs (Table-2).

As per Census 2011 results, States/UTs which are on the top of the list with more 75% FHHs having source of Drinking Water Within the Premises are Chandigarh, Punjab, Lakshadweep, NCT of Delhi, Daman & Diu, Goa and Kerala. The States at the bottom of the list with less than 25% FHH having source of Drinking Water Within the Premises are Chhattisgarh, Manipur, Odisha, Jharkhand, Meghalaya and Madhya Pradesh. Four of these States, Madhya Pradesh, Chhattisgarh, Jharkhand and Odisha form a contiguous patch (Figure-3). There are Nine States which are worst affected and where more 25% FHHs have source of Drinking Water Away from the Premises and have to travel more than 100 metres in urban areas and more than 500 metres in rural areas to fetch the Drinking

Water. Out of these nine states, five states form a contiguous patch.

c) Number of Dwelling Rooms

As per Census 2011 data, 5.2% of FHHs do not have any exclusive room and 39.3% of them have only One Room in comparison to 3.8% and 36.8% respectively for MHHs. The proportion of Five Rooms (2.5%) and Six Rooms & more (2.6%) in FHHs is almost same in comparison to MHHs i.e. 2.6% and 2.8% respectively. So it can be observed that the proportion of FHHs with One Room or No Exclusive Room is on the slightly higher side in comparison to the same proportion for MHHs. More than 10% FHHs in Karnataka (17.0%) and Tamil Nadu (11.5%) do not have any Exclusive Room. On the contrary, around 1% FHHs in Lakshadweep (0.5%), Uttarakhand (0.9%), Punjab (1.0%), Himachal Pradesh (1.0%), NCT of Delhi (1.1%), Kerala (1.2%) and Chandigarh (1.3%) do not have any Exclusive Room. In case of States/UTs with more than 10% FHHs with No Exclusive Room, form a contiguous patch in the south whereas, in case of States/UTs Uttarakhand, Punjab and Himachal Pradesh, with around 1% FHH with No Exclusive Room, form a contiguous patch in the north (Fig.4).

d) Availability of Latrine Facility

In the country, as per Census 2011 data, 51.7% FHHs still do not have latrine facility available within the premises and have to go out to defecate. Twelve States/UTs where more than 50% of FHHs do not have Latrine Facility Within the Premises and have to go out of their residential premises to defecate are Odisha (80.4%), Jharkhand (79.4%), Chhattisgarh (78.2%), Bihar (76.3%), Madhya Pradesh (68.7%), Dadra & Nagar Haveli (65.7%), Uttar Pradesh (62.6%), Rajasthan (60.9%), Tamil Nadu (60.2%), Andhra Pradesh (58.3%), Karnataka (54.5%) and Jammu & Kashmir (53.3%). Except Jammu & Kashmir and Dadra & Nagar Haveli, all these States/UTs form a contiguous patch starting from Uttar Pradesh in north till Tamil Nadu in south and from Rajasthan in west till Bihar and Jharkhand in east (Figure-5). If we look at the other side of the picture, eleven States/UTs where more than 75% of FHHs have Latrine Facility within the Premises are Lakshadweep (97.6%), Mizoram (95.4%), Kerala (94.5%), Chandigarh (92.4%), Manipur (90.4%), Sikkim (88.6%), NCT of Delhi (88.4%),

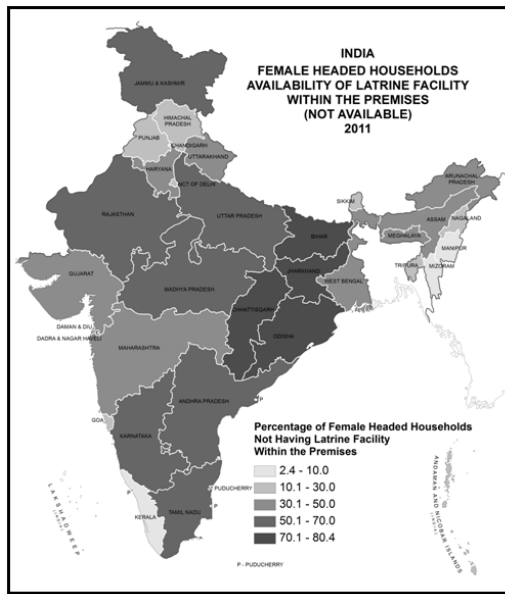


Fig. 5.

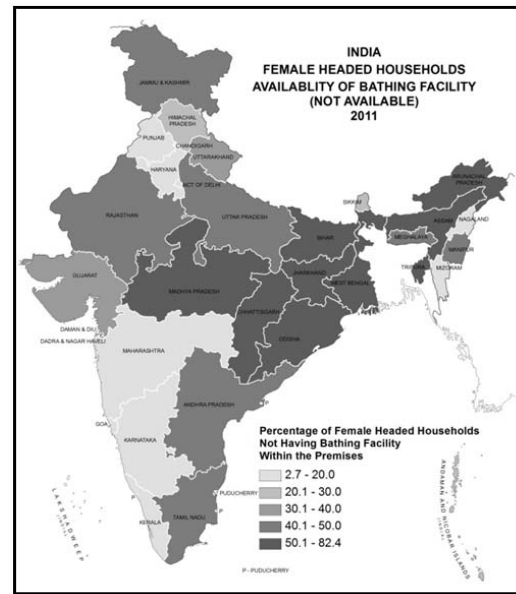


Fig. 6.

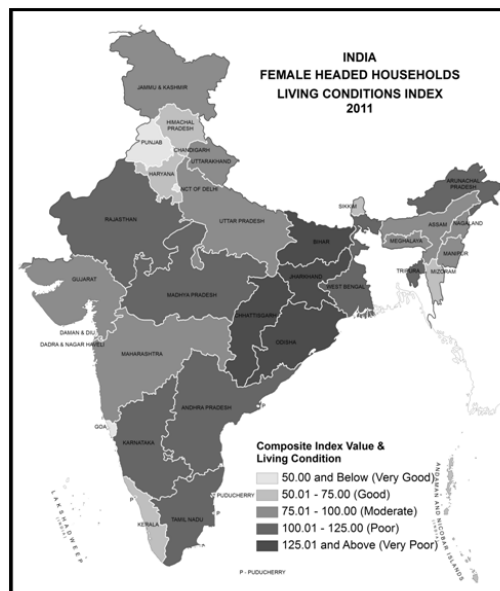


Fig. 7.

Tripura (87.4%), Punjab (79.9%), Goa (78.0%) and Nagaland (77.4%).

e) Availability of Bathing Facility

As per Census 2011, 40.6% FHHs still do not have Bathing Facility available within the Premises. Nine States where more than 50% of FHHs do not have Bathing Facility within the Premises are Odisha (82.4%), Chhattisgarh (81.3%), Jharkhand (76.7%), Tripura (67.2%), Bihar (63.1%), West Bengal (60.7%), Assam (56.6%), Arunachal Pradesh (53.8%) and Madhya Pradesh (51.8%). All these states form a contiguous patch starting from

Madhya Pradesh in the West till Arunachal Pradesh and Tripura in the East via Assam (Figure-6). Whereas, on the other side of the fact is that there are fifteen States/UTs of the country where more than 75% of FHHs have Bathing Facility available, they are Lakshadweep (97.3%), Chandigarh (93.8%), NCT of Delhi (90.4%), Punjab (89.8%), Goa (88.7%), Daman & Diu (86.6%), Karnataka (84.1%), Kerala (83.9%), Maharashtra (83.9%), Nagaland (82.7%), Mizoram (82.6%), Haryana (82.0%), Andaman & Nicobar Islands (78.5%), Puducherry (76.3%) and Himachal Pradesh (75.1%).

f) Availability of Kitchen Facility

As per Census 2011 data, out of 26,778,323 FHHs (excluding households where NO Cooking is done) 9,765,707 FHHs do not have Kitchen Facility inside their house. This Constitutes to 36.5%. There are nine states of the country where more than 40% of FHHs do not have Kitchen Facility within their premises. They are Bihar (68.2%), Jharkhand (91.9%), Uttar Pradesh (58.3%), Andhra Pradesh (53.2%), Madhya Pradesh (51.9%), Rajasthan (49.3%), Chhattisgarh (47.9%), West Bengal (42.8%) and Odisha (41.0%). It can be observed that these are all the major States of the country and form a contiguous patch from Rajasthan in the West till Bihar and Jharkhand in the East and from Bihar in North till Andhra Pradesh in the South along the eastern coast of the country. On the contrary, in eight States/UTs more than 90% of FHHs have Kitchen Facility within their premise and all of them except Kerala are minor States/UTs.

g) Type of Fuel Used for Cooking

As per the Census 2011 data, in the country majority of FHHs (excluding households where NO Cooking is done) use Fire-wood (52.4%) and LPG (28.3%) as Fuel for Cooking. These two types of fuels constitute to 80.7% FHHs. Rest 19.3% FHHs use other types of fuel for cooking. From the Table-3 it can be observed that 71.3% FHHs of the country still use unsafe fuels, as far as health point of view is concerned. Unsafe Fuels include Fire-wood, Crop residue, Cow dung cake, Coal, Lignite, Charcoal, Kerosene and Any other. Amongst them Fire-wood is prominently used in maximum number of FHHs. On the other hand, only 28.7% of FHHs use Safe Fuels which include LPG/PNG (28.3%), Electricity (0.1%) and Biogas (0.3%). Amongst them, LPG/PNG has the maximum number of users. There are only seven States/UTs in the country where more than 50% of FHHs are using Safe Fuels for cooking and they are NCT of Delhi (89.4%), Chandigarh (81.5%), Goa (73.8%), Daman & Diu (66.6%), Mizoram (63.0%), Punjab (59.7%) and Puducherry (58.6%). In rest of the States/UTs, more than 50% of FHHs use Unsafe Fuels for cooking. Amongst them, Odisha, Bihar and Chhattisgarh with 91.2%, 91.0% and 90.4% users respectively are on the top of the list.

h) Household Size

As per Census 2011 results, it is observed that most of the FHHs have small household size. 50.7% of FHHs covered under one, two and three member categories. Comparatively, in case of MHH these three categories constitute only 24.1%. In the country, there are 4,908,452 single member FHHs which constitute to 18.3% of all FHHs. Nine States/UTs, Lakshadweep (3.1%), Manipur (6.3%), Meghalaya (6.8%), Punjab (6.9%), Jammu & Kashmir (7.3%), NCT of Delhi (7.4%), Haryana (7.9%), Sikkim (9.8%) and Mizoram (9.9%) have less than 10% single FHHs. There are only three States, Chhattisgarh (29.9%), Andhra Pradesh (27.1%) and Tamil Nadu (26.1%), where the percentage of single member FHHs is more than 25% which form a contiguous patch. In the northern and north-eastern part of the country, there is no State/UT where one can find more than 20% single member FHHs.

i) Possession of Assets

For Census 2011, data on Assets was collected and tabulated on nine parameters. The data reveals that the percentage of FHHs in the country who possess these specified Assets are; Radio/Transistor (16.1%), Television (45.3%), Computer/Laptop-With Internet (2.5%), Computer/Laptop-Without Internet (6.0%), Telephone (Land line only) (4.3%), Mobile phone (44.3%), Bicycle (28.9%), Scooter/Motorcycle/ Moped (13.7%) and Car/ Jeep/ Van (3.2%). There are 28.7% FHHs which do not possess any of the specified Assets.

The percentage of FHHs which do not possess any of the specified assets is 28.7%. Eleven States/UTs where more than 35% of FHHs do not possess any of the specified assets are Chhattisgarh (51.7%), Madhya Pradesh (48.7%), Odisha (48.7%), Dadra & Nagar Haveli (42.5%), Meghalaya (42.3%), Nagaland (40.8%), Bihar (38.9%), Jharkhand (38.8%), Andhra Pradesh (38.4%), Tripura (38.3%) and Arunachal Pradesh (35.1%). Five of these States/UTs form a contiguous patch and describing it to be a poor belt as far as the Possession of Assets by FHHs is concerned.

Living Conditions Index (LCI)

In order to calculate LCI, percentages of eleven negative indicators of FHHs, 1)

Percentage of FHHs 2) Condition of Census Houses-Temporary, 3) Availability of Source of Drinking Water-Away from Premises, 4) Number of Dwelling Rooms-No Room, 5) Number of Dwelling Rooms-One Room, 6) Availability of Latrine Facility within Premises-Not Available, 7) Availability of Bathing Facility within Premises-Not Available, 8) Availability of Kitchen Facility within Premises-Not Available, 9) Type of Fuel Used for Cooking-Unsafe, 10) Size of Household-One Person and 11) Possession of Assets-None of the Specified have been used.

In order to map, Calculated Composite LCI of States/UTs has been grouped in to five ranges, 50.00 & Below, 50.01 - 75.00, 75.01 - 100.00, 100.01 - 125.00 and 125.01 & Above, and they have been categorised as Very Good, Good, Moderate, Poor and Very Poor respectively.

Four States of the country, Odisha, Chhattisgarh, Bihar and Jharkhand with LCI values 148.37, 130.63, 126.64 and 125.21 respectively fall in the category of "Very Poor" living conditions and eight States, Andhra Pradesh (120.25), Madhya Pradesh (119.48), West Bengal (114.17), Tamil Nadu (112.16), Tripura (109.79), Arunachal Pradesh (109.51), Karnataka (106.95) and Rajasthan (103.46) fall in the category of "Poor" living conditions. These twelve States in the category of "Very Poor" and "Poor" living conditions except Tripura are major States and form a contiguous patch starting from Odisha in the south till Tamil Nadu along the Eastern Coast and from Rajasthan in West till West Bengal in East (Figure-7).

On the other side, five States/UTs, Chandigarh (31.61), NCT of Delhi (35.23), Punjab (42.47), Goa (49.26) and Daman & Diu (49.97) fall in the category of "Very Good" and Kerala (51.69), Lakshadweep (51.89), Andaman & Nicobar Islands (56.09), Himachal Pradesh (57.44), Sikkim (57.56), Haryana (57.98) and Mizoram (59.66), fall in the category of "Good" living conditions.

Conclusion

It is evident from the analyses of Census 2011 data on "Houses, Household Amenities & Assets" among Female Headed Households that the living conditions of FHH in the Indian society are not yet up to the mark. Lack of such a developmentally non negotiable component leads to the vulnerability of female deprivation and female being the poor human resource compared to their male counterparts. Flow of household amenities, assets and condition of houses are important entitlements of a household to ensure their healthy survival. Cultural factors of any society have profound impact of deciding the allocation of household amenities and assets between male and female and income generation capacity in their life course. To uplift the female status in the society, female of the society needs, to be made more aware about various developmental programmes and financial schemes offered by the government for women, to raise literacy level among women so that they become independent. Apart from all, the overall society needs to change the mindset and give equal opportunities to females in all the sectors of life.

Acknowledgement

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Site Suitability Analysis for Business Location: A Case of Triplicane Zone, Chennai using Gravity Model

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Keywords: *Gravity Model, GIS, Thiessen Polygon, Demographic information, Site suitability*

Abstract: Location of suitable site for establishment of departmental stores or new service centre to serve a large population and run the business profitably is the main concern of any business analyst. This paper tries to locate the potential area for the establishment of Departmental stores which will have high potential of success. Triplicane Zone of Chennai City has been chosen as the study area for this analysis. Triplicane is one of the oldest neighborhoods in Chennai, India. Site-location using Gravity Model technique and Geographic Information Systems (GIS) are applied for this analysis. The gravity model which has been incorporated from the Newton's law of Gravity, and has been applied by social scientists to find the interaction between two places based on the market size or population size of the place and the distance between them. Modified gravity model of Newton was initially used by Hammond and McCullagh, (1978) and it has been employed in this study. In this study the population of the different wards of Triplicane zone has been taken and the distance between the central points of the wards are taken to calculate the distance. Mean per capital income of the city was calculated to find the purchasing capacity of the population, the data for which was collected from Department of Income tax. Demographic information has been collected from census of India. Location of different departmental stores has been collected using Global Positioning System (GPS) survey. A feasible new potential store location based on the demographic information has been found using GIS analysis and the gravity model, where both site location analysis techniques were combined to provide results of the areas that have the highest market potential as well as suitable areas for site location and recommendations. Thiessen Polygon and Buffer Analysis in GIS have been extensively employed for the study. The study recommended two sites for the location of departmental stores, and also suggested two other potential sites for future location of departmental store in the study area in the expanding market.

Introduction

The gravity model of trade is analogous to Newton's law of universal gravitation by which the attractive force between two objects is directly proportional to the masses of the objects and indirectly proportional to the distance between them. Gravitational constant (G) is also included depending on the units of measurement for mass and force. A feasibility studies main goal is to assess the economic viability of the proposed business. The feasibility study needs to answer the question: "Does the idea make economic sense?". The outcome of the feasibility study will indicate whether or not to proceed with the proposed venture. There has been a long history in the field of sales forecasting research (William Applebaum

1965). The most popular theory is Reilly's law of retail gravitation (Reilly 1931). Huff (1964) presented an alternative model, where the probability of a consumer traveling to a particular store has positive relationship to the relative size of and negative one to the relative travel time. In today's highly competitive retail environment, it is becoming ever more important for retailers to monitor their trade areas, assess the impact of competition, and choose new store locations strategically. GIS with its capability to manage, display, and analyze business information spatially, is emerging as a powerful location intelligence tool Mishra Sita (2009). According to Hai Rong Lv et al., (2008) the retail store sales prediction and micro-competition analysis based on GIS platform, helps to develop a more elaborate

analysis framework than traditional gravity model. Simulation technique provides the means of directly evaluating the impact of these factors. Pearson K. Jesse (2008) used GIS to locate where future Kowalski's Markets could be located in Twin Cities metropolitan area. Bhattacharyya Ranajoy (2006) Proved that core gravity model can explain around 43 per cent of the fluctuations in India's direction of trade in the second half of the twentieth century. Leitão Carlos Nuno (2010) showed that trade increases when partners are geographically close when partners are geographically close. According to Sekur Tomislav (2008) use of relatively simple and easy to-get data, such as the GDP and distance has made the gravity model particularly popular in explaining trade patterns of transitional economies that lack more sophisticated and longer-series data on foreign trade. According to Aarthy.C (2012) retail location decisions are said to be the most vital decisions because it simplifies getting the stock to the ultimate consumer at the right place, at the right time, in the right quantities, and at the right price. Thus, retailers can go outside standard data analysis by using GIS tools to assimilate, view, and analyze data using geography. The present studies aims to identifying the location feasibility for Business site in Triplicane zone, Chennai.

Methodology

The gravity model incorporates the use of primary data of the location of departmental stores using Global Positioning System (GPS),

secondary data regarding the demographic characteristic of the study area, income of the population and topographic sheets for the preparation of base maps. These data were finally incorporated in the formulae of the gravity model and finally the data were analyzed using ARC GIS. The flow chart below graphically depicts the methodology used.

Gravity Model Formula

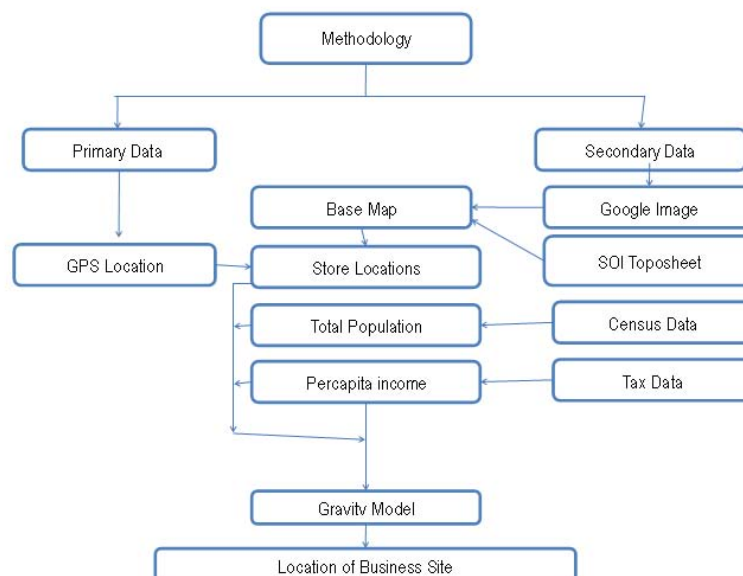
$$M_x = \sum (P * a) / D$$

Where:

- M_x = domestic market potential of town X (TRIPPLICANE MARKET)
- P = population of each region/city (TRIPPLICANE ZONE AREA)
- a = mean per capita income for the region/city
- D = distance between town X and the median centers of regional/city populations

Profile of the Study Area

Triplicane is one of the oldest neighborhoods Chennai, India. It is situated about 3.808 km² (3.9031 mi). Triplicane zone is located at 13°03'19.26" N and 80°16'48.93" E. Triplicane zone is located in the northern outskirts of Chennai and close to Bay of Bengal. It is situated on the Bay of Bengal coast and about 0.5 km (0.31 mi) from Fort St George. The area of around 5 sq. km, Triplicane is home to over 100,000 people, in addition to a floating population of 50,000 to 70,000. Fig. 1 shows the



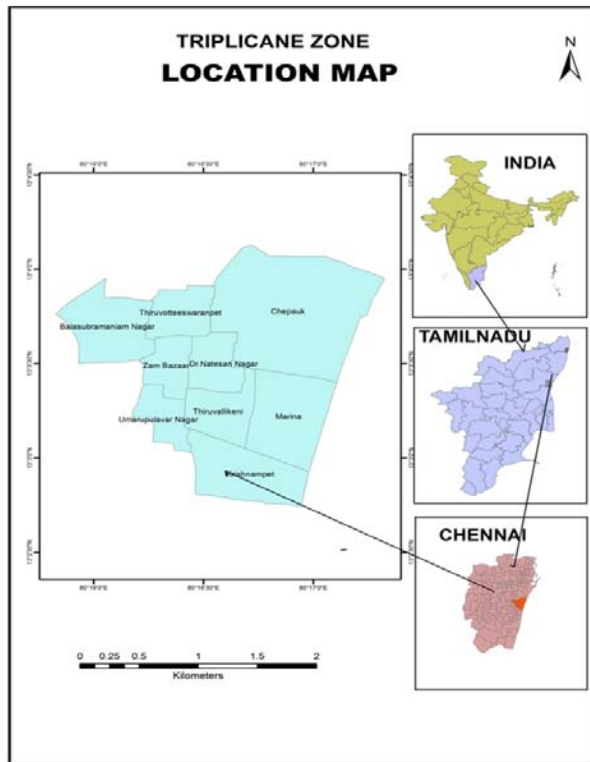


Fig. 1.

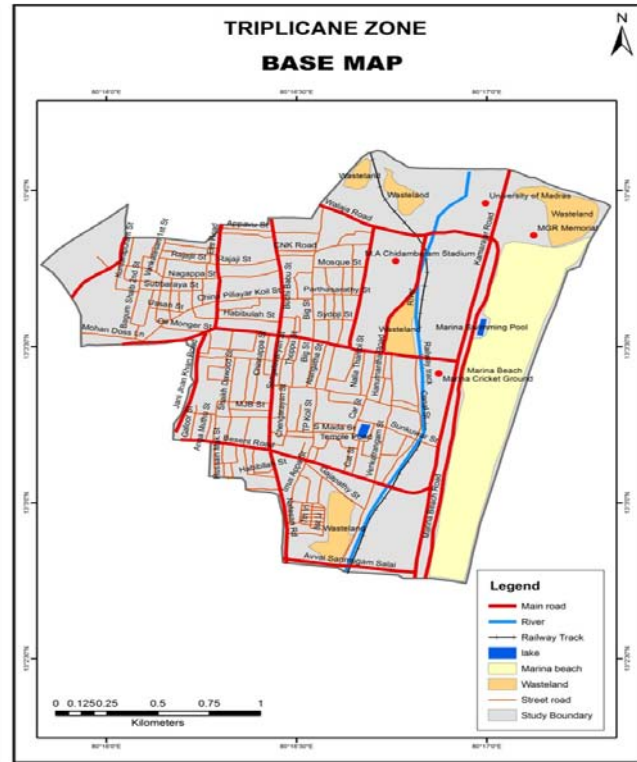


Fig. 2.

location of Triplicane where as fig. 2 shows the nine wards in Triplicane, table 1.

The table shows the nine wards under study. It also gives the detail of the number of streets in each ward and its population along with the number of the ward assigned by the Corporation of Chennai. Figure 3 shows the location of different streets, where as figure 4 shows the location of the different departmental stores in each wards.

Multiple Buffer Analysis: The map shows multiple buffers created with an interval of

100m. The yellow color shows 100m distance from the stores and red color represent a distance of 200m; the green color shows a distance of 300m from the stores. All the buffer shows the area which may fall under the influence of the departmental store. All the nine wards under study are served by 69 departmental stores and in some area even the hundred meter buffer zone overlap with each other where in some location even the two hundred meters buffer does not overlap with each other. Thus the area having too much overlapping of 100 meters are congested

Table 1.

Sl. No.	Ward Name	Ward Number	Total Street	Population 2001	Male Population	Female Population
1	Balasubramaniam Nagar	83	29	20990	10798	10192
2	Thiruvotteeswaranpet	84	19	15913	8816	7097
3	Dr.Natesan Nagar	85	22	13395	8205	5190
4	Chepauk	86	6	15285	8464	6821
5	Zam Bazaar	87	12	15121	7785	7336
6	Umarupulavar Nagar	88	18	20921	10767	10154
7	Thiruvalikeni	89	15	16358	8345	8013
8	Marina	90	9	16549	8348	8201
9	Krishnampet	91	23	21557	10718	10839
Total			153	15608	82246	73843

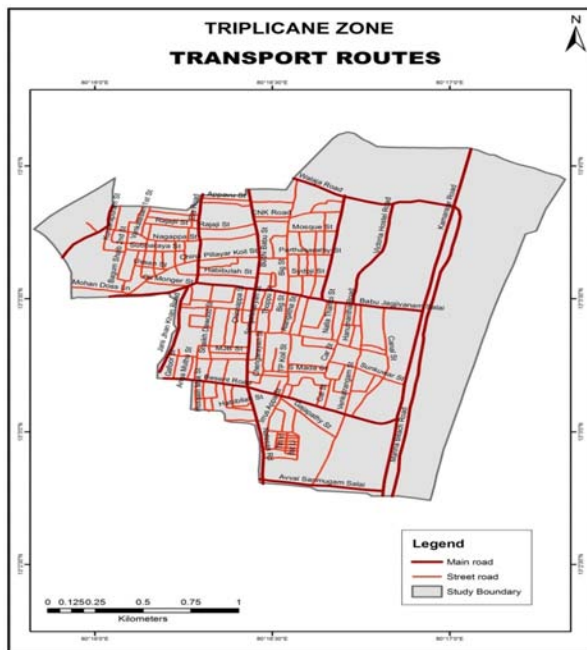


Fig. 3.

with departmental stores where as the area having too less or no departmental store can be potential area for the establishment of new departmental store. The analysis is shown in figure 5.

Thiessen polygon Analysis: The Thiessen polygon analysis is a very easily applied model that can be valid in densely populated areas without geographical barriers in addition to

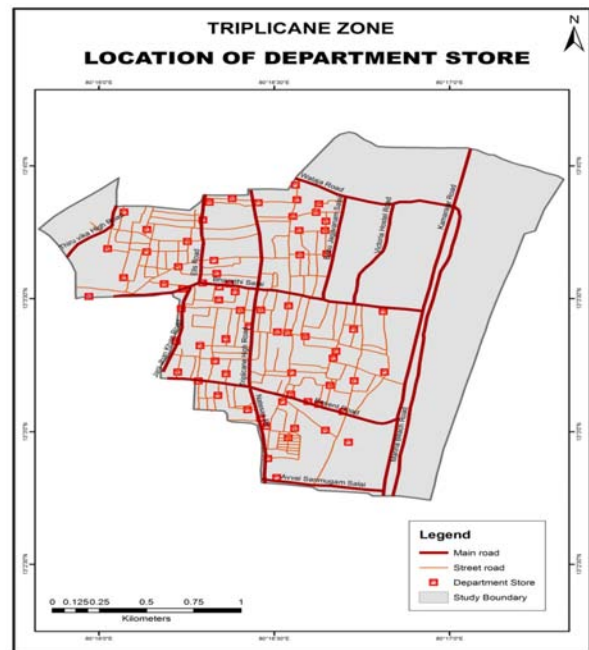


Fig. 4.

relatively homogeneous demographic factors. Thiessen polygons are general using analysis tool in Arc GIS. These polygons shows the area of influence of each service sector and also provides for the regional coverage to which facility can be provided by these service center, in this case the departmental stores. The polygons are shown in figure 6.

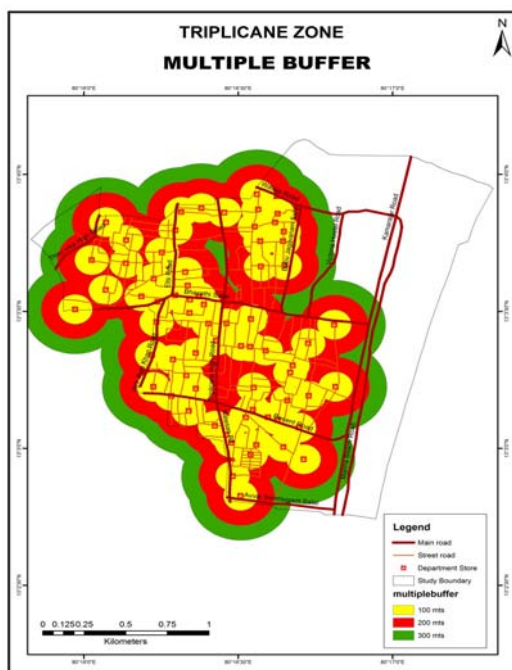


Fig. 5.

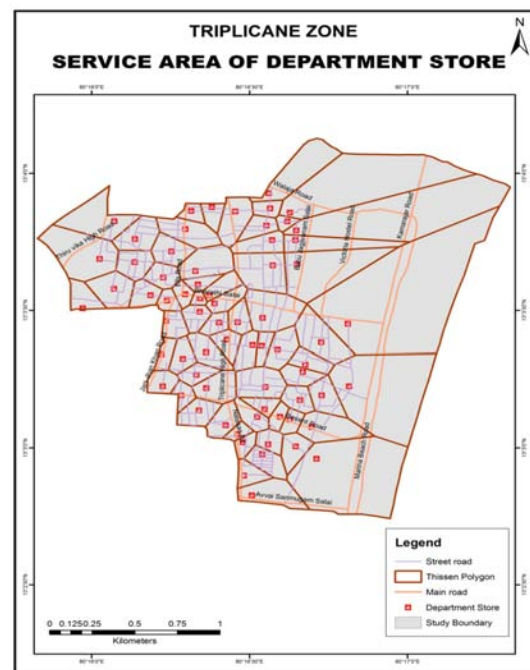


Fig. 6.

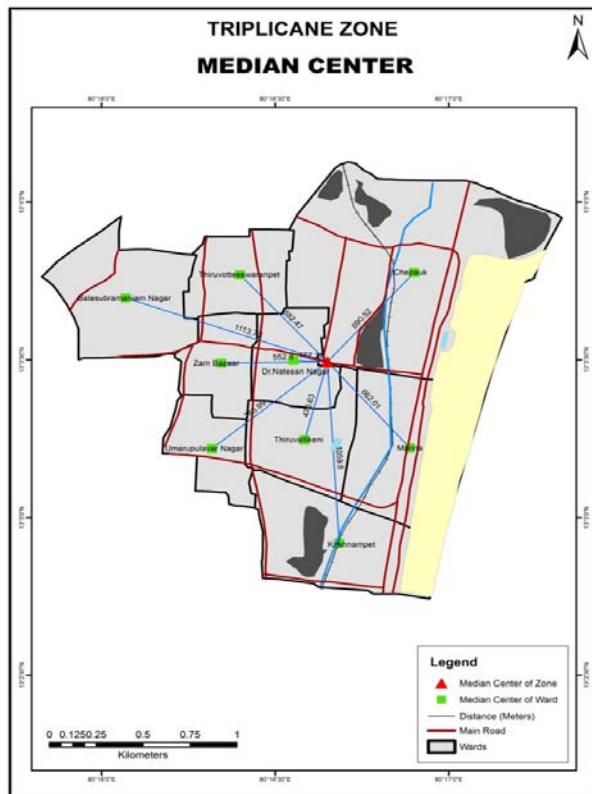


Fig. 7

Median Center: The median center map (fig 7) depicts the distance of each ward from the zone center. The whole study area is a comparison of one zone which is divided into nine wards. The triangle in the map represents the zone center whereas the green dots represent the ward center. The line connecting the zone center to the ward center is the short route distance from the ward center to the zone center. The median center is contained to finally derive the Gravity Model map. It can also be marked that, the straight line distance are generated on the assumption that the plane isotropic and the zone center is connected with the ward center with short route distance.

Site suitable for Present Department Store: Figure 8 shows the over lay of Thiessen polygon, 50m buffer of present Department stores on the potential market area generated. Using query in Arc GIS using four criteria. i.e income, population, house hold and working population. This map has been used as one of the inputs to discuss the final out map.

Potential Market Area: The potential market area map (Fig. 9) has been generated using the four criteria and making use of the

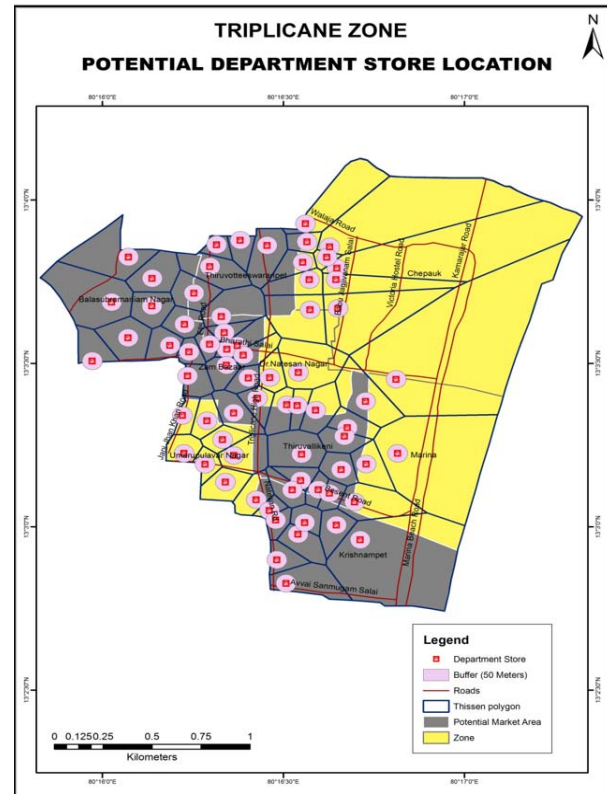


Fig. 8

query system in ARC GIS which is shown in table 2.

Table 2.

"TOT_P">10000 AND "Year_Incom">1500000 AND
"No_HH">3000 AND "TOT_WORK_P">4000

Site Suitability Analysis of New Department Store: This map has been prepared using the model builder, which is shown in figure 9 using the model builder suitable site has been derived in the potential wards for the location of departmental store. Also the model has categorized the highly suitable sight and has ranked them based on the potential for maximum business.

Potential Location using Gravity Model: The gravity model was used to verify the domestic market potential for each town selected from the GIS analysis. The purpose of the gravity model in this analysis is to obtain another perspective of how attractive one area is to another. Using the formula of gravity model the domestic market potential was obtained by multiplying the population of the city by its mean per capita income and dividing by the distance to an adjacent city.

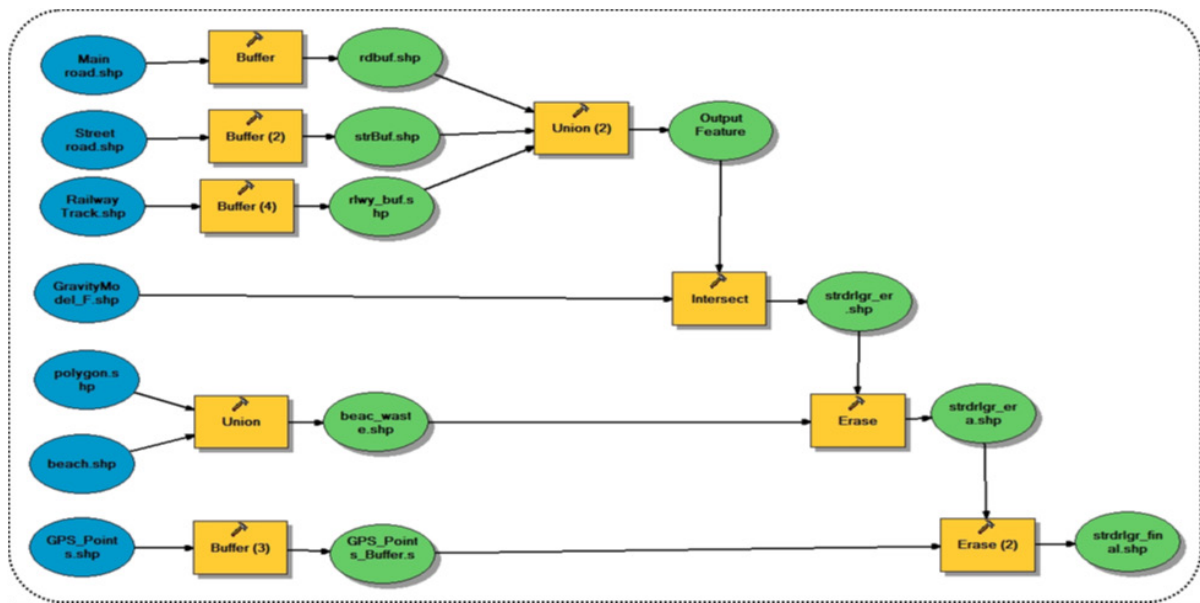


Fig. 9

The resulting figures for the entire adjacent Ward were added together to achieve the market potential for a market. The gravity model found that Triplicane, Zam Bazaar and Thiruvotteeswarpet had the highest market potential. This can be attributed to the higher per capita income in both of those Zones. The Gravity Model illustrating the domestic market potential for the prospective Department store locations. The finally best place of site location is Dr. Natesan Nagar. Table 3, shows the potential area according to gravity model where as figure 10 shows the location of the potential area using gravity model.

Table 3.

Sl. No	Ward name	Rank	Market Potential
1	Dr.Natesan Nagar	1	1825760000
2	Thiruvotteeswaranpet	2	331863010
3	Chepauk	3	327484990
4	Thiruvalikeni	4	187684000
5	Krishnampet	5	176671010
6	Balasubramaniam Nagar	6	92324400
7	Zam Bazaar	7	80293400
8	Marina	8	35786300
9	Umarupulavar	9	14311800

Conclusion: This site-location analysis provides the recommended site locations. In addition, it provides a traditional and technological process to identify areas that have

the highest market potential as well as future possibilities based on the criteria defined in this analysis. The analysis was based on Department Store demographic attributes that were used to determine the potential market areas in the Nine Wards. The Thiessen polygon and buffer analysis determined each store's trade area, and the gravity model showed the domestic market

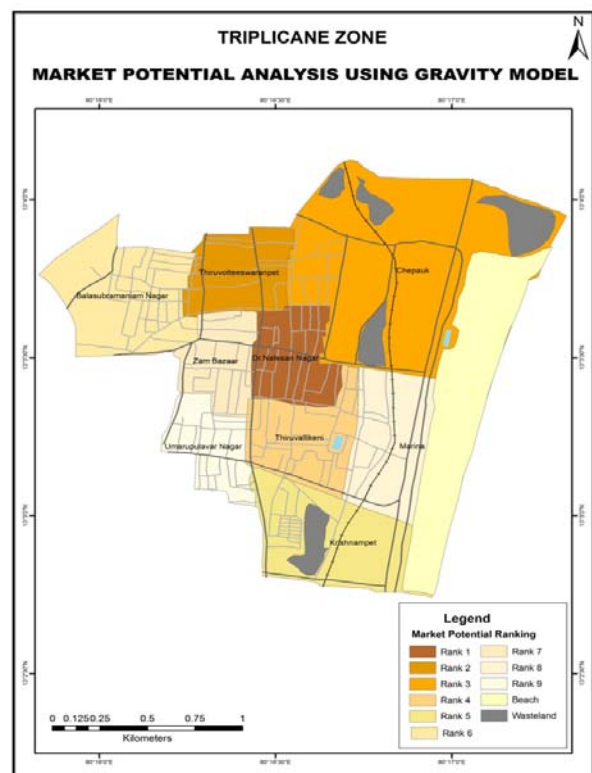


Fig. 10

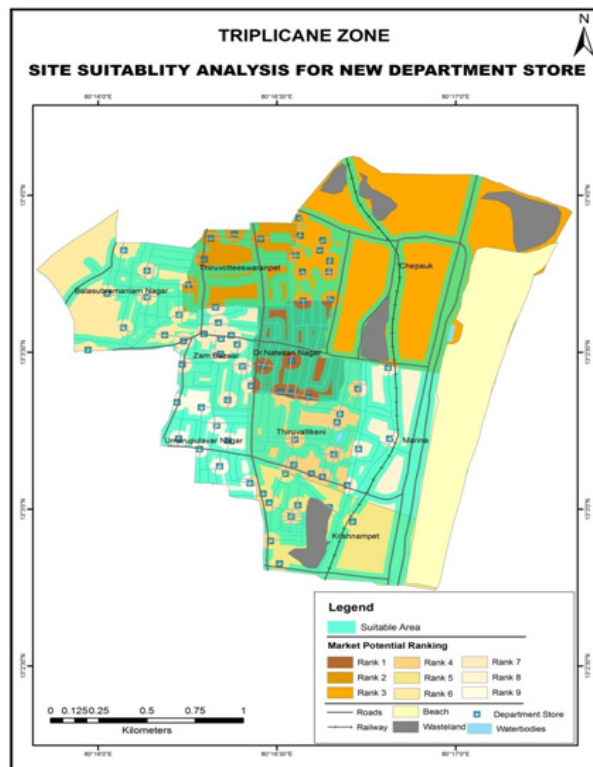


Fig. 11

potential for each city. For this site-location analysis to be successful, it was very important to have multiple analysis techniques and to take each one into consideration. Although GIS is being used by many retailers to locate new stores, there is still a need to have industry knowledge to make the final decisions.

Department Store now possesses the knowledge potential market areas to target for new stores from this analysis. With this significant geographic and competitive advantage, Department Store will have a decreased chance of a new store closing in the future and will see their market share increase with successful store opening. The study has analyzed the location of the suitable site for the location of the departmental store, using GIS model based on demographic criteria, gravity model and model builder to demarcate the specific sight for the location of departmental store, and the output map (figure 11) indicated the sight which can be used to locate the departmental store for a successful and profitable business operation. According to the findings of this project, for triplicane zone, Dr. Natesan Nagar ward is the best option for the location of new departmental store

followed by Thiruvotteeswaranpet, Chepauk and Thiruvallikeni wards.

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Measuring Agricultural Sustainability in Rainfed Regions in India - Spatial Evaluation of Watershed Projects

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Abstract: Watershed development project is a popular NRM and agriculture development strategy in rainfed agriculture. The program has attracted huge investments since its initiation in 1980s in the country. Till date several phases of watershed projects have been implemented under guidelines that have been modified at regular intervals to adapt to changing situations. However use of tools of Geomatics makes the task manageable and provides the facility to measure the immeasurable, namely sustainable development. This paper presents a methodology developed to measure sustainable agriculture in rainfed regions. The paper discusses how the methodology was used to monitor changes in treated watersheds in two districts – Nalgonda and Rangareddy in AP, India. Temporal study since 2006 helped in indicating which aspects of watershed development projects were critical and contributed to sustainability. This information could be vital for the PIA of the projects who can use the information for mid-term correction or for overhauling the whole projects based on actual requirements in the field. Study indicated that although full sustainability has not been achieved, watershed development program was found to be useful and had contributed positively to agricultural development in rainfed regions.

Assessment of sustainability of watershed projects using GIS and remote sensing tools was carried out in eight micro-watersheds in four villages in Rangareddy (RR) and Nalgonda districts since 2006. Area under four villages encompassing over 6000 ha of agricultural land located in various blocks in Nalgonda and Rangareddy in southern Telengana region encompassing AESR 7.2 were studied to measure agricultural sustainability. Over 450 farm households were surveyed annually using two structured questionnaire developed for monitoring and evaluation (M&E) of watershed projects at household and field/watershed levels. Fifty- one indicators were initially constructed with a score card and by 2009 it was possible to identify 13 critical indicators that were found to be critical for sustainable agriculture. Out of these, six indicators were found to contribute over 68% towards sustainable development in rainfed agriculture in AESR 7.2. During 2012 it was possible to segregate the monitoring indicators from the evaluation indicators. Each of the four villages selected for the study, could be divided into 7 to 19 micro-watersheds, out of which one treated and one untreated micro-watersheds covering an area of 100 - 150 ha each, were selected for the study. All watershed projects were implemented under DPAP and NWDPR guidelines during 1998-2004. Since

April, 2008 watershed development guidelines have been changed, however, the information generated from this study is valuable as it shows how tools of Geomatics can be used to carry out spatial evaluation of watershed projects and measure agricultural sustainability that is considered 'immeasurable'. This is indeed a notable progress and as Geomatics provides a valuable tool to measure 'sustainable development', progress can be ensured as it now becomes an entity that can be monitored and evaluated.

Based on temporal analysis of the watershed projects in Telengana region in AP, it was seen that the project had contributed positively albeit marginally to sustainable development. Twelve indicators were identified as critical for Monitoring and Evaluation (M&E) procedure. Two evaluation methods one empirical employing PCA analysis and traditional method and another using Geomatics - *Raster Calculator Tool* in *Spatial Analyst Module* of ArcGIS software, were developed. The results corroborated well with the field level study. A DSS for evaluation of watershed projects is being developed.

Introduction

Watershed development projects have been the basis of natural resource management and

Table 1. Study area

District	Name of Agency	Name of Watershed	Location (Toposheet no.)	Funding Agency
Rangareddy	DPAP, Govt. of AP	Dontanpalli, Shankarpalli Mandal	56 K / 3	MORD
Rangareddy	PROGRESS	Pamana, Chevella Mandal	56 K / 3	MORD
Rangareddy	DOA	Chintapatla, Yacharam Mandal, near Ibrahimpatnam	56 K / 12	MOA
Nalgonda	DPAP, Govt. of AP	Gollapalli, Chintapalli Mandal	56 L / 13	MORD

agricultural development in the rainfed regions in India. The program attracted huge investments since its initiation in 1980s and since 2008 a common set of guidelines were announced for implementation of the projects by various agencies in the country. Till date several phases of watershed projects have been implemented under a series of guidelines that have been modified at regular intervals to adapt to changing situations. Monitoring and evaluation of watershed projects have always been a challenge and under the ICAR National Fellow scheme awarded to the first author, tools of Geomatics were used to make this manageable. This paper presents a methodology developed to measure sustainable agriculture in rainfed regions. The paper discusses how the tools of Geomatics were used to monitor changes in eight treated and untreated watersheds in two districts – Nalgonda and Rangareddy in AP, India since 2006.

Area under four villages encompassing over 6000 ha of agricultural land located in various blocks in Nalgonda and Rangareddy in southern Telengana region encompassing AESR 7.2 were studied to measure agricultural sustainability (Table 1). Over 450 farm households were surveyed annually using two structured questionnaire developed for monitoring and evaluation (M&E) of watershed projects at household and field/watershed levels. Fifty-one indicators were initially constructed with a score card and by 2009 it was possible to identify 12 critical indicators that were found to be critical for sustainable agriculture. Out of these six indicators were found to contribute over 68% towards sustainable development in rainfed agriculture in AESR 7.2. During 2012 it was possible to segregate the monitoring indicators from the evaluation indicators.

Each of the four villages selected for the study, could be divided into 7 to 19 micro-watersheds, out of which one treated and one untreated micro-watersheds covering an area of

100 - 150 ha each, were selected for the study. All watershed projects were implemented under DPAP and NWDPA guidelines during 1998-2004. Since April, 2008 watershed development guidelines have been changed, however, the information generated from this study is valuable as it shows how tools of Geomatics can be used to carry out spatial evaluation of watershed projects and measure agricultural sustainability that is considered 'immeasurable'. This is indeed a notable progress and as Geomatics provides a valuable tool to measure 'sustainable development', progress can be ensured as it now becomes an entity that can be monitored and evaluated.

Based on temporal analysis of the watershed projects in Telengana region in AP, it was seen that the project had contributed positively albeit marginally to sustainable development. Twelve indicators were identified as critical for Monitoring and Evaluation (M&E) procedure. Two evaluation methods one empirical employing PCA analysis and traditional method and another using Geomatics - *Raster Calculator Tool* in *Spatial Analyst Module* of ArcGIS software, were developed. The results corroborated well with the field level study. A DSS for evaluation of watershed projects is being developed.

Materials and methods

To evaluate impact of watershed development program (WDP) and consequent changes in watersheds, a complete methodology was evolved. Evaluation procedure comprised of field work for soil sampling and conducting socio-economic survey, lab work including database creation, construction of relevant indicators, interpretation of satellite data and mapping, and finally analysis of impact of WDP and study of change in the watersheds. In this paper a brief description of the methodology is presented along with the spatial tool developed and used for the objective evaluation of watershed projects in

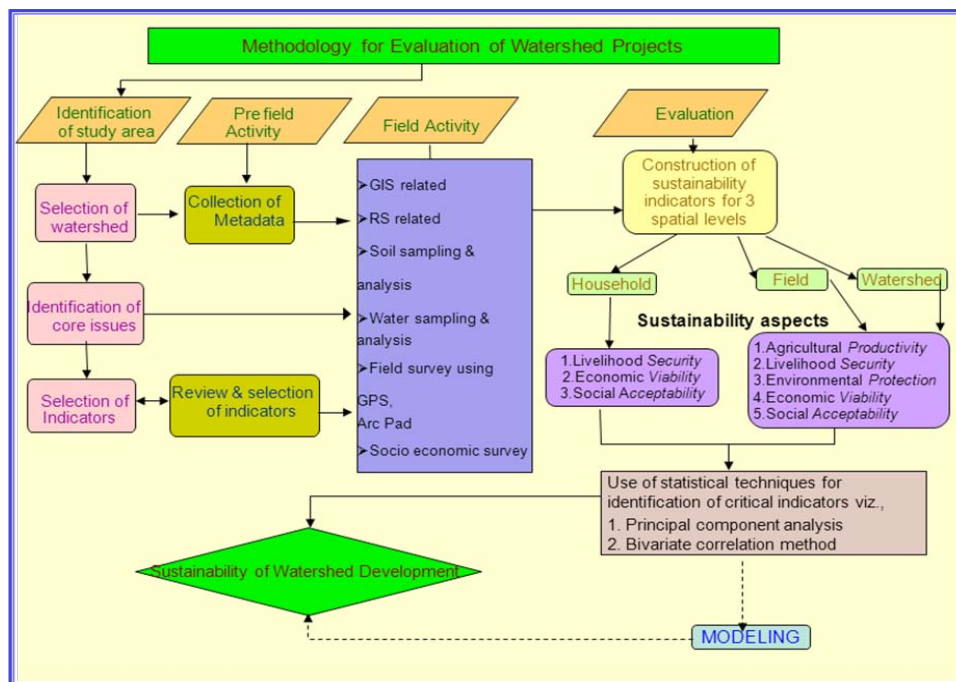


Fig. 1: Methodology for evaluation of watershed projects

the study area (Kaushalya et. al. 2009; 2010; 2011). The complete procedure developed and applied for this study is indicated in Fig. 1.

Using the methodology indicated in Figure 1 and use of statistical techniques like Principal Component Analysis (PCA) and Bi-Variate Correlation Technique (BVC) on the data collected annually, twelve critical monitoring indicators were identified. It also indicates that out of these, six indicators were found to be vital as they contributed over 68% of sustainability at three spatial levels – household, field and watershed levels. In the same process, 6 critical evaluation indicators were identified. These evaluation indicators are non-plastic or non-correlated and hence ideal for evaluation of watershed projects. Using these sets of indicators a spatial evaluation tool was developed using Spatial Analyst module of ArcGIS. The entire procedure of monitoring and evaluation (M&E) has been developed into a two-level procedure and the details are presented in this paper.

Monitoring & Evaluation (M&E) Procedure

The two-level procedure for M&E comprised of Level-1 where empirical method could be used and Level-2 where Geomatics based tool was to be used.

Level – 1: Empirical method for M&E

Level- 1 is based on empirical method for monitoring & evaluation of watershed projects. After identification of critical indicators as indicated in Table 2, a method was evolved to make quantitative indicators viz., ‘crop production’ and qualitative indicators like ‘status of S&WC structures’ comparable. This was essential to make the whole procedure objective, measurable and robust. This also makes it possible to compare the performance of indicators. For this a concept of Threshold Value (TV) was devised. It was assumed that the state of NRM and agriculture in a treated watershed would be better than elsewhere and hence TV would be higher in case of all farmers and land holdings in treated watersheds. TV was derived as 20% above the mean based on community performance, in case of any indicator (Gomez et al., 1996).

Where only qualitative data were to be considered for analysis, then maximum score was assigned to TV. Ratio for each indicator was calculated by dividing actual value by corresponding TV. For finding out sustainability, the value against each of the twelve indicators is averaged and a Composite Sustainability Index (CSI) is determined for each household/ field (land-holding) / watershed.

Table 2. Critical Indicators for monitoring sustainability of WDP

House-hold	Field-level	Watershed-level	Contribution of indicators (<i>weight in %</i>)		
			House-hold	Field-level	Watershed-level
Improving availability and encouraging cultivation of fodder			50	1.6	3.5
Improving nutritional security	Increasing total crop production		25	14.1	7.8
Reducing input cost	Increasing gross agricultural income		25	9.9	7.8
	Maintaining S & WC structures			19.7	17.9
	Large scale adoption of soil moisture conservation measures			15.5	17.9
	Encouraging farm OM recycling			5.5	13.4
	Improving gainful employment			9.9	3.5
	Practicing Crop Contingency Planning			4.5	8.6
	Improving security of tenure			1.6	7.8
	Increasing Crop Diversity (No. of crops/Cultivated area)			5.3	3.5
	Improving availability of water for irrigation			3.2	3.5
		Increased role of extension agents	Increase in cultivated area		9.4	4.9

Depending on the CSI value, sustainability for each field is determined as follows: CSI < 0.25 (Unsustainable); 0.25 – 0.5 (Poor); 0.5 – 0.75 (Moderately sustainable) and > 0.75 (Fairly sustainable).

Level – 2: Spatial analysis for M&E at watershed-level

Spatial analysis enables one to assess the impact of WDP on various bio-physical matrixes of agricultural systems at a watershed-level. While statistical technique like PCA and BVC could help in empirical analysis of WDP at household- and field- levels, the GIS facility enables overlaying of various thematic maps to understand the impact of WDP at watershed-level, considering it as one unique entity which would otherwise have not been possible. Thematic maps pertaining to various M&E indicators as described in the previous tables were drawn. The *Raster Calculator Tool* in *Spatial Analyst Module* of ArcGIS software, helped in overlaying the thematic maps both vector and raster images, assigning scores as per estimated Threshold Values (TV) derived from empirical methods. While some values could be derived directly viz., agricultural production or income, others had to be interpolated on a spatial basis viz., Soil OC and slope etc., that were derived and then used for thematic mapping and eval-

uation. The spatial tool treats the watershed as a unit area and not as an aggregate of various fields / land holdings or land parcels.

For raster based evaluation, each Survey No. / Land holding was considered to be a polygon and scores derived for an indicator was assigned one value for a polygon in each thematic layer pertaining to an identified sustainable indicator. In this manner thematic layers were created for twelve Monitoring Indicators as indicated in **Table 2** out of which six indicators were identified as critical evaluation indicators. For each indicator a raster layer was created from the vector polygon layer with corresponding attribute values by using conversion options in ArcGIS. Indicators were weighted using *Raster Calculator* in Geospatial Analyst Tool in ArcGIS. As mentioned earlier, the respective weight had been estimated statistically for each indicator through PCA. The weights for each critical indicator is listed against it and indicated in Table 2.

To assess agricultural sustainability achieved in individual farm holdings (Survey No.) within a watershed, the weighted thematic layers were summed and normalized with aggregate weight. Figure 2 indicates the working of Spatial Analysis Tool to evaluate sustainability at the watershed-level.

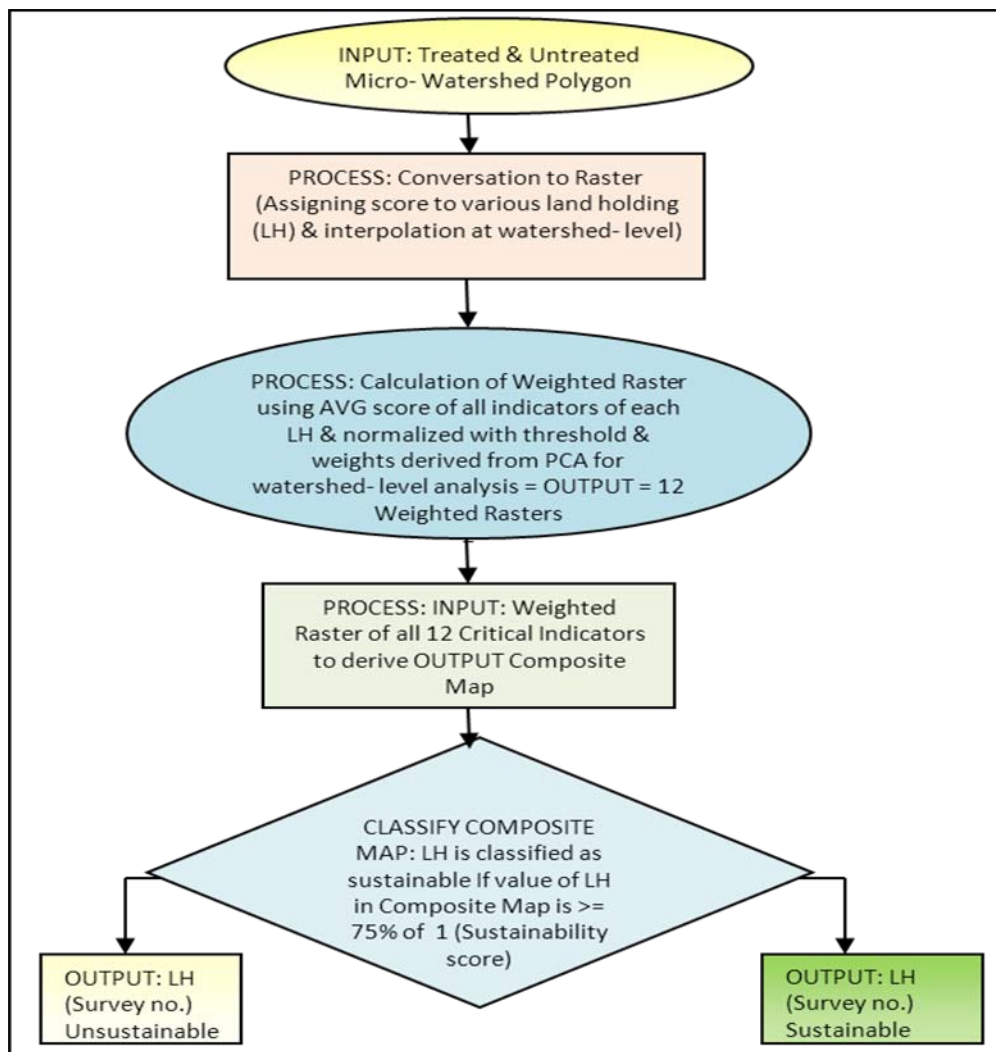


Figure 2: Scheme for spatial evaluation of sustainability at watershed-level

Results and discussion

Trend in change in treated micro-watershed

To analyse a change in treated micro-watershed (TMW), the change were identified after field survey and analysis of satellite data (Table 3). It may be seen that in case of one TMW in Chintapatla village, four indicators pertaining to *Environment Protection* were achieved, while in Pamana and Gollapalli the soil and water conservation (SWC) structures had not been looked after and hence declined. In case of Dontanpalli village, the WDP lost prominence as there had been massive land use land cover change (LULC) due to rapid pace of development in Hyderabad urban agglomeration. In case of *Economic Viability*, four indicators were evaluated. Analysis indicated that in case of Chintapatla and

Gollapalli villages, a positive gain was achieved contrary to the treated watershed in Pamana. For *Agriculture Productivity*, four indicators were analyzed. Except for a decline in *availability of irrigation facility* in all three TMW, other aspects had been achieved. In case of *Livelihood Security* only one indicator - *gainful employment* - was found critical and study indicated that all TMW had gained positively as a result of WDP than in untreated micro-watershed (UTMW) in the respective villages.

Evaluation of WDP using empirical method (Level - 1)

M&E of sampled watersheds in Rangareddy and Nalgonda districts was carried out during 2012 like in previous years. Household, Field survey and Focus Group Discussion (FGD) were held for e.g., in Pamana village

Table 3. Monitoring of WDP in study area using empirical method

Sustainable Aspect	M & E Indicators	Types of Watersheds							
		Chintapatla		Gollapalli		Pamana		Dontanpalli	
		TMW	UTMW	TMW	UTMW	TMW	UTMW	TMW	UTMW
Environ. Protect.	S& WC measures	1	0	0	0	0	1	1	1
	Soil moisture conservation	1	0	0	0	1	1	1	1
	Farm OM recycling	1	1	1	1	1	1	0	0
	Security of tenure	1	1	1	1	1	1	1	1
Economic Viability	Agriculture income	0	0	1	1	0	0	0	0
	availability of fodder	1	1	0	0	0	0	0	0
	Credit facility	1	1	1	1	1	1	1	1
	Crop Diversity Index	1	1	1	1	1	1	1	1
Agri. Prodvty	Contingency Crop Planning	1	1	1	1	1	1	1	1
	Agriculture production	1	0	1	1	1	1	0	0
	Role of extension agent	1	1	1	1	1	1	1	1
	Availability of irrigation facility	0	0	0	0	0	0	0	0
Livelihood Security	Gainful employment	1	1	1	1	1	1	1	1
Total		11	8	9	9	9	10	8	8

Note: score 1 = Increasing trend; 0 = Decreasing trend.

during post-Kharif season in November, 2012. Thirty-five households in TMW in Pamana who operated 65 land-holdings, and were surveyed and their fields and agricultural activities, evaluated. In UTMW taken as control within the same village, 17 households with 22 land parcels were also evaluated. The 12 critical monitoring indicators and one unique evaluation indicator as indicated in were used to monitor and evaluate the watersheds.

Sustainability Index was derived from the Mean Value of 13 indicators for each sample farm / land-holding. It was seen that Survey No. 242 in TMW and 220 in UTMW were found to be fairly sustainable although they did not score '1'. Cob-web diagram was used to indicate the comparative performance of various indicators in both types of watersheds. Three indicators that imparted a fair amount of sustainability to agriculture in the TMW were increase in

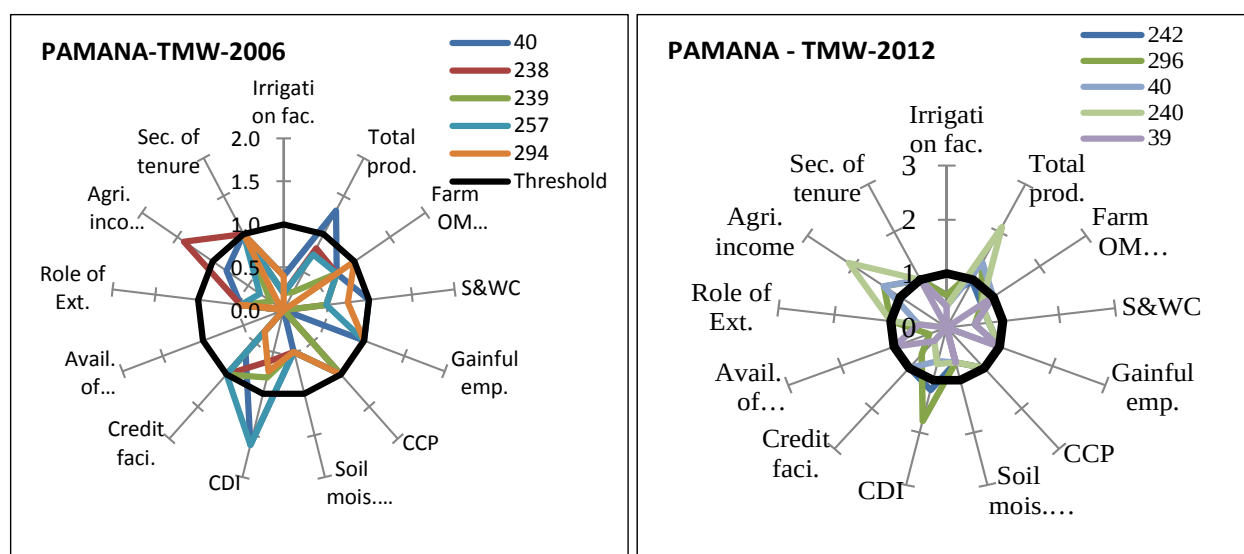


Fig. 3: Cob-web diagrams to indicate relative gain in sustainability in Pamana treated watershed through the years

agriculture production, agriculture income and Crop Diversity Index (No. of crops / unit area). However in UTMW, CDI was seen to be poor (Figure 3).

Evaluation of WDP in Pamana, indicates that no farmer attained complete sustainability. Figure 3 indicate the comparative situation in treated and untreated MW. The axis emanating from the central hub denotes the various critical indicators used for the evaluation. The thick grid line denotes the Threshold Value. The other lines indicate the gains made by leading farmers in respective watersheds.

Similar analysis was undertaken in case of other villages also. In Chintapatla watersheds, survey of 30 households operating on 65 farm holdings in TMW and 23 households with 16 farm holdings in UTMW was surveyed during October 2012. Two holdings in UTMW were found to be sustainable and while one Survey No. in TMW was found to be fairly sustainable. Like Pamana, WDP in Chintapatla has also lent sustainability through gains in *Agriculture production, Agriculture income* and the Crop Diversity Index (CDI).

A similar exercise was undertaken in case of Gollapalli watersheds. Survey of 28 households with 38 farm holdings in TMW and 29 households with 38 farm holdings in UTMW was carried out during September 2012. Two holdings in both - TMW and UTMW were found to be fairly sustainable. However, situation in UTMW was better. *Agriculture production, Agriculture income* and CDI have imparted fare degree of sustainability as in other watersheds.

Trend in sustainability achieved through WDP during current decade

In Pamana TMW, Survey No. 296 was found to be sustainable. In UTMW land holding (Survey no.) 227 was assessed to be sustainable. A brief description of the farming activity of each of these farmers is given below to show how they had achieved agricultural sustainability. One farmer named *Sakali Vittalaiah* who owned 2.5 ha in Survey no. 296 also owned a bore-well and cultivated cotton and carrot. From cotton he achieved a harvest of 20q/ ha and got an income of Rs. 68750/ha. Previously he used to cultivate vegetables, maize and paddy and was able to grow only 32q/ha and but earned

Rs.74375/ha. This decline in income was seen due to avoiding paddy cultivation owing to fall in ground -water table. It was seen that the farmer practiced compartmental and contour bunding and incorporated FYM in soils and followed fertilizer recommendation. He had a bore- well in his field and had adopted S& WC measures, practices soil moisture conservation techniques besides soil amendments like FYM, vermin- compost and undertakes summer ploughing. The temporal trend in impact of WDP in Pamana has also been indicated in Figure 4.

Evaluation of WDP in Pamana

Evaluation of impact of WDP indicated that net area under sustainable agriculture increased marginally from 53.63 ha accounting for 40% area in TMW in 2006 to 57.0 ha (43%) during 2012. In case of UTMW the gain was also impressive. Extent of sustainable agriculture increased from Nil in 2006 to over 16.23 ha (16%) by 2012. In Pamana village, WDP was impressive till 2008; however since then there has been a decline in agricultural activity due to major changes in LULC in that region due to growth of Hyderabad metropolitan region.

As mentioned earlier, the spatial evaluation method treats the watershed as a unit area and not as an aggregation of different field holdings or land parcels. Under spatial evaluation the weighted thematic layers were summed and normalized with aggregate weight according to procedure developed under the NF scheme. According to spatial analysis, the evaluation results were comparable. Thus it may be appropriate to state that both methods - Empirical and Spatial as illustrated in this paper are robust for use in M&E of WDP. While Level -1 can be used by PIA who doesn't have GIS facility, the level-2 provides a powerful tool to evaluate WDP projects and its impact on sustainable development like never before. Evaluation of NRM projects like WDP stand to gain by the application of tools of Geomatics as discussed in this paper

Conclusion

Based on temporal analysis of WDP in the four villages in Nalgonda and Rangareddy districts, it may be stated that WDP in Chintapatla had achieved more than the other two watersheds namely, Gollapalli and Pamana.

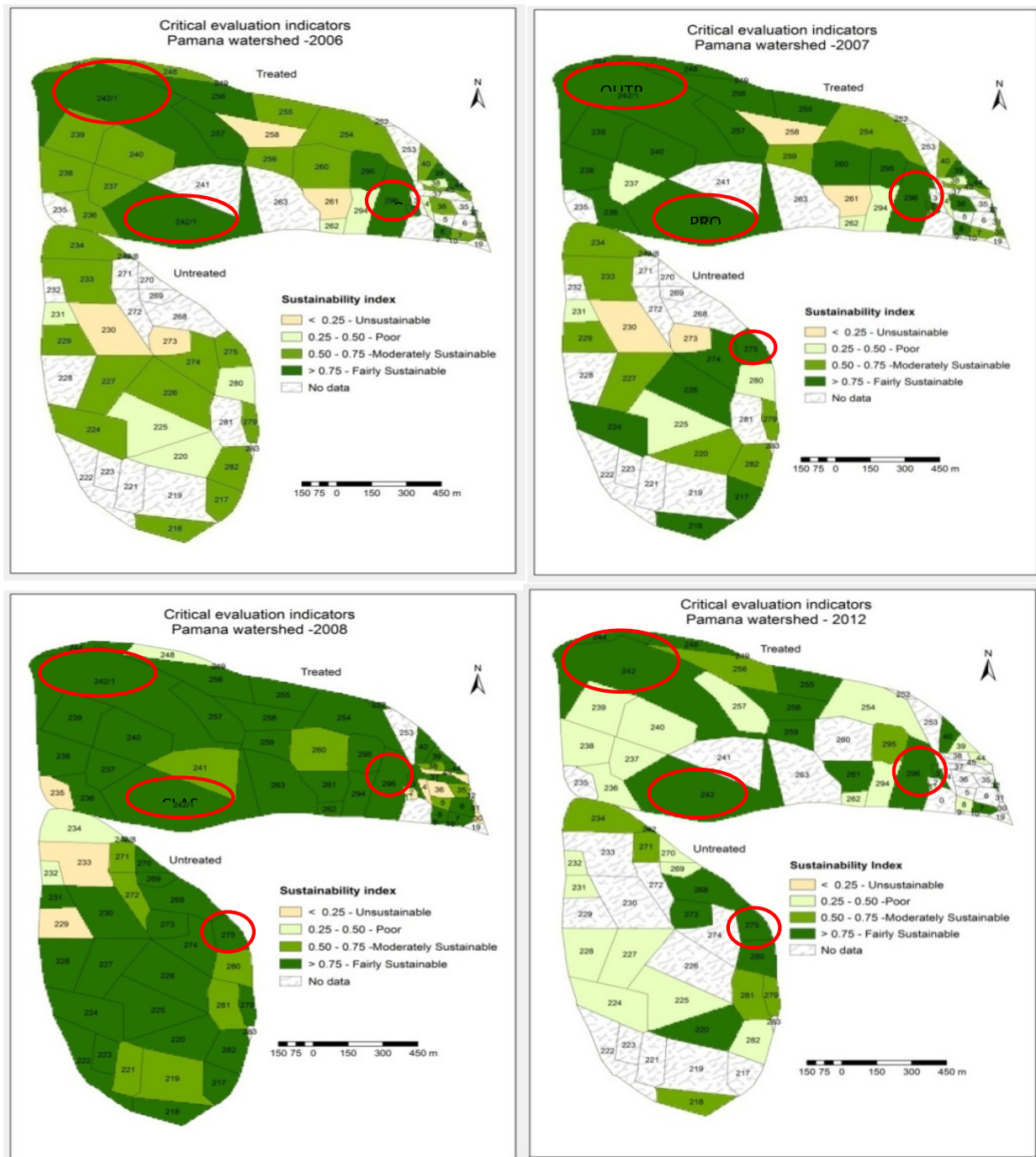


Figure 4: Evaluation of sustainability of Pamana watersheds

In Pamana, situation in UTMW seemed better due to gains from proximity to TMW and also to the market. Twelve Monitoring Indicators including four Evaluation Indicators and one unique evaluation indicator namely *Credit Facility* were used to monitor and evaluate eight sample watershed projects in Rangareddy and Nalgonda districts in AP that were being assessed since 2006 onwards. The results

of M &E based on Empirical method have been described here. For spatial evaluation of sustainability a *Raster Calculator Tool* in *Spatial Analyst Module* of ArcGIS software was used to perform M&E of the watershed projects.

According to spatial analysis, the evaluation results were comparable. Thus it may be appropriate to state that both methods -

Empirical and Spatial as illustrated in this paper are robust for use in M&E of WDP. While Level -1 can be used by PIA who doesn't have GIS facility, the level-2 provides a powerful tool to evaluate WDP projects and its impact on sustainable development like never before. Evaluation of NRM projects like WDP stand to gain by the application of tools of Geomatics as discussed in this paper.

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Geoinformatics in Pricing Irrigated Agriculture – A Case Study

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Keywords: *Irrigated agriculture, Tariffs, Gram panchayat, High resolution satellite images & Cadastral maps*

Abstract: The principal sources of water supplies are rainfall and stored supplies mainly surface water and ground water. Scarcity of these supplies becomes more intensive during dry periods and the stress on stored water supplies grows even further in irrigated agriculture sector. Water policies and strategies may now require the implementation of some form of charging for irrigation sources. During one such operational study, numerous field visits were made in different seasons covering south Bengal collecting water level depths and yield data. Apart from ground water data collection one major observation was made in irrigated agriculture. A large section of the farmers especially during zaid/summer crop (boro paddy in West Bengal) cultivation, irrigated water were traded by private and local farmers where government irrigation schemes were absent or were defunct. This led to conceive this paper on formation of methodology document on water tariff in irrigated agriculture. This paper investigates published national and international standards used for charging irrigated agriculture. Various reports, technical papers, their knowledge and experience in charging for irrigation services have been considered. The principal aim over here has been to generate methodology document for irrigated agriculture in Narayanpur Gram Panchayat, Nabagram Block, Murshidabad district primarily to supplement operational and management cost of the irrigation systems. High resolution (Cartosat – 1 Pan + IRS P6 LISS IV Mx) orthorectified satellite images and Cadastral maps of the concerned gram panchayat have been used for preparing geospatial layers on 1:10,000 scale. These layers along with extant standards on irrigated water charges will investigate and form methodological document on irrigated agriculture tariffs.

Introduction

In West Bengal, seventy two per cent of the total populations living in rural area are agriculture predominant in terms of occupation in the state. Moreover agriculture in the state is farmer centric with a 90 per cent of the cultivators being small and marginal farmers. Small and marginal farmers hold about 84 per cent of the state's agricultural land. Marginal operational holding (less than 1 hectare) accounts for 88 per cent of the total operational holding as against 69.8 percent at all India level (NABARD). Progressively, with increase in population and inadequate employment generation, the pressure on land and irrigation sources has increased considerably leading to fragmentation of holding and overall increase in small and marginal farmers. The direct threat over here due to smaller land holdings limits the scope for adoption of intensive crop

production technologies which are capital intensive. This is where water trade by local and private farmers is prevalent. Over here water policy and strategy is required where implementation of some form of charging for irrigation service is introduced

West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005 first published in the Kolkata Gazette, Extraordinary, 31st August, 2005 do not mention the requirement of implementation of some form of tariffs in irrigated agriculture sector however, the present agricultural scenario of the state especially intensive irrigated agriculture during zaid/summer season is prevalent of water trade for irrigation at local levels. The most common objective of this policy will relate to cost recovery – especially recovery of the ongoing cost of operation and maintenance.

Objectives of irrigation water charging

1. To encourage the concept of development with peoples' participation which will help in generating the feeling of ownership in the participatory development of the gram panchayat.
2. Beneficiaries should pay the full ongoing cost of system operation, maintenance, replacement and upgrading facilities.
3. Operation and maintenance cost of the main irrigation system can lead to overall improvement of the system including the operation efficiency thus creating service delivery.
4. Maintenance of water quality is usually viewed as public good and therefore it is controlled by regulation by directly taxing the disposals of polluted effluents.
5. Under public investments it will ensure that all users under prioritized condition get sufficient water.

Although the available literature identifies a number of theoretical objectives of irrigation water pricing, in practice just two objectives dominate most of the literature and practice: to achieve some level of cost recovery and to bring about a reduction in irrigation consumption. These targets depend upon the season of cropping and the extent of cropping.

Pricing methods

Extensive research on pricing methods in charging irrigated agriculture published in national and international standards have been considered. Various reports, technical papers, their knowledge and experience in charging for irrigation services have also been taken into consideration. However it appears that broadly four categories of pricing methods exists, *i.e.* Volumetric Methods, Non-volumetric Methods, Market based Methods and Pricing Structure in practice (Table 1).

1 Volumetric Method: Volumetric method charge per unit volume of water supplied at the measuring point. They require information on the volume used by each farmer or a defined group of users. This method is not suitable in the state as there are large numbers of small and marginal farmers. The cost of installing

Table 1. Pricing Methods

Bases for irrigation water charges	
TYPE	DETAIL
Area based	a) A fixed rate per hectare of farm, where the charge is not related to the area irrigated, the crop grown or the volume of water received. It is usually part of a "two-part" tariff designed to cover the fixed costs of the service. Different tariffs may be used for gravity and pumped supplies. b) A fixed rate per hectare irrigated. The charge is not related to farm size, type of crop grown or actual volume of water received (except that a larger irrigated area implies a greater volume of irrigation water).
Crop - based	A variable rate per irrigated hectare of crop, <i>i.e.</i> different charges for different crops, where the charge is not related to the actual volume of water received, although the type of crop and area irrigated serve as proxies for the volume of water received.
Volumetric	a). A fixed rate per unit water received, where the charges is related directly to, and proportional to, the volume of water received. b). A variable rate per unit of water received, where the service charge is related directly to the quantity of water received, but not proportionately (<i>e.g.</i> a certain amount of water per hectare may be provided at a low unit cost, a further defined quantity at a higher unit cost and additional water above this further quantity at a very high unit cost). This method is referred to as a rising block tariff.
Tradable water rights	The entitlements of users in an irrigation project, or more widely, other users, are specified in accordance with the available water supply. Rights holders are allowed to buy or sell rights in accordance with specified rules designed primarily to protect the rights of third parties. Sales require authorization by a licensing authority.

Source : FAO, Water Reports. 28

water measuring devices and monitoring individual users are often prohibitively expensive – especially in systems designed to provide uniform schedules of irrigation over large areas.

2. Non-volumetric Method: The only entirely non volumetric system of water charging is based on the size of the farm. In some Indian states, the land tax depends on whether the

land is capable of being irrigated; elsewhere, particularly where a two part water charge is imposed, one component is often related only to the size of holding, thereby providing the irrigation agency with a guaranteed source of income. In some areas where rice is the prevalent crop, the water charge is dependent on the area actually irrigated. It is perhaps the most common form of charging system, the payment is based on the area irrigated and the crop – so that higher rates may be payable for more water-consuming crops. These various systems in fact introduce a degree of volumetric payment. A farmer who irrigates five hectares has received more water than a farmer who irrigated two hectare, and a farmer irrigating sugar cane uses more water than a farmer irrigating cotton. However, there is no direct linkage between volume and payment – so that the same charge is paid in a particularly dry season as in a very wet season

3. Market based Method: Water markets provide a flexible and efficient way to allocate water while providing incentives that are beneficial for water users. Where water savings are tradable, they provide extra income to farmers. A defined tradable water right, with charges related to the cost of the irrigation service allows farmers to continue farming or to sell the right at an open market price to the highest bidder.

4. Pricing Structure in practice: Most agencies rely on simple, fixed cost, pricing structures, most frequently based on the irrigated area. On these schemes, the variable element reflects the energy cost associated with pumping and pressurizing water delivery system.

Pricing Irrigated Agriculture - Indian Scenerio

Gujarat: There seems to be full flexibility and control over water deliveries at farm level allowing volumetric pricing to be feasible and indeed it is practiced by the farmers' groups who own wells. Although the state subsidizes electric power, current prices for irrigation water in Gujarat are high. Given the site-specific nature of farmers' crop selection, varying market prices for crops, different water table depths and the variable yields of different aquifers; it is unlikely that a uniform policy of increased energy prices could reduce irrigation demand to the levels needed to

sustain ground water levels. If the flat-rate tariff structure for agriculture is replaced, so that farmers pay for the amount of energy actually consumed, the energy suppliers may be returned to solvency, provided that collection can be enforced.

Haryana: The state of Haryana addresses the issue of water scarcity by a system of water allocation. Allocation decisions between sectors are made at the political level, and that between farmers is based on well established and fixed rules. First, the water demands for non-agricultural and agricultural use are prioritized at state level. Expected allocations to irrigation are dawn up, based on reservoir storage levels and projected inflows. Finally, the water allocation to irrigation is distributed proportionally across all area. Thus, there is essentially no scope for moving towards more flexible and volumetric delivery with the pricing at the farm level. However it provides a well codified and recognized framework for water management.

Approach for Narayanpur Gram Panchayat

Charging mechanism vary within a single country or state reflecting different objectives, different sources and different degree of water scarcity and irrigation schemes with different technologies. Farm/crop type, size of land holding or even status of socio-economic authority may reflect different charging mechanisms.

In West Bengal, for example, western terrain, coastal plain and Gangetic plain enjoy different hydro-geomorphological conditions and accordingly price or tariffs for irrigated agriculture will also vary. In such a situation tariffs can be prioritized on the basis of agro-climatic sub regions as prepared in West Bengal for "State Agricultural Plan for West Bengal" by NARARD, West Bengal. Considering this condition, options such as fixed rate per hectare of farm, where the charge is not related to the area irrigated, the crop grown or the volume of water received can be used or the most prevalent in Murshidabad district can be adopted where fixed rate per hectare irrigated depending upon season when the crop is grown. This paper attempts to use the former one as this is already in practice in the study area.

Clarity of the objectives in formulating water charges is the biggest issue here. High water charges to discourage waste will impact heavily on the poorest farmers and sophisticated charging system, based on volumetric measurements are expensive to introduce and operate. The charge required to recover the cost of operation and maintenance is the exact charge considered in this paper.

The issue remaining now for pricing irrigated agriculture is the determination of the area of crop/farm irrigated and the season when the crop is grown. In case of Narayanpur gram panchayat, seasonal crop/farm can be easily detected with multi-season remote sensing data and in this paper only boro/summer crop is considered. More acute problem will be the determination of the size of the irrigated crop/farm land based on cadastral information and the details about it. This problem regarding this farm/land details will be taken care by superimposing geo-cadastral data where details like the dag/part number of the parcels practicing irrigated agriculture is found.

Role of Geo-informatics and its findings

Satellite image - Cartosat-1, 2.5m PAN and IRS-P6,LISS-IV,5m Mx, Cadastral maps of Narayanpur Gram Panchayat, Survey of India topo sheet @50K, Census (2001) and police station maps of Nabagram block, Murshidabad district were extensively used to generate geo-database consisting of land use/cover, cadastral, village, gram panchayat and block map. Manual for land use/cover and cadastral data generation of "Space Based Information Support for Decentralized Planning" was followed thoroughly to maintain national standard.

The process of installing, charging and operating the entire irrigation system can be totally granted to the local panchayat members as they are the best persons to decide and judge their irrigation needs. Above all, during agriculture stress period, that is, agriculture during summer season or practice of "boro" paddy, their spatial location and the area can be derived and analyzed by help of Remote Sensing and GIS. This will facilitate the panchayat/government members to take informed decision and judgment on the matter relating to irrigation services like addressing the areas where irrigation services are fast

deteriorating or where irrigation service is completely absent or areas where irrigation is extensively practiced.

The methodology adopted to derive land use/cover of Narayanpur gram panchayat and cadastral information is given in fig. 1. As the main objective of this paper is to derive the extent and area of the boro paddy/farmland, the derived cadastral data is superimposed over satellite image and parcel wise land use/cover is generated (Fig. 2). Spatial adjustment of the cadastral data with satellite data will play a vital role here as the entire process of land use/cover generation on parcel basis is dependent on it. Three major types of agricultural parcels can be detected from the satellite data, first, the magenta class where boro/summer paddy is practiced, second the agricultural fallow land with high moisture content and low moisture content. (Overlay of cadastral with satellite images as shown in snap shots) This overlay analysis of cadastral with satellite images will now accomplish to derive the followings:

1. Parcel wise land use/cover
2. Parcel/dag/part numbers and other details of irrigated agriculture.
3. Spatial extent and area of the irrigated agriculture.
4. Disparity between irrigated and rain fed areas.
5. Inadequacies in investment and planning in irrigated agriculture
6. Potential parcels for irrigated agriculture.
7. Drawing specific guideline offering flexibility for the choice of irrigation technology to enable the farmer for adoption of location specific and cost technology and
8. Adequacies in infrastructure and coordination approach.

Finally the tariff generated in Narayanpur gram panchayat from the data above and as per price standards now being used in Murshidabad district by local and private farmers i.e. @ Rs. 2500/bigha (Rs 2500/0.13378 Hectares) during boro/summer paddy season will now stand to around Rs. 28 lakhs. The price mechanism applied here is - variable rate per irrigated hectare of crop, i.e. different charges

for different crops, where the charge is not related to the actual volume of water received.

According to Vision Document "Road Map for Panchayats in West Bengal" published by Panchayat and Rural Development, Government of India, ".....every gram panchayat will prepare GIS based maps showing existing irrigation system." The idea for adopting such guideline is to find better scientific options to execute decisions on measures to control and regulate ground/surface water development.

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Cartography and Geographic Information Science: Converging Contemporary Art with Technology

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Keywords: Irrigated agriculture, Tariffs, Gram panchayat, High resolution satellite images & Cadastral maps

Abstract: Maps and geographic information (GI) have special power through their ability to connect and integrate data sets by the inherent geographical location, and present the information contents in a user-friendly and understandable visual and tactual way. Such ability has long been recognized as an intrinsic property of the map artefact, as well as contemporary geodatabases. As such, it has voluntarily forced thematic cartography to bring on-going changes in the last 50 years. At the same time, it has also increased in the capabilities within its technical aspects, especially automation. These changes has induced varied technological shifts in the map-making process. Thematic cartographers now tend to view their objective as one of graphic communication rather than one of making graphic displays. Secondly, they are also being forced to expand their conception of what constitutes a map, to accept new products, to tighten definitions, and to allow more variables in their methodologies. Finally, thematic cartographers are beginning to view the field of cartography as a science, one that is rather independent of both the fields of geography and civil engineering. Thus, it has given birth to a new branch, called as CartoGIS.

The power of maps and geographic data handling has been recently recognized in many real world applications and strategic decision making situations related to current topics like crisis management, early warning systems, efforts for supporting sustainability and decreasing global poverty. The spread of advanced technology - remote sensing and geographic information science - and better forecasting techniques and models are used by the decision-makers. GIS data are vital to efforts to deal with environmental issues, to answer the basic questions of what was happening, where and why. GIS has revolutionized changes in the data collection and demands, from single to interdisciplinary assessments, from single to multiple-risk assessments, from post-event to real-time event responses and from paper to digital products. Also, GIS provides a scope for the integration, analysis and visualization of data from multiple sources to derive a scientific basis for decision-making. With the substantial growth of the user community and market for spatial and location-based data, the transition from maps to spatial databases, the need for a coordinated approach for access to spatial data and technology at the local, national, regional and global levels, integration between those levels and the establishment of location-related protocols has been felt. In fact, the sources of geographic databases had grown enormously at the different levels. Present paper reviews research in geographical cognition that provides part of the theoretical foundation of geographical information science which has converged various streams of cognitive science and produces a coherent research community with the enormous potential of CartoGIS.

1. Introduction

Maps and geographic information (GI) have special power through their ability to connect and integrate data sets by the inherent geographical location, and present

the information contents in a user-friendly and understandable visual and tactual way. Such ability has long been recognized as an intrinsic property of the map artifact, as well as contemporary geodatabases. The power of maps and geographic data handling has been

over the time recognized in many real world applications and strategic decision making situations related to current topics like crisis management, early warning systems, efforts for supporting sustainability and decreasing global poverty.

Maps and geographic information systems (GISystems) both encode spatial relationships in structured formal representations. These representations enable shared understanding of geographic phenomena and their interdependencies. This formal encoding makes maps and GIS well suited inherently to facilitating collaboration among human participants in thinking and decision making about the geographic scale environment. Recent conceptual and technical developments in geographic information science (GIScience), and in information technology more generally, suggest we are on the cusp of a substantial increase in the role of maps and GISystems as mediators of collaboration – in a range of contexts that include urban planning, resource management, scientific inquiry, and education. The keywords are as follows:

1. Geographic information: Geospatial Information is considered as a synonym, and Geospatial is used in contexts where it is commonly used.
2. Metadata and SDIs: in the text spatial data infra-structures (SDIs) have a synonym of 'geospatial data infrastructure'; by adding the geoprefix we can emphasize the real contents of the data in question.
3. Geospatial analysis and modelling: the emphasis is on the extraction of added value from the processing of spatial data on maps and the use of analysis and modelling techniques to initiate, support and supplement the mapping process.
4. Usability: this keyword covers a range of issues which connect the human user of spatial data with its representation, its processing, its modelling and its analysis.
5. Geovisualization, visual analytics: here the visual representation of spatial data, in map and in other forms, is discussed, along with methods of using such representations.
6. Map production: It is for the numerous stages in mapping and map production as

technical processes, but also production of various map types from atlases to Internet maps.

7. Cartographic theory: the fundamental concepts which form the basis of all our spatial data handling are incorporated under this keyword.
8. History of cartography and GI science: the importance of the development of methods and practices through-out history was recognized in the brainstorming session: all current-day activity is informed by detailed accounts of such development.
9. Education: to ensure a valid and viable future, there is a need to research and implement methods to educate and train future generations and develop suitable methods of doing this.
10. Society: Use of such spatial data handling in societal structures and by different groups of the people.

2. A Need for Research

Dramatic developments in communication, information and computational technologies alone promise to revolutionize our lives even further. Advances in these fields will change the way science is performed and expand its capabilities dramatically. They will influence the ways we teach and learn—perhaps even the way we think.

The development of geographic information systems was led by applications in land management and record keeping in government. GISs also have become powerful tools for researchers in the environmental and social sciences. Geographic information systems can support both exploratory and confirmatory analysis, provide tools for both inductive and deductive approaches, and support both scientific research and the implementation of public policy based on GIS models. However, GIS and geospatial technologies are not used in research as widely as they could be or should be because issues of human-computer interaction impede scientific adoption of GIS, especially in fields where computer literacy is not high. Across many scientific domains, researchers using geographic information struggle when they attempt to compare or integrate their data with data collected and processed by others.

There is wide variability in the levels of adoption of GIS, spatial analysis, and related tools and methods across the environmental and social sciences. Scientific advances often are driven by the availability of both analytical tools for analysis and data required by those tools, and some sciences are missing out on the insights that could be provided through spatially-explicit problem solving enabled by GIS. For example, several impediments to greater use of GIS by geologists have been identified, and are typical of many other fields as well:

- the lack of 3- and 4-D oriented spatial analysis tools; these include mathematical, cognitive, and statistical tools;
- the inability of generally available systems to accurately depict the natural variability of geologic features, or to represent associated uncertainties;
- the lack of access to sub-discipline specific tools for exploring and modeling geologic systems- for example, many such tools have been developed for the oil industry but are too expensive for all but a few universities to obtain; and
- the lack of well done examples to help break the inertia of science. Most geoscientists know about GIS, but do not embrace it because they wonder if the investment in time, effort, and research dollars to deal with GIS will result in better science.

These or similar impediments likely are applicable in most of the environmental and social sciences. But if and when such impediments are overcome, GIS can have a significant role in accelerating diffusion of ideas across the disciplines. And since untrained viewers often can understand maps and other graphic displays, GIS can serve an important role in communicating science to the public.

3. Cognitive research in Cartography

Although studies on the perception of orientation and imaginary maps showed an early interest in the cognitive processes used in map reading, cartographers did not demonstrate much additional interest in cognition until the 1970s. An important exception from the 1950s was a landmark study of distortions in perceived sizes of cartographic symbols.

In a communication model of cartography, if the decoder (human perception during map reading) is known to introduce systematic distortions, then the inverse of the distortion should be used when constructing the map, so that the perceived map is unbiased.

Maps must provide accurate information to be useful, but they also must have an understandable message and be aesthetically pleasing. When cartographers began to study the nature of maps to understand symbolization and design principles, this resulted in an appreciation of maps as communication tools and the discovery of a need to understand the cognitive processes used by map readers. To fulfill this need, some cartographers embraced an experimental paradigm and studied the interaction between the map and map reader. Sheppard (1995) studied drivers' use of road maps for route finding. Other important early issues were the organization of information, the perceptual response to cartographic symbols, and the visual comparison of maps.

In addition to being familiar with computer graphics technology, the current generation of cartographers must be part artist and part cognitive scientist as they try to construct better maps. The idea of using visualization to discover patterns has only recently been discovered by a number of disciplines, but is an old and familiar concept for cartographers. The design and use of interactive maps and map animations have been of particular interest to cartographers.

4. Research in Geographic Information Science

Geographic Information Science (GIScience) is the basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems. GIScience also examines the impacts of GIS on individuals and society, and the influences of society on GIS.

Geographic information systems are similar to many statistical packages, in that they are commercial software systems widely used both within and outside the research community. However, there is an important difference between the two areas: statistics has a more universally agreed-upon foundation, whereas there is not yet an equivalent mature foundation

for GIS software. And GISs are used in some of our most pressing societal problems, such as crime, health, and disaster response.

Basic research in GIScience addresses complex problems that require multidisciplinary solutions. Fundamental problems in such a field are at risk of falling through the cracks between traditional disciplines, especially in the absence of targeted funding to support it. GIScience may begin with deep ontological questions regarding the nature of space and phenomena in space.

5. The Need to Integrate Theoretical and Applied GIS Research

There is a need to an integrated approach to both kinds of GIS-related research. This research field is clearly an area in which applications motivate the science. Difficulties encountered in applying GIS to spatial problems and phenomena can expose interesting and significant problems requiring basic GIScience research for their solution. Likewise, awareness of theory can improve applications, putting them on a solid conceptual foundation.

5.1 Design, implementation, and theoretical basis of Group-SDSS

One of the key arguments behind development and implementation of GIS over the years has been its potential to integrate information representing multiple perspectives and disciplines, thus its potential to support complex location-based decision making. In spite of this expected application, early GISystems were not well suited to support of decision making for at least three reasons. GISystems were (and often still are) designed for application to well structured problems (Armstrong, 1994), it lacks tools that support decision making directly (Copas, 1993), and it does not contain tools that support group work (Armstrong, 1993). Spatial decision support systems (SDSS) address these issue by extending GISystems with tools designed to overcome these limitations, individually in most initial efforts (e.g., (Carver, 1991, Lesser et al., 1991, Densham, 1991, Copas, 1993, Armstrong, 1993, Heywood et al., 1995)). The NCGIA Initiative 17 on Collaborative Spatial Decision-Making served as an important stimulus for research directed to addressing the issues collectively (Densham et al., 1995).

Armstrong (1993, 1994), in a pair of papers, identifies important links to ongoing research in CSCW (e.g., (Greif, 1988, Grudin, 1990, Ishii and Mryake, 1991) and outlines a set of core objectives for Group-SDSS. These objectives involve supporting three stages in the decision making process: strategizing (formulating an initial solution strategy), exploration (generating and evaluating alternative solutions), and convergence (narrowing the focus of analysis to consider a subset of competing viable alternatives). A parallel three-step typology (initial screening, refined evaluation, and selection) is used by Nyerges and colleagues (1997b) to develop a detailed task model of the decision making process involved in deciding among competing transportation improvement site selection projects.

Their task model is then used to summarize the influence of various aspects of group-based GISystems technology on decision making in this context. Related work in decision support systems that incorporate environmental process models (but not GISystems) suggests that breaking an apparently ill-structured environmental decision making process into a series of structural components makes the process tractable. Appropriate information management tools and techniques can then be matched to each component (Reitsma, 1996).

5.2 Participatory GIS – empowering people through access to mapping/GISystem tools

Some of the research directed to PPGIS, as with that directed to Group-SDSS, has considered method and tool development. More emphasis, however, has been given to the social and political processes that determine who has access to geospatial data and GISystems and to the role of geographic information technologies in empowering or disenfranchising participants in public policy decisions. As Obermeyer (1998) points out, Participatory GIS is a direct outgrowth of research on societal implications of GISystems (Sheppard, 1995). Researchers who are developing Participatory GIS or studying its use are as likely to be GIScience “outsiders” as “insiders.” Their work often draws upon theoretical perspectives provided by critical social theory, social cartography, policy studies, library science, or urban and regional planning. A key distinction in Participatory GIS research, thus, exists between those who focus

on public participation as a social-political issue, and those who focus on development and implementation of technology to facilitate that participation.

Among the social-political issues considered within the context of Participatory GIS are: access to information and its complement of information confidentiality (Barndt, 1998, Harris and Weiner, 1998), power and control exerted through information access (Elwood and Leitner, 1998, Harris and Weiner, 1998), the failure of traditional GIS to encode what matters to many of the stakeholders affected by decisions, such as information about "place" and values (Schroeder, 1997), the limiting map-based metaphor that underlies GIS and makes it difficult to encode non-metric information (Harris and Weiner, 1998), and the lack of access to GIS technology due to its cost and complexity (Barndt, 1998).

Collaboration as specific issues in Participatory GIS has been considered primarily from a practical rather than a theoretical perspective (Roche and Humeau, 1999). The general conceptual approach taken, however, matches Healey's (1996), contention that urban planning, as a "place-making" activity, should be approached using collaborative interaction among stakeholders. She outlines a trend in planning theory more generally that is characterized as "inclusionary argumentation." This is a perspective that advocates a decision making environment in which all members of a political community are contributors and that recognizes the range of ways participants have of knowing, valuing, and giving meaning to relevant issues.

5.3 New software and display forms to facilitate group work

Several investigators have directed attention to creating or adapting technology that can facilitate collaboration using geospatial data and models. Specific problems considered include: (a) representing multiple forms of information in group settings and allowing group members to interact with, and change, the representations; (b) adapting and applying electronic meeting software designed to facilitate both individual and collective decision making; and (c) facilitating efficient use of expert knowledge to assist non-experts in information retrieval.

Within the same time - same place category of collaboration, Shiffer (1992, 1993, 1995), has developed some of the most innovative tools to facilitate both public understanding of planning proposals and public involvement in planning meetings. The ideas have been implemented in his Collaborative Planning System (CPS). The CPS links GIS with multimedia methods to increase the breadth of information forms and perspectives incorporated in decision making. In particular, Shiffer's CPS makes use of formal geographic representations (e.g., map, air photos, etc.) linked to images, video, sound, and animation to give non-specialists a better understanding of the context for planning decisions and their potential implications. The overall goal of the system is to enable an integration of gestural, visual, and verbal discourse.

The importance of facilitating direct user interaction with representations has been noted by several authors (Faber et al., 1997, Shiffer, 1998, Florence et al., 1996). Direct interaction can help users to understand various alternatives (by making it possible for them to pose specific questions and try specific alternatives) and can result in the users feeling that they have a real voice in the decision because they were able to present their perspective. With this goal in mind, Faber and her colleagues (1997) have developed tools that allow users to graphically evaluate differences between alternative plans and to leave both verbal and graphical comments. Although direct manipulation interfaces that rely on a point-and-click metaphor are quite common for individual desktop computing environments, both technical and conceptual issues must be addressed in order to extend the potential of direct manipulation to group settings.

Technical issues include those associated with generating a large display that can be seen from a distance and with methods and devices that allow interaction from beyond arms reach. Since very large and high resolution displays will probably not be affordable in the near future (at least for local public meeting spaces) projection-based large format displays may be the answer. Interacting with these large displays, whatever technology they are based upon, will require remote pointing devices and ways to negotiate conflicts in attempts to simultaneously control the display.

Large collaborative displays can make use of virtual reality methods to facilitate understanding (by making proposed structures appear more like the real world. With such displays, it is becoming possible to present separate images keyed to each user's viewpoint (Agrawala et al., 1997), making it possible for each participant to consider only those sets of information relevant to their role in the process.

6. Communication of geographical information

Besides viewing maps as vehicles for performing spatial inferences, they can be studied as a means of communicating spatial knowledge. Thus the topic of generating sketch maps for the purpose of describing places or routes or for complementing verbal descriptions of space is of interest. One ancient and reliable means of conveying geographical information is a map. Useful maps, like other useful graphics, are not simply reductions in size of actual worlds; rather, useful maps extract the essential information and eliminate the inessential. Of course, what is essential and what is inessential depends on the goals of the user. The schematization of graphics often parallels the schematization of the mind.

Yet another way to convey spatial information is through language, also a venerable way to communicate about space. Useful analyses of the connections between language and space appear in many of the papers. Spatial expressions typically describe a target or figural object in relation to a background object, as in 'the church is west of the town hall'. Languages typically have several different reference systems for describing spatial relations. *West of* uses an extrinsic (also called geocentric or environmental) reference system. An expression like *'the church is left of the town hall'* is ambiguous in English, using either a relative or intrinsic reference system. A relative reference system is centered on a viewer and uses a three-term relation: the church is in front of the town hall from the viewer's perspective. An intrinsic reference system is a two-term relation projected from the intrinsic sides of an object (or person). In this case, the church is in front of the front of the town hall. Neuropsychological evidence indicates that locations are perceived according to all three (and maybe more) reference systems.

What perspective is used for description depends on a number of variables. There are some languages that do not use the relative reference frame, using an extrinsic reference frame instead. For languages that use all three reference systems, the relative frame seems to be used primarily for environments that can be viewed from a single point. For larger environments that cannot be seen from a single viewpoint, people's descriptions use both extrinsic reference frames as in survey descriptions and intrinsic reference frames with a person as the central reference object as in route descriptions. Quite frequently, people switch perspective, usually without signaling. When environments have features on several size scales and contain many alternative routes, there is a shift in preference toward more survey descriptions.

Route directions are of particular interest as an aid to way demanding. In his analysis of a large corpus of route descriptions, there are two types of statements: references to landmarks and prescriptions of actions. Route directions can be segmented by actions that use landmarks as referents. In another set of studies, judges rated spontaneous directions for quality. Sketch maps are also a good tool for way ending, and, in fact, schematize routes in much the same way as verbal directions.

7. Conclusion

Scenarios for geographic information use suggest great potential to extend the capabilities of scientific researchers, decision-makers, and the public. This potential, however, will only be realized if there are substantial advances in Geographic Information Science, enhancing knowledge of geographic concepts and their computational implementations. Needs for basic research in this emerging science and technology field has been assessed. The broad range of the disciplines involved in Geographic Information Science and technology. Two important research streams have been identified: research in basic Geographic Information Science (hereafter, GIScience), and research using geographic information systems (hereafter, GIS). It is imperative that research in these two areas be integrated, as applications motivate the science, and awareness of theory improves applications. Basic research in GIScience

has several compelling components. First is software integration, a general problem that needs specific research to solve its geospatial dimensions. Second, scale and resolution are spatial problems that interact with the scales (characteristic lengths) of environmental and social processes and with data quality. Third, process models are a general computing problem, but again geographic applications will require uniquely geographic solutions. And fourth, usability of systems and technologies is also a major component in need of research. In addition, uncertainty and spatial dependence have also been recognized as important crosscutting research themes. Geographic Information Science is clearly a coherent research field of strategic importance. "Expeditions into the 21st Century" will virtually bring together scientists, engineers, and computer scientists from academia, government, and industry to "live in the technological future." The mission of these expeditions could be accomplished by using technologies that are quantitatively and qualitatively more powerful than those available today.

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Mangrove Zonation and Succession Pattern of Fazergange and Bakkhali area at Sundarban, W.B., India Using Remote Sensing & GIS Techniques

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Keywords: RS & GIS, Mangrove Zonation and Succession pattern

Abstract: The West Bengal part of the Ganges-Brahmaputra delta, popularly known as the Sundarban delta, of Namkhana Island of Fazergange and Bakkhali area is a system where intricate estuarine and coastal processes are influenced by adjacent marine, terrestrial and meteorological systems and the dynamic interface amongst the three. In the study area of using Landsat ETM+ imageries 2013, are using RS & GIS techniques. The relationships between several spectral vegetation indices and plant canopy techniques of Mangrove zonation and Succession pattern analysis of LAI and nature canopy cover through PVI have been assessed. The effects of variations in background types, typical of those found beneath mangrove canopies, on these spectral indices have also been examined. The results presented here indicate that the estimation of LAI and percent canopy cover using the ratio-or difference-based and derivative indices investigated here, can be achieved but must be approached with caution. These forest ecosystems support a wide array of living resources and protect the coastal zone, thus helping in improving socio-economic conditions of the coastal communities and protecting the coastal/marine environment. Mangroves are one of the most productive ecosystems, which can efficiently fertilize the sea, potentially protect the coastal zone. However, world over, mangroves are facing degradation, mainly due to anthropogenic pressure wherein, the mangroves are used as fodder, fuel, timber and the areas being converted for aquaculture and other developmental purposes. Loss of mangroves is a serious environmental and economic concern and so immediate efforts are required to protect these critical habitats.

Introduction

Two contrasting coastal environments are prevailing in the area, namely; the macro tidal Hooghly estuary in the east; and the mesotidal Midnapore Coastal plain to the west. A morphogenetic study based on the terrain mapping unit (TMU) concept reveals the form- process-material interactions of these two contrasting coastal environments with a possible geo-history model of the coastal Quaternaries. It has been established that the entire process-response system of the coastal tract of the Bengal plain started operating after the rise of sea level around 6000yrs B.P. (i.e., optimum of flandrian transgression) and the Hooghly estuary, the mangrove vegetation plays a significant role as the dominant geomorphic agent in the evolution of the tidal shoals and their eventual accretion to the main landmass resulting in delta progradation. In the present-

day scenario, the Hooghly estuary becomes the abandoned part of the Ganga-Brahmaputra delta in India, and is also turning destructive and forming erosional regime in the mesotidal Midnapore coastal area.

Aim: Identification of Mangrove Zonation and Succession Pattern of the study area.

Objectives of the Study Area:

- Land use & Land cover Classification and mapping.
- Leaf area index measurement to find out mangrove area zonation.
- Measurement of Greenness index to find out canopy cover density.
- To assess correlation between Leaf area index and Greenness index.

- Perpendicular Vegetation Index (PVI) to assess vegetation cover.
- To assess correlation between Perpendicular Vegetation Index (PVI) and Greenness index (GI).
- To assess correlation between Red Band and Infrared Band.
- Different type of Mangrove

Study Area: The location of the study area on the Namkhana Island is shown in figure 1. The study was undertaken at Bakkhali-Fraserganj and Henry Island, which is a part of Namkhana Island of the western Sundarbans. This extends from $88^{\circ}13'55''\text{E}$ to $88^{\circ}18'50''\text{E}$ longitude and $21^{\circ}32'30''\text{N}$ to $21^{\circ}38'50''\text{N}$ latitude.

The island is regularly inundated by diurnal tide up to a certain distance from the northern coast and North-South spinal road approaches from northern coast up to nearly middle of the island. The study sites were selected on either sides of the spinal road.

Remote Sensing Data: LANDSAT ETM+ data of March 2013 pertaining to the study area were used and it was verified by ground truthing.

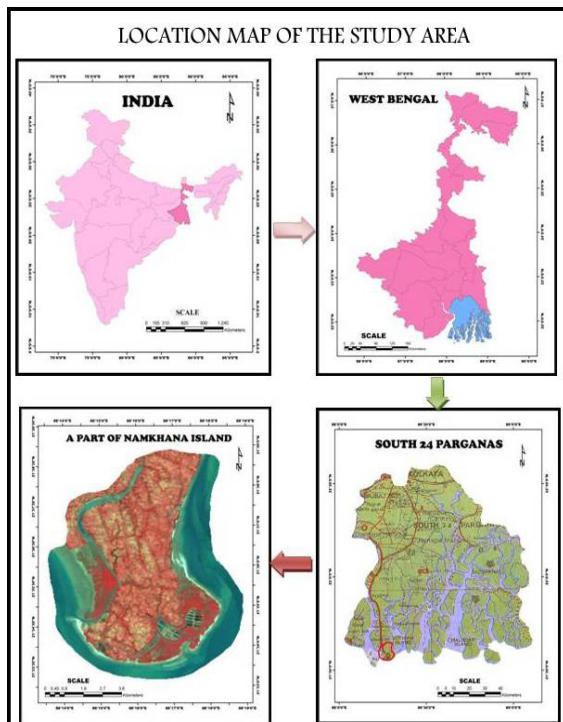


Fig. 1.

Land Use and Land Cover: The land use/land cover map (Fig. 2) is an appraisal of spatial information of the physical and social cover types (i.e. both natural and cultural/anthropogenic) on the existing scenario (Andrade, et al. 1988). Land use could be defined as anthropogenic/human activities (ef. Cultivable land, homestead plantation/garden etc.) Whereas land cover is the vegetational (both natural and, cultural forests, plantation) and artificial construction (ef. Settlement, road, embankment etc.)

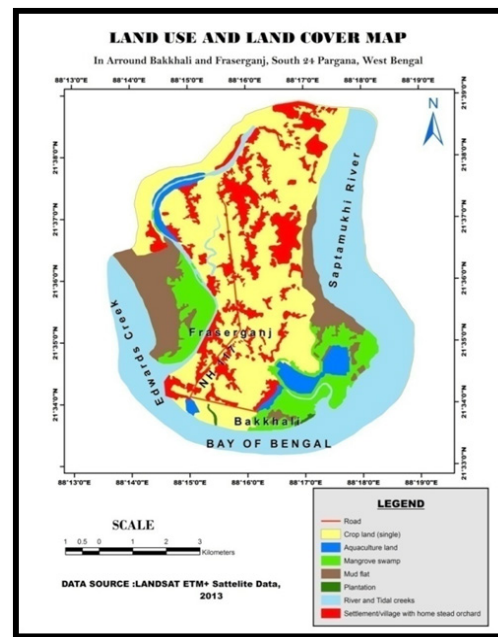


Fig. 2. Land Use & Land Cover Map.

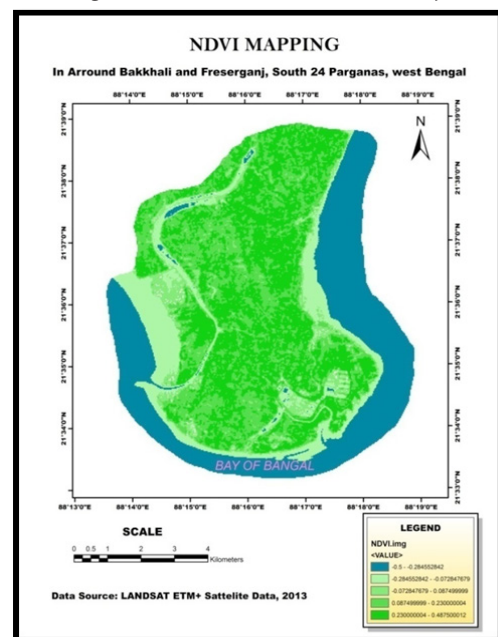


Fig. 3. NDVI.

Normalize Difference Vegetation Index (NDVI):

$NDVI = (NIR - RED) / (NIR + RED)$. In ETM+ image of the study area (Bakkhali and Fraserganj) applying NDVI modeler to detect the greenness of the area.

The first two classes are denoting river and wetland. Where as it is clearly shown that the high range of mangrove swamp area is found in Fraserganj and also in some part of domestic area. Medium range is representing the plantation area of Fraserganj (Fig. 3).

Leaf Area Index (LAI): The spectral characteristics of canopy are influenced by Leaf area index (LAI) and per cent of vegetative cover, growth stage, stress condition. Besides background soil, moisture content of the soil has significant influence on the vegetation reflection or absorption during the early stages of the growth.

Since every floristic species has its own unique leaf arrangements and unique leaf structure. It is an important biological parameter because:

1. It defines the area that interacts with solar radiations and provides much of the remote sensing signals.

2. It is the surface that is responsible for Carbon absorption and exchange within the atmosphere (Chen and Black, 1992)

$LAI = (41.325 * GREEN / RED) - (42.45 * GREEN / IR)$. In Fig. 4 it is seen that, the LAI ranges between 0 to 38, where 0 to 12 represents low leaf area conditions, 13 to 25 represents moderate leaf area condition and 26 to 38 represents high leaf area condition. From this estimation the nature of canopy cover can be visualized and it can also distinguish the floristic diversity as per the LAI value.

LAI Value	Canopy Nature	Remarks
0-13	Shrubs or Grasses	No or Low Canopy
13-19	Medium trees Intermediate	Moderate canopy
19-37	Tall trees/mangrove proper	High canopy

GREENNESS INDEX (GI): Greenness Index for TM band is – $(0.24717 TM1 - 0.16263 TM2 - 0.040639 TM3 + 0.85468 TM4 + 0.05493 TM5 - 0.11749 TM7)$. In Fig. 5 it is seen that the greenness value ranges between 24 to 115, where within this cluster 0 to 11 denotes low greenness or less vigor species, 12 to 23 denotes moderate greenness and 24 to 35 denotes the high greenness of the plant species. It is noteworthy that from this index we can't define the canopy pattern except the health of the species.

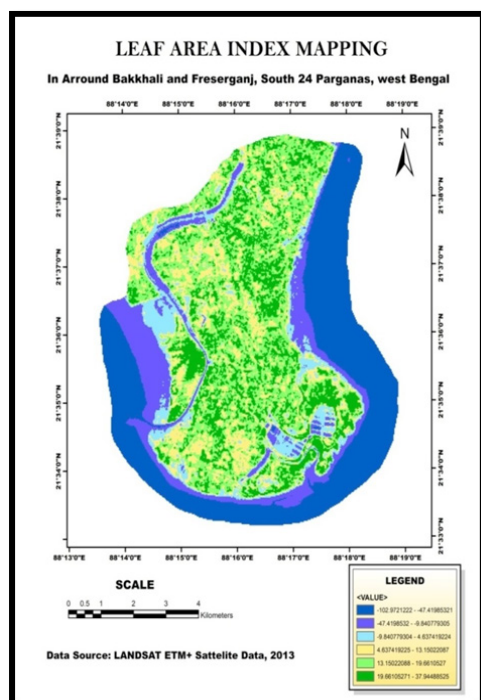


Fig. 4. LAI.

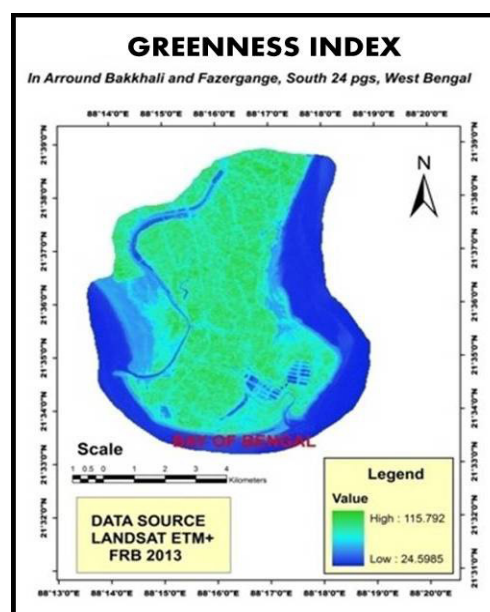


Fig. 5. Greenness Index.

Perpendicular Vegetation Index (PVI): This is such an index that uses the soil base line coefficient (slope and intercept). Here the soil base line is a relationship between the reflectance in the red and infrared regions for the range of the soil types without the vegetation cover. This can be defined as a perpendicular point presented by the red and near infrared reflectance from bare soil baseline, expressing the distance between canopy red and near infrared and the soil baseline (Fig. 6 and 7).

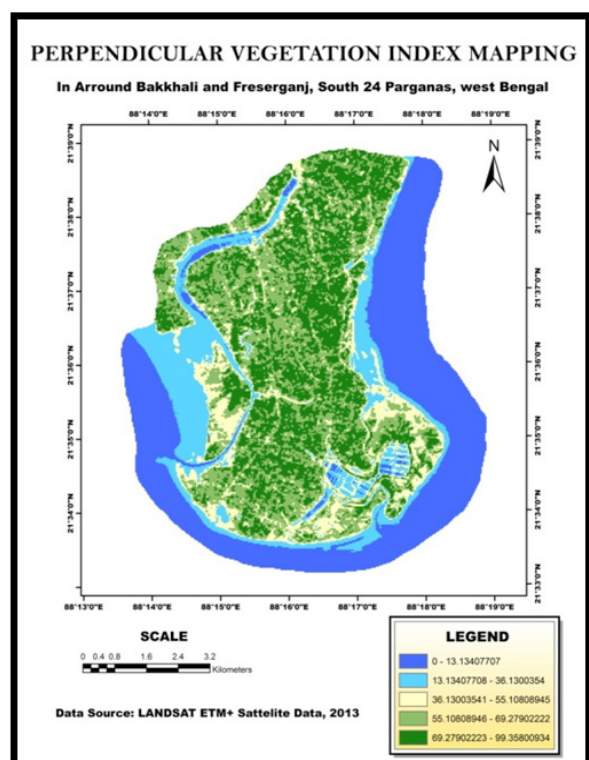


Fig. 6. Relationship between LAI and GI.

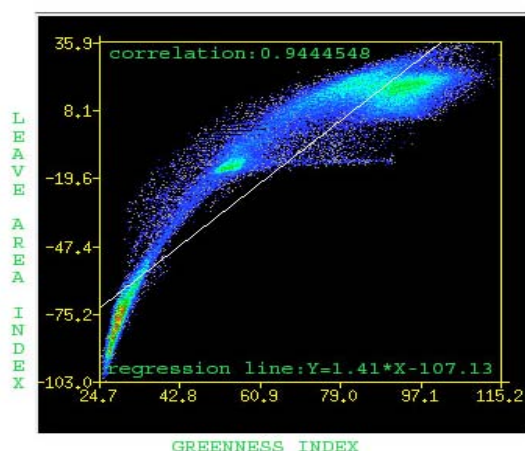


Fig. 7. Perpendicular Vegetation Index.

Forest Canopy Density Mapping: Now if an intersection operation (Boolean and operator) is followed over the LAI, PVI and GI. Now it can identify the succession pattern as well as the nature of the canopy coverage. The outcome of this operation is shown in Fig. 8. This has been said prior that no clear succession pattern is seen in the Bakkhali regions.

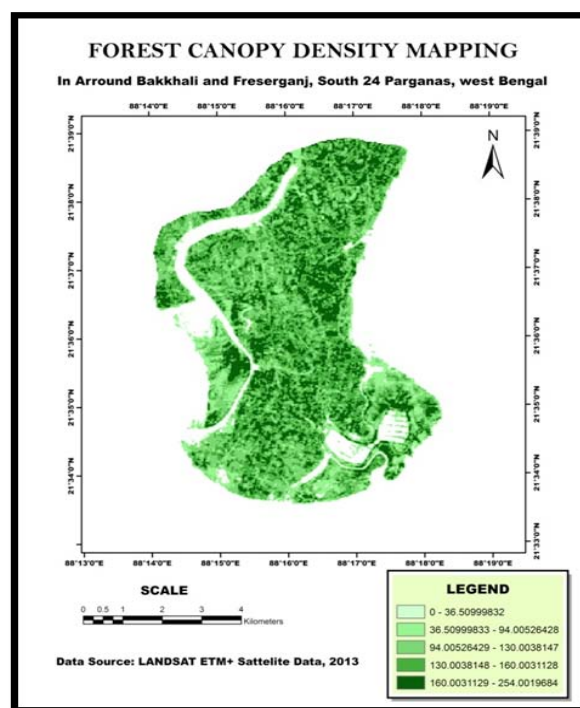


Fig. 8. Forest canopy Density Mapping.

The tidal behavior, creek dynamics, mangrove, salt marsh interactions and the differential colonization of the halophytic species etc. hinders the Zonation of the floristic environment.

So a micro level Zonation would be a wise approach. It is seen that within this estuarine area basically 3 vegetation zones are prominent, where after comparing with PVI and LAI, the zone 2 was showing the dense nature of vegetation, having the true groups of mangroves. But on the other hand zone 2 according to the PVI and LAI denotes the presence of moderately dense cover having basically mangrove and salt marsh to low dense cover having marsh grasses etc respectively. But this is distinct from GI that at the river and creek bank margin the vegetation growth is high and the habitat is of mangrove proper, then comes associates or

trees with medium height (having LAI of 13 to 19 and thereafter marsh grass or mud flat species (LAI of 4 to 13). Apart from these digital indices vegetation zones can clearly be clustered from the scatter plots of pixel of Red and NIR feature space.

Conclusion

- The relationships between several spectral vegetation indices and plant canopy LAI and nature canopy cover through PVI have been assessed.
- The effects of variations in background types, typical of those found beneath mangrove canopies, on these spectral indices have also been examined.
- The results presented here indicate that the estimation of LAI and percent canopy cover using the ratio-or difference-based and derivative indices investigated here, can be achieved but must be approached with caution.
- In this present study a strong relationship is seen between the GI and LAI but from this relation the segmentation of the canopy nature may be erroneous due to differential leaf geometry and alignments.

- So it is better to identify the vegetation pattern and nature (three tire orientation) from the scatter plots of Red and NIR feature space.

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Change Detection Analysis of Mine Environment using Remote Sensing & GIS – A Case Study of Vastan Lignite Mine, Surat, Gujarat, India

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Keywords: *Change Detection, Mine Environment, Land use/land cover, Image Classification, Vegetation vigor*

Abstract: Mining is the most dynamic process with direct as well as indirect impact on the environment. Hence, mine area provides ideal situation for evaluating the chronological changes in land-use patterns. The present study, carried out for Vastan Mine Lease area of Mangrol Taluka, Surat District, Gujarat, India shows that “Space inputs” at different time interval helps in analyzing the changes in the spatial extent of mine along with the associated activities. Remote sensing data of Indian Remote Sensing Satellite series with varying time period (2000-2012) and spatial resolution (23.5m to 2.5 m) were used to depict the changes in the landuse pattern of the mine area along with the spatial and temporal analysis using converging technologies viz. Geographic Information System (GIS) and Global Positioning System (GPS). The landuse/ land cover classification (Level-III) was carried out using hybrid classification approach involving Digital (Supervised, Unsupervised and NDVI) and visual extraction of various classes. The overall classification accuracies of LULC maps at an interval of three years (2000-2012) were ~89 % with Kappa statistic of ~0.85. Further, qualitative changes were analyzed using the vegetation vigor and the quantitative changes were identified from the post classification comparison technique.

Introduction

Land use/cover (LU/LC) change detection is very essential for better understanding of landscape dynamic during a known period of time for sustainable management. Change in land use and land cover has been recognized as an important driver of environmental change on all spatial and temporal scales (Tansey et al., 2006), as well as it is emerging as a key environmental issue. Remote sensing data of better resolution at different time interval help in analyzing the rate of land use/cover changes as well as the causative factors or drivers of changes. Hence, it has a significant role in regional planning at different spatial and temporal scales. Converging technologies viz. Remote Sensing technology for capturing the spatial data, Geographic Information System (GIS) and Global Positioning System (GPS) for undertaking integrated analysis, presentation of spatial and associated attribute data are found to be much more effective to know the change

detection of Land use/ land cover (Lillesand et al., 2001).

Many techniques have been developed for change detection analysis during the past three decades. Although frequently criticized and despite many alternatives, due to its simplicity and intuitive manner, post-classification change detection still remains one of the most applied techniques for assessing per pixel changes. Post classification comparison method not only locate the changes, but also provide “from-to” change information.

This investigation is attempted to understand change detection in Vastan mine lease (ML) area of Gujarat Lignite Power Company Limited using different remote sensing data for twelve years for detecting the changing trend using the ‘pixel based’ post classification comparison technique. The study area was very small and 100% ground survey had maximized the accuracy of the classification. Post classification comparison method used for this study, as

it detect land cover change by comparing independently produced classifications of images from different dates. This change detection method minimize possible effects of atmospheric variations and sensor differences (Fan et al. 2007; Lu et al. 2004; Yang 2002), as well as vegetation phenology between different dates, since data from different dates are separately classified and hence reflectance data from those two dates and slightly varying resolution need not be adjusted for direct comparability.

2. Study Area

The Vastan lignite mine is located in Mangrol taluka of Surat district, Guajrat, India. The area falls between 73°4'E to 73°9'E longitude and 21°22'N to 21°28'N latitude covered by Survey of India toposheet no. 46 G/3 on 1:50,000 scale. The area is generally flat with some minor upland. Terrain has general elevation of ~40 meter above MSL. Minimum temperature during winter is 14°C and maximum during summer reaches up to 41°C. There are no permanent surface water bodies in the area except river Kim, which receives water during monsoon period. The current lignite mine leasehold area (Vastan mine) constitutes a part of its catchment.

3. Materials & Methods

3.1 Data used : In this study, space borne data of best resolution IRS/RESOURCESAT series satellite imageries were used (Fig1. a). The study was done for the 'rabi' Season For 2006, 2009 and 2012 LISS-IV (RESOURCESAT-1 and 2) data of 5.8 m ground resolution was used for path/row- & date of pass are as follows - 201/103 of 12-Mar-2006; 202/74 of 25-Mar-2009 and FMX 94/57 of 15-Jan-2012, respectively. Panchromatic (PAN) data of Cartosat-1 of 2.5 m resolution has been used for same season path/row & date of acquisition- 512/298 of 5-Mar-2006; 512/298 of 12-Apr-2009 and 512/298 of 15/01/2012. For 2000 and 2003 landuse study LISS-1C (path/row- 94/57; date of overpass 17-Jan-2000) and LISS-1D (date of overpass 15-Jan-2003) of 23.5 m resolution data were merged with information at 5.8 m spatial resolution panchromatic data, which has significant implication on higher level mapping for 2000 and 2003 landuse pattern. PAN imagery of 17-Jan-2000 (path 94/57) and 6-Mar-2003 (path 93/57) were used to generate

hybrid LISS-PAN merge product of better resolution. Along with these, other collateral data used were the Survey of India Toposheet 46 G/3 in 1:50,000 scale. An extensive field visit was undertaken during February 2013. DGPS (Sokkia Radian IS) survey was also carried out to collect various location / elevation data in and around the ML area. Information related to land form; slope, extent of erosion, natural vegetation, their spatial and temporal variation and existing crop pattern were also collected during ground survey including discussion with farmers.

3.2 Image pre-processing: All the satellite imageries were checked for radiometry and eventual errors like line stripping, band to band co-registration *etc.* Images were radiometrically normalized to minimize the effect of atmospheric differences over different dates using Top of Atmosphere (TOA) correction. Images were geometrically corrected for removing geometric distortions using Ortho Rectification tool of Leica Photogrammetric Suite (LPS) from ERDAS Leica Geosystems / Intergraph. Ortho-rectification was carried out for cartosat-1A, 2012 imageries using bundle block adjustment using the DGPS points collected during the ground survey as elevation reference. Necessary editing were done using the LPS Terrain Editor in Leica Terrain Format (LTF). AutoSync tool has been used to register IRS-LISS-IV, LISS-III and the remaining PAN data using the ortho-rectified Cartosat-1A image of 2012. About 75 to 100 control points were acquired for each scene and RMS error was kept minimum by thinning out of the points showing high error. For the hybrid LISS-PAN merged product generation, out of all resolution merge techniques, Brovey transformation with cubic convolution resampling technique showed the best result and the products were used for the further processing.

3.3 Land use / cover Classification: Based on the small spatial extent and the field knowledge of the study area, 14 classes were adopted for image classification. Land use/ land cover analysis was carried out using hybrid approach (supervised / unsupervised classification & on-screen digitization Fig.1.c). Classification is performed in the following steps *viz.*

- Digital classification-calculation of statistics of training sets for class separability using maximum likelihood classification algorithm.
- Visual Interpretation of probable intermixing classes.
- Normalized Difference Vegetation Index (NDVI).
- Acquisition of ground truth & correction of land use/cover categories.
- Checking of classification accuracy both in terms of class wise and overall.

3.4 Classification accuracy assessment:

The classification accuracy assessments of the resulting land cover maps was carried out by comparing samples of the classified layer and reference layer. Randomly generated 200 points were used for comparing classified cells and reference cells in each of the pixel-based classified imageries. Fifty reference points were verified by field visits and 150 reference points through comparison with historical Google Earth imagery, previously tested maps, aerial photos, or other data (assumed truth). The overall classification accuracies of LULC maps of all 2000, 2003, 2006, 2009 and 2012 were around 89 % with Kappa statistic of ~ 0.85.

4. Change Detection Analysis

4.1 Analysis of Vegetation Vigor (Qualitative Change Analysis): The spectral response of green and healthy vegetation is characterized by a strong absorption in the red region together with a higher reflection in the near infrared (NIR) region of the electromagnetic spectrum. Normalized Difference Vegetation Index (NDVI) is of considerable importance for analysis of vegetation health, yield prediction and internal / external stresses, if any. The range of value varies from -1 to +1. In the present study, the absolute value of NDVI were used and finally grouped in to 5 classes namely Very poor, Poor, moderate, good and very good based on the NDVI value.

4.2 Post Classification Change Detection (Quantitative Change Analysis): All the landuse categories were reclassified into 6 classes for comparison based on their importance as well as the similarity. For change evaluation the grouped land use map of *rabi season* for 2000,

2003, 2006, 2009 and 2012 were used separately as given below:

- a. Class-I: Manmade (Built-up and all other human activities like mining, solar plant, ash pond, lignite depot, settlement and industry).
- b. Class-II: Agricultural fallow land.
- c. Class-III: Crop land (*rabi* crop land only).
- d. Class-IV: Plantation (Both orchards & plantation over dump/backfill).
- e. Class-V: Water bodies (canal, waterbody, river and dry riverbed).
- f. Class-VI: Wastelands (land without scrub, land with scrub, ravine/eroded land).

In ERDAS, logical table was prepared where grouped 3 years interval landuse/cover maps were taken and overall change (Table.2) and "From-To" confusion matrix (Table.3 to 6) generated. In the resulting change detection maps (Fig.1.d), three types of values were assigned *viz.*, 1 (no change areas), 2 (positive change areas) and 3 (negative change areas). The no changed class indicated that the same land cover type was found on the sample point over the two point of time land use. Under the positive change, the positive change in vegetation status was considered. Under the negative change category the human-induced changes as well as the natural change areas were considered which may be irreversible or sometime reversible, *i.e* the original status of the land cover may restored when conditions permit. Current fallow lands were also considered in the negative class. But those areas like extinct drainages, mine affected areas, change due to the built-up activities may be irreversible and unlikely.

5. Results & Discussion

5.1 Vegetation Vigor (Quantitative Change Detection)

For qualitative change assessment (relative vegetation vigor/density) using Normalized Difference Vegetation Index (NDVI) approach five thematic NDVI layers produced (Fig.1b).

Significantly high vegetation vigor observed in the year 2012 (Table 1). All mine areas were least vegetated due to mining activity whereas crop and the plantation over the mine dump, or

Table 1. Vegetation Vigor from 2000 to 2012 (3 years interval) (area in hectare)

Vegetation Vigor	2000	2003	2006	2009	2012
Very Poor	756.33	1063.83	881.78	735.63	664.23
Poor	1278.87	1243.51	1256.47	1337.87	590.03
Moderate	847.13	653.97	646.55	584.74	1153.60
Good	353.54	137.07	457.77	369.89	406.72
Very Good	208.76	346.25	202.06	416.50	630.05

(area in hectare)

re-vegetation over the backfill area has grown in the density and therefore fall in the “very good” vigor category. The undisturbed declared lease had some vegetation cover compared to the fallow land and because of that categorized in a high vegetation density class than that of the fallow “very poor” and “poor” class. Due to the utilization of the generated ash and other by product for brick construction, ash ponds were almost abandoned. Good vegetation vigor also observed for these ash ponds also.

5.2 Post Classification Change Analysis

The large proportion of no change area reveals that there was no significant change happened in the land use fabric except the mine activities (Table 2). Positive change are more

for the year 2006 Vs 2003 in comparison to year 2003 Vs 2000, mainly because of the plantation activity started by the mining authority above the mine dump site and along the periphery of the lease area (south eastern side of the lease area). Overall statistics revealed that maximum change observed in the year 2012 both positive as well as negative. The positive change results mainly due to the ‘green belt’ developed by mining authority all around the mining site as well within the declared lease area around the new south Vastan pit as well as the old Vastan mine area. New nurseries also developed in that area for supplying seedlings were also marked under the plantation category. Reclamation/re-vegetation of the backfill area of the Vastan pit was the considerable positive change observed in the year 2012. The negative changes in 2012

Fig 1. Spatio-Temporal Variation in Vastan Mine Lease Area

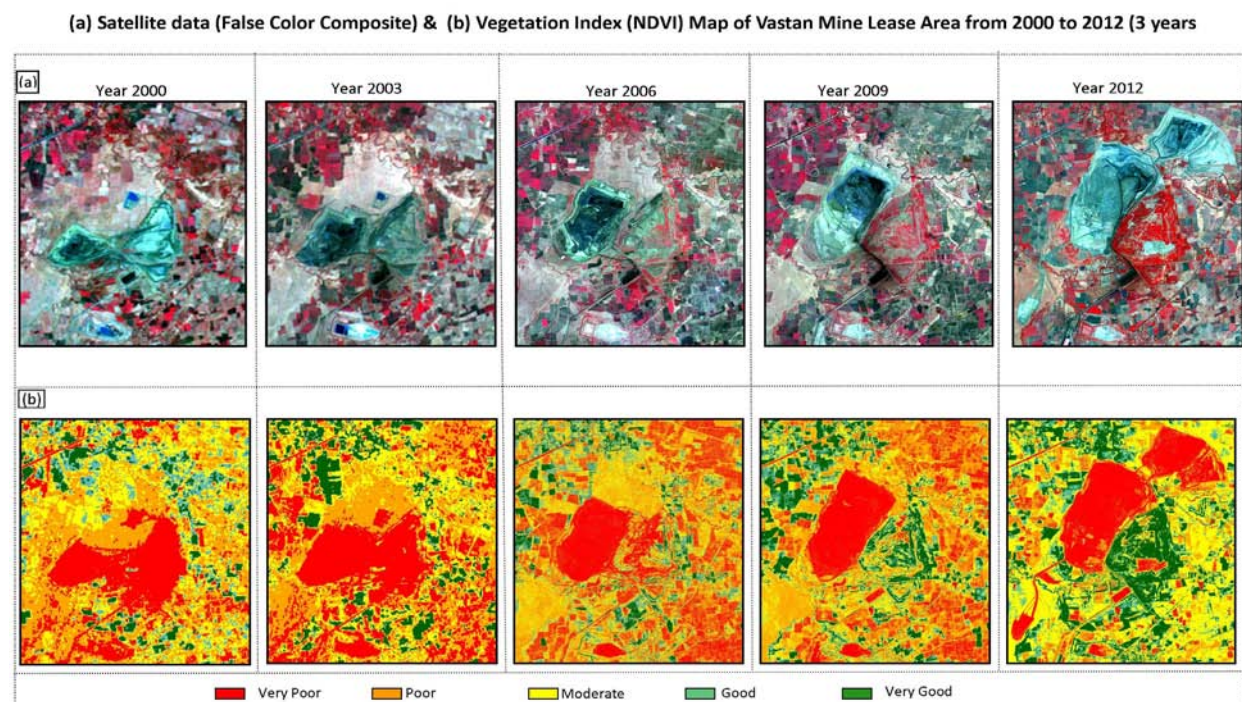
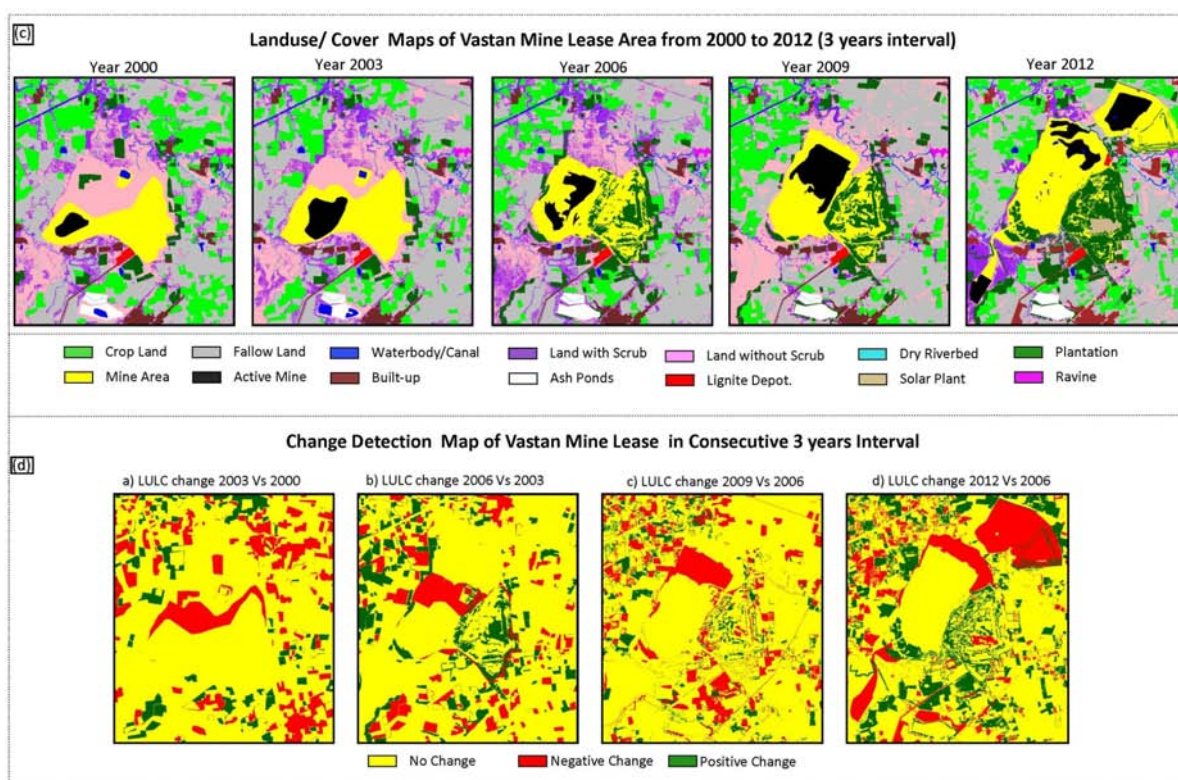


Fig 1 (cont.) Spatio-Temporal Variation in Vastan Mine Lease Area



were basically due to new mine pit in the South Vastan area.

Positive change are more for the year 2006 Vs 2003 in comparison to year 2003 Vs 2000, mainly because of the plantation activity started by the mining authority above the mine dump site and along the periphery of the lease area (South Eastern side of the lease area). Overall statistics revealed that maximum change observed in the year 2012 both positive as well as negative. The positive change results mainly due to the 'Green belt' developed by mining authority all around the mining site as well within the declared lease area around the new south Vastan pit as well as the old Vastan mine area. New nurseries also developed in that area for supplying seedlings were also marked

under the plantation category. *Reclamation/re-vegetation* of the backfill area of the Vastan pit was the considerable positive change observed in the year 2012. The negative changes in 2012 were basically due to new mine pit in the South Vastan area.

5.1 (a) Change detection 2003 Vs 2000:

Most land cover changes are the result of mine lease area acquisition and the sowing in fallow lands of the earlier year of 2003 (Table.3). About 221.37 ha fallow land area of 2000 *rabi* season was under crop during 2003 *rabi* season. About 377 ha and 52.68 ha area of 2000 *rabi* sown area converted to fallow and wasteland, respectively. The changes from 'manmade' to 'waterbody' by 6.49 ha was due to filling of the ash ponds in the year 2003. Considerably

Table 2. Changes in the Land use / Land cover

Change Type	2003 Vs 2000	2006 Vs 2003	2009 Vs 2006	2012 Vs 2009
No Change	2594.81	2566.20	2680.19	2172.48
Positive Change	263.54	448.73	237.40	638.31
Negative Change	586.27	429.69	527.04	633.84

(area in hectare)

Table 3. "From-To" confusion matrix for the LULC change analysis 2000 to 2003.

From/To	Class I Manmade	Class II Fallow	Class III Crop	Class IV Plantation	Class V Water	Class VI Wasteland	Total Change
Class I (Manmade)	....	....	....	....	12.06	25.68	37.73
Class II (Fallow)	....	....	221.37	....	...	...	221.37
Class III (Crop)	....	377.33	....	....	....	52.68	430.01
Class IV (Plantation)	0.07	....	....	....	....	30.6	30.67
Class V (Water)	6.49	....	....	....	....	....	6.49
Class VI (Wasteland)	119.10	....	38.85	3.24	0.21	....	161.40
Total Transition	125.67	377.33	260.22	3.24	12.27	108.96	887.69
Actual gain/loss	88.02	155.93	-170.45	-26.47	5.93	-52.66	....

(area in hectare)

(30.6 ha) plantation area was cleared in 2003 (north and southwest of the mine pit) within the lease area boundary. About 119.10 ha area were converted from 'wasteland' to 'manmade' category mainly due to the mining and pit area extension.

5.1 (b) Change detection 2006 Vs 2003:

Significant increase in plantation area is also noticed during *rabi* season of 2006 in comparison to 2003 (Table.4). The changes from 'man-made' to 'plantation' was basically due to the plantation started over the dump which was bare and exposed in the years 2000 and 2003. About 257.32 ha fallow area of 2003 *rabi* season were under crop during 2006 *rabi* season. The change from 'wasteland' to 'manmade' by 119.96 ha was likely the result of the extension of the mine area within the declared mine lease area (categorized as wasteland earlier). Rural settlement extent was also increased in 2006. Considerably 90 ha area of 'wasteland' category was converted to 'plantation' because of the new plantation/nursery site developed along the periphery of the lease area (south eastern side of the lease area).

5.1(c) Change detection 2009 Vs 2006:

Significant conversion of the 'fallow' land to the 'wasteland' was due to the classification of the 'long fallow' over the studied years to the class 'land without scrub' and 'land with scrub' (Table.5). Conversion of the 53.79 ha 'manmade' to 'plantation' area was likely the result of the increase in the plant cover over the Vastan dump site. The change of fallow land, cropland, plantation and wasteland to the 'manmade' category comprise of the changed land cover by 1.85 ha, 0.95 ha and 31.55 ha respectively; mainly because of the increase of the mine area extension.

5.1(d) Change detection 2012 Vs 2009:

Considerable area (182.76 ha) of 'wasteland area' converted to 'manmade' land as the already declared mine lease area which was under the wasteland category were fully utilized in 2012 by the maximum expansion of the Vastan mine and the new South Vastan mine pit (Table.6). Significant observations were conversion of 92.97 ha of 'manmade' to 'plantation' category as well as the conversion of 31.70 ha of 'plantation area' to the 'manmade'

Table 4. "From-To" confusion matrix for the LULC change analysis of 2003 to 2006.

From/To	Class I Manmade	Class II Fallow	Class III Crop	Class IV Plantation	Class V Water	Class VI Wasteland	Total Change
Class I (Manmade)	....	....	....	97.86	0.53	17.01	114.87
Class II (Fallow)	....	....	257.32	....	...	...	257.32
Class III (Crop)	0.05	235.86	....	8.38	....	52.24	296.53
Class IV (Plantation)	0.42	5.78	3.18	....	....	0.57	9.94
Class V (Water)	14.72	....	....	....	....	....	14.72
Class VI (Wasteland)	119.96	....	....	90.00	....	....	209.97
Total Transition	135.15	241.64	260.50	196.24	0.53	69.29	903.35
Actual gain/loss	23.85	-14.59	-35.10	184.20	-14.18	-144.17	....

(area in hectare)

Table 5. "From-To" confusion matrix for the LULC change analysis of 2006 to 2009

From/To	Class I Manmade	Class II Fallow	Class III Crop	Class IV Plantation	Class V Water	Class VI Wasteland	Total Change
Class I (Manmade)	....	....	....	53.79	0.27	2.75	56.81
Class II (Fallow)	1.85	....	15.91	....	....	163.64	383.85
Class III (Crop)	0.95	132.07	....	10.11	....	43.66	186.79
Class IV (Plantation)	31.55	12.02	5.64	....	....	....	49.21
Class V (Water)	....	....	....	....	....	....	2.77
Class VI (Wasteland)	90.04	....	....	19.32	....	....	90.04
Total Transition	124.39	346.54	21.55	83.21	0.27	210.05	769.46
Actual gain/loss	69.38	-79.87	62.05	10.67	-4.88	-57.35	....

(area in hectare)

category. First was because of the plantation over the mining land/ dump and the second was because of the establishment of the new 5 MW solar plant over the Vastan dump site which was covered by plantation in 2009. Waterbody increased due to the accumulation of water in some portion of the abandoned Vastan pit. Conversion of 'water' to the 'wasteland' by 17.05 ha as well as the 'water' to the 'manmade' by 10.34 ha was due to the blockage and diversion of Shah nallah (for expansion of north boundary of Vastan mine). Due to expansion of mine area, some portion of Shah nallah completely extinct. Few small seasonal drainages were also disappeared. Conversion of 1.04 ha 'crop land' and 189.97 ha 'fallow land' to the 'manmade' category was due to the establishment of new mine area (Shah Pit/ Mangrol Mine) in the northern side of the Vastan Mine.

6. Conclusion

Post classification comparison is usual change detection method. Accuracy of input map affects the post classification change accuracy hence change detection using post classification comparison method should be

used cautiously. Besides, subtle changes are ignored while generalizing the categories for change detection. The presented approach emphasizes that the extraction of land cover classes from multi-date and multi-sensor imageries with different spectral, textural and topological characteristics by means of pixel based classification approaches lead to improved workflows for land cover classification. Post classification pixel-based change detection of 2000 to 2012 for 3 years interval study using the best resolution IRS/RESOURCESAT series satellite imageries has led to high change detection accuracies. It was found that the changes in the Vastan mine region were very drastic and mining was the major and only driver of changes in that region.

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Table 6. "From-To" confusion matrix for the LULC change analysis (ha) of 2009 to 2012

From/To	Class I Manmade	Class II Fallow	Class III Crop	Class IV Plantation	Class V Water	Class IV Wasteland	Total Change
Class I (Manmade)	....	....	....	92.97	3.04	9.51	105.51
Class II (Fallow)	189.97	....	182.81	46.63	....	103.99	419.40
Class III (Crop)	1.04	244.98	....	3.82	....	....	249.84
Class IV (Plantation)	31.70	4.76	1.86	....	....	....	38.31
Class V (Water)	10.34	....	....	....	....	17.05	27.39
Class IV (Wasteland)	182.76	....	76.20	48.88	9.91	....	317.74
Total Transition	415.80	249.73	260.86	192.29	12.95	130.55	1158.19
Actual gain/loss	272.91	-76.19	-5.14	147.79	-22.40	-344.51	

(area in hectare)

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Geoenvironmental Evaluation of Rajghat Dam, Sagar (M. P.) Using Geo- Informatic Techniques

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Keywords: Geo-environmental, land use/ land cover, remote sensing

Abstract: This study was conducted on the Rajghat dam situated in Sagar District of Madhya Pradesh, India; the remote sensing techniques have been proved to be very efficient in identification geoenvironmental aspects of the study area. The various thematic maps have been prepared on 1:20,000 scale such as geology and land use/ land cover helped in evaluating of geoenvironmental status of the study area. The study shows that the integration of all attributes provided geo-environmental status around Rajghat dam.

1 Introduction

The Rajghat dam is rock and earth fill type of dam. This dam is 1680.0 m long with 400.0 m masonry spillway, and which get water from Bewas River, Parkul River, and Jamunia River junction at Hinota village. Bewas River is 53.03 kms, Parkul River is 33.93 kms, and Jamunia River is 18.05 kms long at the dam site. The catchment area of Bewas river at the dam site is 472 sq. kms is located between 23° 23' 36" N to 23° 46' 22" N latitude and 78° 30' 32" E to 78° 46' 42" E longitude. The total water capacity of dam is 96.0 million cubic meter with 80.0 live storage, and 16.0 dead storage. Bed level of river is 495.0, minimum sill level is 509.0 m, maximum water level is 518.0 m, and maximum bed level is 520.0 m at dam site. The Bewas River originates from the northeast part of Raisen district located at about 720 meter near the Pipalia Katan. The study area falls in Survey of India (1:50,000) toposheets No. 55I/9, 55I/10, 55I/11, and 55I/14, fig. 1). The normal annual rainfall of the study area is 1234.8 mm about 90% of the annual rainfall takes place during the southwest monsoon period i.e. June to September only 5.5% of annual rainfall takes place during winter and about 4.5% of rainfall occurs during the summer months. January is the coldest months with the temperature falling as low as 8.6° C and max. up to 24.5° C, and in the month of May, the temperature goes up to 46.7° C.

For integrated geoenvironmental management/planning remote sensing has proved

useful in RS/GIS analysis in conjunction with ground truths data on soils, land use, vegetation, surface & groundwater, geology, landforms, topography, settlements, etc. This paper attempts an overview of the application of remote sensing to geo-environmental and geo-hydrological studies of Rajghat dam, Sagar (M. P.).

2 Data Acquired

1. The remote sensing data has been acquired from IRS-P6 LISS-IV Mx data (5.8 m), Dated: April 16, 2010, LANDSAT-7 ETM + Data (30 m), Dated: 02 December, 2009.
2. The survey of India toposheet no. 55 I on 1:250,000 scales and no. 55 I/9, 55 I/10, 55 I/11, and 55 I/14 on 1: 50,000 scale for detailed analysis.
3. Geological studies:
 - a. The Geological Map has been collected from P.H.E. Dept., Sagar (M.P.), and updated through satellite remote sensing data + Data with limited field check
4. Land use/ land cover studies:
 - a. The land use/ land cover map has been prepared using google and it was also verified through limited field check.

3 Results and Discussion

3.1 Geological studies

The detailed geological and geomorphological work has been done by Agarwal

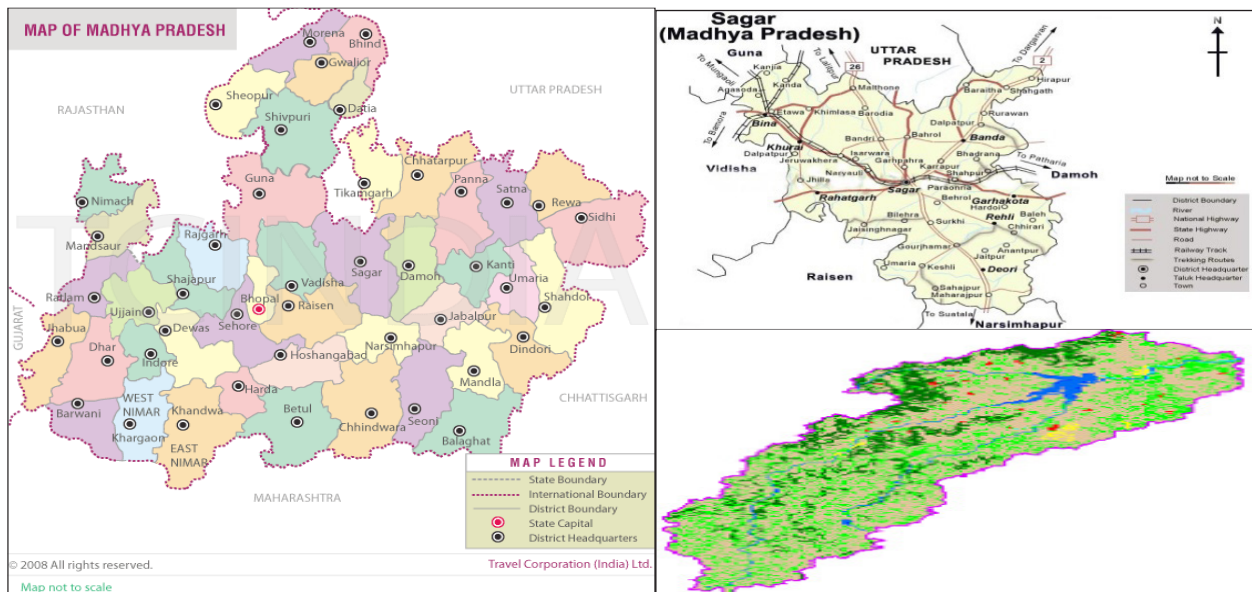


Fig. 1. Index Map of Rajghat Dam, Sagar (M.P.); Source: www.google.co.in.

& Mishra (1992), Jain & Ahmad (1993) and Rao et.al. (2003).

The geological (lithological) map has been prepared using IRS-P6 LISS-IV Mx data. The important litho-units existing in the area are Upper Vindhyan Sandstone, Deccan Traps Basalt, and Alluvium. In the Vindhyan sandstones, primary porosity varies from negligible to high depending on the degree of compaction. The storage and movement of ground water in these formations is

controlled mainly by the secondary porosity and permeability resulted due to weathering of joints and fractures. Overall groundwater condition is good along the lineaments and at their intersections. Deccan traps are the most important formations in the study area due to their large aerial extent. The weathered jointed, fractured and vesicular units of basalts form moderately potential aquifers. The zeolitic basalt or weathered zone form good aquifer. A common weathering product of the Deccan trap

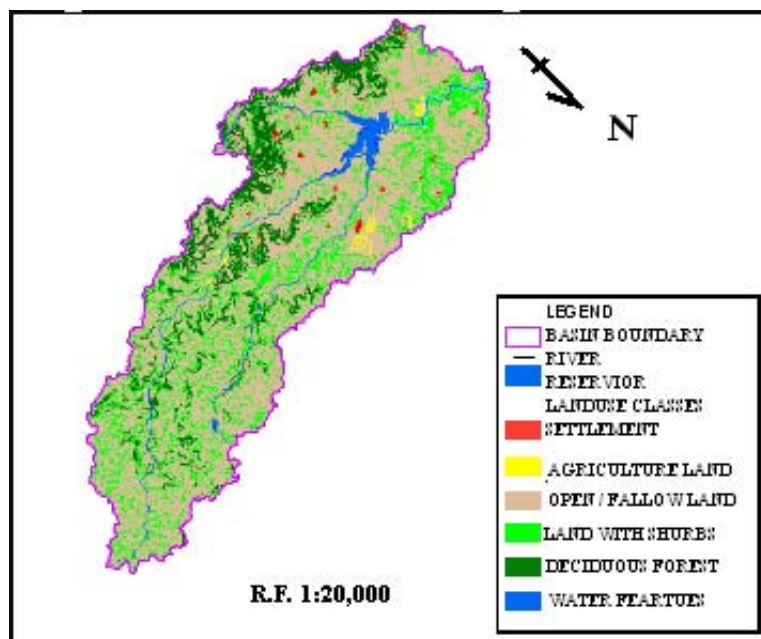


Fig. 2. Land Use / Land Cover Map.

basalt is a friable light greenish or yellowish green earth material. The alluvial deposits are confined mostly to the area along the river courses and in the northeastern parts of the study area. It is composed of fine to medium sand, silt, clay and kankar, which are high potential aquifers. The valley fills and buried pediments are good groundwater potential zones.

4.2 Land use/ land cover studies

Later, an account on land use or land cover mapping, soil erosion modeling, rainfall- runoff modeling, water balance calculation and morphometric analysis has been submitted by Pareta (2003, 2009 & 2011) using RS/GIS techniques.

Land is the most important natural resource, which includes soil, water and associated flora/ fauna involving the total ecosystem. The comprehensive information on the spatial distribution of land use/ land cover categories and the pattern of their change is a prerequisite for management and utilization of the land resources. The land use pattern of any terrain is the result of the complex physical processes acting upon the earth surface. These processes include climate, geologic and topographic, distribution of soils, vegetation and occurrence of water. For better development and management of the catchment areas of reservoirs, it is necessary to have timely and reliable information on environmental status. The authors have prepared a land use/land cover map, Fig.2 which depicts that there are four units of land cover/land use pattern, which are shown on the map. Agricultural land: open land/ fallow land, Land with shrub; Forest: deciduous forest, degraded forest; and Water features.

4 Conclusions

Remote sensing techniques with an emphasis on geology and land use/ land cover has

helped in identification of the potential zones for geoenvironmental planning and predicting limitations to their implementation with reasonable accuracy.

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Identification of Sources of Pollution in Sagar Lake Using Remote Sensing Techniques

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Keywords: Amphitheater like basin, Severe polluting spots, Maintenance and management

Abstract: The most beautiful natural lake (locally known as lakha banjara) is located at the heart of Sagar city, Madhya Pradesh (Banajara Times). After visualizing the peculiar topographic position/location and cultural importance of this natural lake, it appears that it was constructed to fulfill the needs of local people of surrounding areas. Topographically, the lake is located at the staircase of an amphitheater like basin. Due to insufficient financial support from State and Central government and unsystematic/unplanned discharge of polluted water from all around the lake and lack of awareness of local people towards water pollution the lake is severely polluted. The present study brings out the result of analysis of satellite image of Sagar Lake and identified several spots which are in fact continuously adding pollutants to lake water in the study area. The image for the present study was downloaded from Google earth.

Introduction

Sagar Lake is located in heart of Sagar city in Sagar district of Madhya Pradesh (Fig. 1) and covers an area of about 68 hectares and a small wetland of 14 hectares. It falls on the toposheets no. 55 I/9 and 55 I/13. It is believed that this beautiful natural lake came into existence in the 11th century, later named as Lakha Banjara Lake (i.e. named after the oldest tribe of central provinces).

Geographically and geologically, this lake is located in the heart of the city on Vindhyan rocks on one side and Deccan Trap rock on the other side (West and Chaubey, 1964). This natural lake receives major part of fresh water from seasonal rains during June to September every year while rest part is received during remaining period through mismanaged colonies, hospitals, houses and slum areas surrounding this. Apart from all these, invading of cattle, washing of clothes, washing of vehicles, the poor maintenance and mismanagement from Local Municipal Corporation and others are continuously increasing level of pollution. Thus, the lake water has totally become unsuitable for drinking, fish culture and even for bathing

and washing purposes. The outflow is through Mongha weir from the main lake situated at the back of the Ganga Mandir.

Previously, it was fresh water lake but with the passage of time due to continuous and unplanned discharge of polluted water from the surrounding, the overall ecosystem specially quality of water has degraded, which has finally resulted an increase of nutrient content, toxicity, turbidity, odour, etc. Now, the situation has become so serious that neither it can be used for drinking purpose nor even for bathing and washing purposes. The areas which directly add polluted water to this lake are marked on satellite image (fig. 2), are 1. Tili hospital, 2. Chatinaya hospital, 3. Shriram Nagar, 4. Ahmed Nagar, 5. Bus stand, 6. Sanichari, 7. Bariya ghat.

Results & Discussions: Through, detailed remote sensing analysis main spots from where pollutants are being directly added to lake water have been identified and marked on the base map. Drainage lines carrying pollutant are shown in fig. 3. Suitable remedial measure to control water pollution will be suggested after results of detailed chemical analysis of surface and sub surface water are obtained.

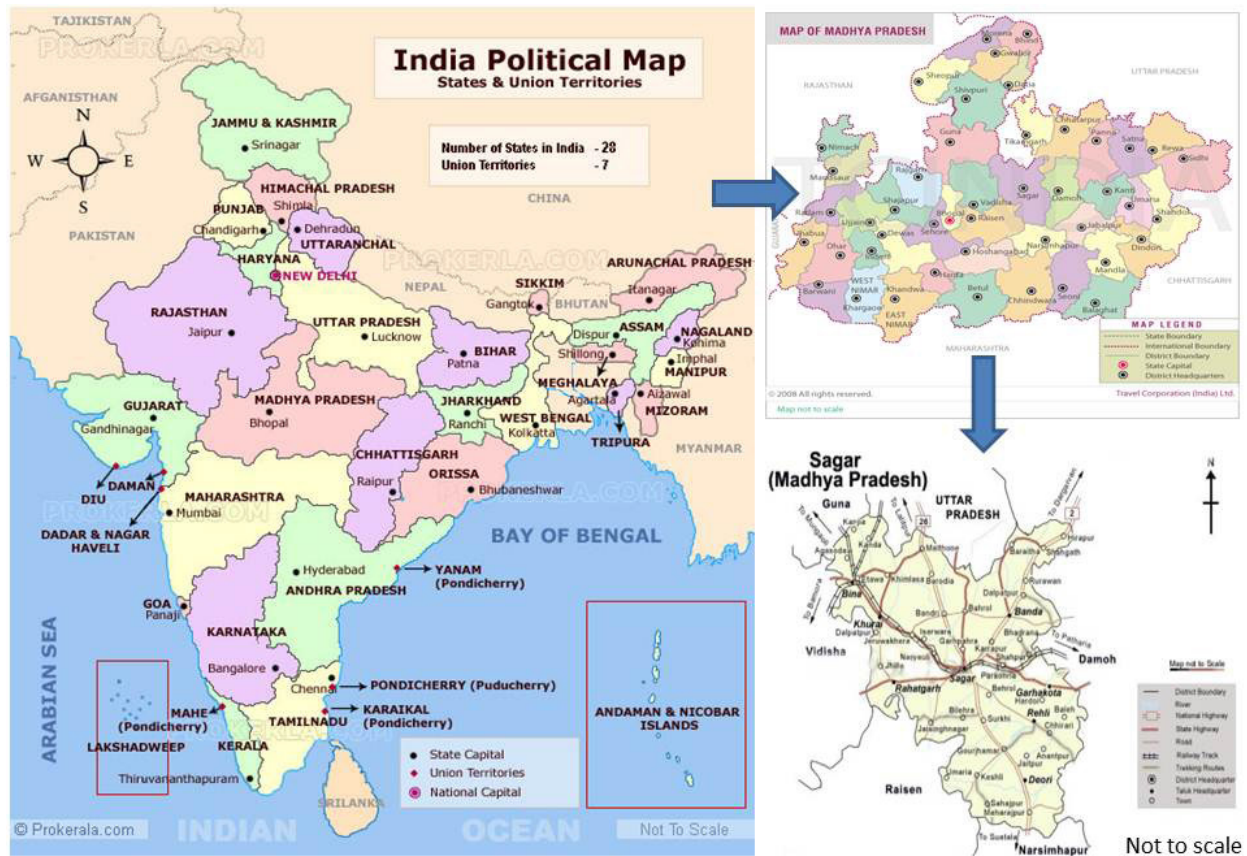


Fig.1. Location map of study area.



Fig.2. Image showing Sagar lake along with polluting spots identified. (Source: Google Earth)



Fig.3. Base Map showing polluting spots.

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Analysis of Increase in Salinity Content in the Coastal Areas of Gujarat due to Ground Water Depletion through Remote Sensing and GIS Technologies

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Keywords: Saline soils, salinity indices, GIS, Remote sensing, HWSD Database, Ground water depletion, Calisols, Leptosols, pH value, visual interpretation.

Abstract: The total length of coastline in India is 4800 kms. Out of which, Gujarat possesses one-third coastline and Saurashtra and Kutch area possess coastline of 1125 kms. In the coastal area of Saurashtra, which is 765 km. long, the issue of salinity has been observed due to natural factors of salinity of ocean water and also due to human interference in the natural balance. This problem has aggravated over the years due to the following reasons:- Less and irregular rainfall, Porous geographical formation, less natural water filling, Weak land management, Excessive lifting of underground water by farmers for irrigation.

Introduction

Due to increase in salinity, a total of 700120 hectore area, 534 villages, 1079733 persons and 32750 wells were affected. The economical condition of this area was adversely affected and issues of migration of people had also taken place due to deterioration of underground water due to salinity and adverse effect on agricultural products and industries based on agricultural due to excessive lifting of water by the farmers. Recent advances in the application of GIS & Remote sensing technology in mapping & monitoring degraded lands, especially in salt-affected soils, have shown great promise of enhanced speed, accuracy & cost effectiveness. With the use of HWSD database we have observed that the calisols and leptosols content in the soil leads to increase in salinity along with the sea water intrusions. Landsat mss, etm+ images are used to analyze the salinity content.

Study area

The state of Gujarat lies on the western coast of India. The geographical location of Gujarat is between 20° 6' N to 24° 42' N north latitude and 68° 10'E to 74° 28'E east longitude (Fig.1). Gujarat is one of the most industrialized states and of the fastest growing economies in India. The Arabian Sea borders the state both to the west and the south west.

Gujarat Geography

Gujarat is situated on the west coast of Indian peninsula. The state is bound by the Arabian Sea on the west, Pakistan and Rajasthan in the north and northeast, Maharashtra in the south and Madhya Pradesh in the southeast. Gujarat is spread across an area of 196077 sq. km. With a coastline stretching over 1290 kilometers along the Arabian Sea, Gujarat has the longest coastline among Indian states. The geography of Gujarat divides the state into 3 based on the physiography of the state:

1. Kutch
2. Saurashtra
3. Kathiawad



Fig. 1. Study area.

Kutch represents the northwestern region of the state. The Rann of Kutch falls in this region. The speciality of the Rann of Kutch is that the area gets submerged in water during rainy season and during other seasons it becomes completely dry. The Saurashtra region consists mainly of hilly tract sprinkled with low mountains. The mainland extending from the Rann of Kutch and the Aravalli Hills to the river Damanganga is on the whole a level plain of alluvial soil. Narmada, Sabarmati, Tapi, Purna, Damanganga, Rukmavati, etc, are the main rivers that flow through the state of Gujarat. Only less than 10% of the total land area of Gujarat is covered by forest. Gir forests in Gujarat are the only place in India where one can find Asiatic Lions.

Climate of Gujarat

Gujarat has a very diverse climatic condition. While the southern regions have a moist climate, the northern regions of Gujarat have a dry climate. Though the state lies in the tropic region, Gujarat's proximity to the Arabian Sea reduce the climatic extremes and make the climate more pleasant, comfortable and healthy. The summer season in Gujarat starts from the month of March and lasts till May. During this season, temperature during day time can go upto 41° C and night temperature will be around 30° C. Gujarat summers are extremely dry and humid. During winter, Gujarat has a pleasant climate. Winters are mild and dry and the temperature during winter averages 29°C during day time and 12°C during night time. Winter season in Gujarat starts in November and lasts till February. Monsoon season in Gujarat starts in June and during this period the southern region of the state receives an average rainfall ranging from 76 to 152cms. The northern region receives around 51 to 102cms of rainfall during monsoon.

Methodology

Seven ETM+ bands, collected on 26/11/1999, over the Kutch area selected for this study. These images were chosen, because late summer represents the most suitable time for direct soil investigation, especially soil salinity study, owing to maximum evaporation and enhancement of salinity problems, a clear sky and the absence of rainfall for a sufficient number of weeks before satellite overpass producing a dry enough soil

surface. For this study, the available soil salinity data relating to the Non-cultivated areas with almost stable surface conditions were used for further analysis

Landsat 7 (ETM+) is the latest NASA satellite in a series that has produced an uninterrupted multispectral record of the Earth's land surface since 1972.

Data analysis

Two indices: Salinity Index (SI) and Normalized Difference Salinity Index (NDSI) were applied to identify the salt-affected soils.

$$SI = (\text{Band 1} \times \text{Band 3})^{1/2}$$

$$NDSI = (\text{Band 3} - \text{Band 4}) / (\text{Band 3} + \text{Band 4})$$

$$BI = \text{sqrt}((\text{Band 3})^2 + (\text{Band 4})^2)$$

Normalized Differential Vegetation Index (NDVI) was included in the analysis to identify salt-affected soils which are usually characterized by stressed vegetation which is an indirect measure of the presence of salt in the soil (Fig. 2).

$$NDVI = (\text{Band 4} - \text{Band 3}) / (\text{Band 3} + \text{Band 4}).$$

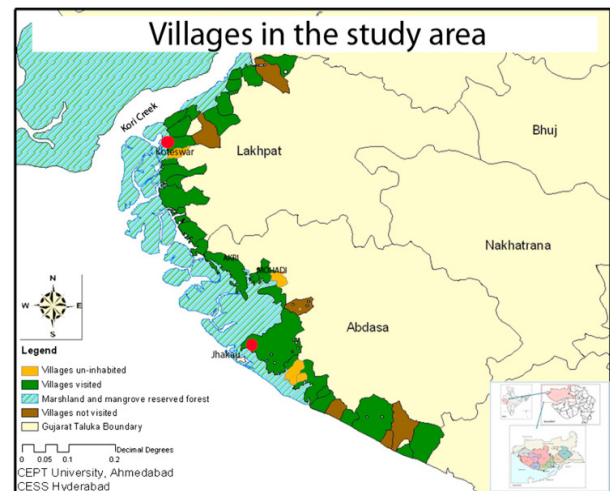


Fig. 2.

Results and discussion

Based on the database obtained by the coastal salinity prevention cell, we observe a map that shows the areas affected by the salinity (Fig. 3).

Most salinity is observed in the Lakhpat, Abdasa, Mandvi, Mundra, Gandhidham and Bhachau.

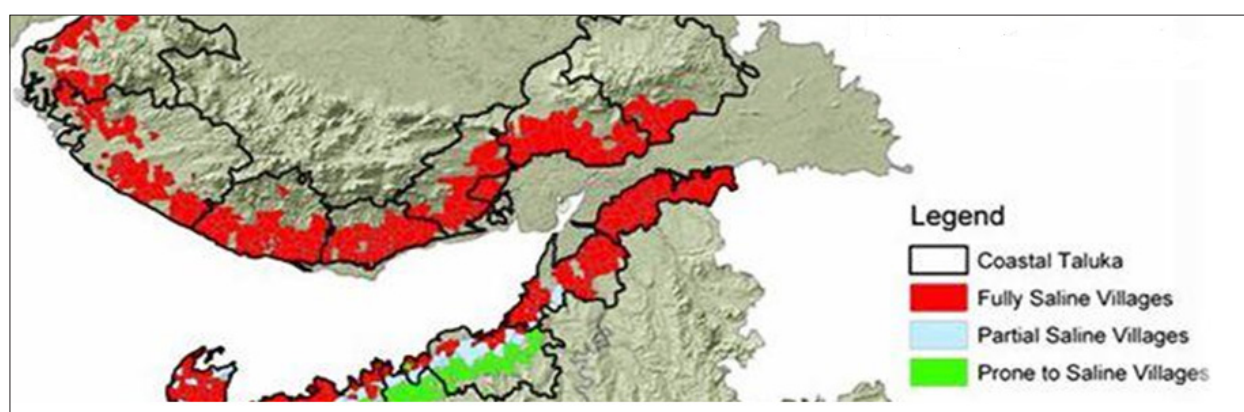


Fig. 3. Salt affected areas.

Soils present in this area is calisols which can be observed through the HWSO database shown in fig. 4.

Application of brightness index which gives the idea of the soil brightness that shows the saline particles in the soil.

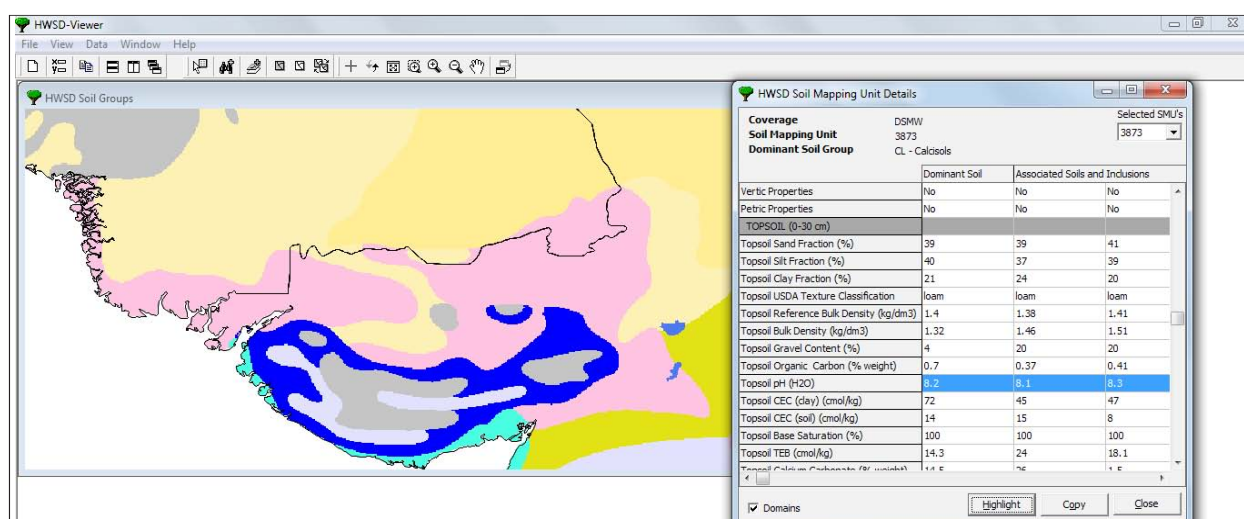


Fig. 4. HWSO Raster Database model.

Also, the soil in grey portion shows the leptosols content which also is a factor of salinity.

Application of Remote Sensing indicators for salinity identification

Salinity Index helps to generate a color composite image to isolate and interpret salt-affected lands.

Application of Normalized Difference Salinity Index (NDSI) helps to generate a color composite image.

Conclusion

Study area villages have the pH level higher than 8, which leads to the increase in salinity. Due to depletion of the ground water, sea water intrusions takes place and the salt content is observed through the verification of indices with the HWSO database. The content of salinity can be reduced using the concept of percolation tanks, rainwater harvesting and recharging, various desalination processes are also carried out by the state government. The pH value is in the range of 8.1 to 8.7. The high reflectance present in the satellite image is due to the presence of salt in the soil.

NDVI Based Assessment of Desertification in Arid Part of Rajasthan in Reference to Regional Climate Variability

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Abstract: At the national scale, India is among the countries experiencing the heat of desertification; about 120 m ha area is degraded by various processes of degradation and in western part of Rajasthan; about 76% area has been mapped under wind erosion and deposition form of land degradation. The present study was carried out in Jaisalmer district which falls within arid region of India and cover maximum area of Thar Desert in India. The district can be best described by a dominant sandy terrain and climatically a very low rainfall region of the country. Absence of any substantial vegetation cover and agricultural activities, coupled with high wind velocity make the region more vulnerable to sand movement through wind erosion and depositional processes. Satellite remote sensing provides an alternate technique for monitoring and characterizing trends of land degradation. In this paper, we used time series datasets of Normalized Difference Vegetation Index (NDVI) obtained from MODIS available from 2000 to 2009. Decline in vegetation cover is one of the indicators in the assessment of state of desertification. Therefore, NDVI derived from remote sensing satellites can also be used as indicators of desertification. Recent researches also link desertification with El Niño and La Niña events. Our observation showed, years 2002, 2004 and 2009 has very low range of NDVI values while 2001, 2003, 2006 has the combination of higher, moderate and low NDVI values.

Introduction

Over the past 40 years, there have been many definitions of desertification, few of the mostly accepted ones, are, (1) UNEP (1991): land degradation in arid, semi-arid and dry sub-humid areas resulting mainly from adverse human impact and, (2) the Earth Summit at Rio, held in 1992: land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities". The difference between these two definitions is the recognition of climate which is a major factor to determine the spatial variability of areas vulnerable to desertification. At the national scale, India is among the countries experiencing the heat of desertification; about 120 m ha area is degraded by various processes of degradation (Anon., 2008) and in western part of Rajasthan, according to a report, 76% area of the arid Rajasthan, across all land uses, was affected by wind erosion, 2% by salinization, 3% by vegetation degradation and 0.10% by mining activities (Kar, et al, 2007a). Arid areas in India, which falls within the

rainfall zones, 100 – 500 mm, under a dominant sandy terrain, experience gradual change in natural vegetation in various habitats. Thus, these regions are more vulnerable to land degradation. Adequate Information through various studies are available now to specify the major causes for land degradation in this region using both field based interpretation and remote sensing. Sikka, D.R, 1997 studied land degradation correlated with climate change. Kar, *et al.*, 2009, based on a national level mapping assessed various types of land degradation in India and presented a national level database on desertification. Kaushalya R. *et al.*, 2013, assessed vulnerability of Indian agriculture to rainfall variability using NOAA-AVHRR and MODIS (250 m) data. PiaoShilong et al. 2005 used NDVI to indicate decline in desertification in China in the past two decades. Santra and Chakraborty, 2011, analyzed both seasonal and annual change in vegetation and found suitability of MODIS data for quick assessment of vegetation changes in Thar Desert.

Study area and Environment

The state of Rajasthan in its western part follows a climatic gradient from 500 mm in the east bordering Aravalli hills to ~150 mm in the extreme west in Jaisalmer district. Therefore, it is expected that a very high NDVI values in the eastern fringe and a low NDVI to be associated with dry/arid western part of the region. The present study was carried out in Jaisalmer (Fig. 1) which is the largest district of the state covering an area of 38,401 sq. km. Located in the extremely hot arid part of India (Latitude between 26°1' N and 28°2'12" N and Longitudes, 69°30' E and 72°20'30" E), it is classified under arid western plain as per agro-climatic zonation of the country. The district is also part of Thar Desert in India and can be best described by a dominant sandy terrain and climatically a very low rainfall region of the country. Absence of any substantial vegetation cover and agricultural activities, coupled with high wind velocity make the region more prone to wind erosion and deposition form of degradation. Gradual introduction of the Indira Gandhi canal network within this desert has led to faster changes not only in the agrarian situation but also in anthropogenic spheres. Under such climate, terrain and edaphic conditions, the region is vulnerable to land degradation of various types, the primary factor being the wind erosion and deposition. We have tried to assess the situation of land degradation using NDVI based remote sensing technique which is an alternate to understand the relationship between change in vegetation and associated land degradation.

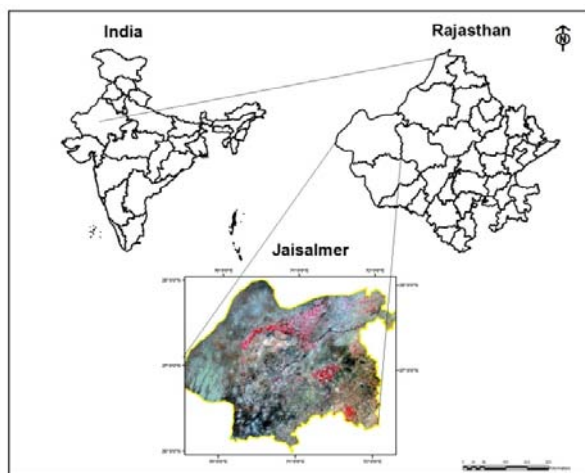


Fig.1. Location of study area

Climate variability

The eastern part of the district receives about 250 mm of annual rainfall while some of the areas in the western margin receive about 100 mm. The occurrence and distribution of the rainfall is also erratic. Of late, the region has also witnessed higher annual rainfall, for example, the rain gauge at Jaisalmer, recorded 421 mm of annual rainfall in 2006, 265 mm in 2011 and 158 mm in 2003. The maximum temperature during summer months often sores above 47° C, while during winter the daily minimum temperature sometimes goes down to the freezing point. Jaisalmer region experiences the highest wind speeds in the arid western Rajasthan. Peak wind speeds are observed in June which records a mean monthly wind speed of 27.2 kmph. Crop growing seasons are also about 4 – 6 weeks only. The growing season available for pastures is 8 – 10 weeks normal conditions of rainfall and the grassland are subjected to drought conditions once in four years during the growing phase, affecting the forage production. The crop production under rainfed conditions in the district is confined mainly to the south eastern part where the mean annual rainfall is around 250mm. Under all these conditions, aeolian processes become highly efficient and trigger up owing to such climatic variability, producing vast area under sand dunes and sandy hummocks. In fact such sandy plains cover more than 60 % area. While soil cover is generally thin except on sandy plains, natural vegetation consists mainly of grasses and shrubs of poor morphology which sustains only low rainfall regimes and under conserved moisture condition.

Rainfall data over the years (2000 to 2009), collected from three rain gauge stations at Jaisalmer, Pokaran and Fatehgarh were plotted to understand the rainfall variability and pattern (Fig. 2). It was found that trend of rainfall was much higher in the SE part than the western part over the years.

Data used and Methodology

- NASA MODIS CMG Monthly NDVI (Global) data has been used. These data were processed by NASA Goddard from the Terra sensor projected on a 0.05 degree (5.5 km resolution) Climate Modeling Grid (CMG).

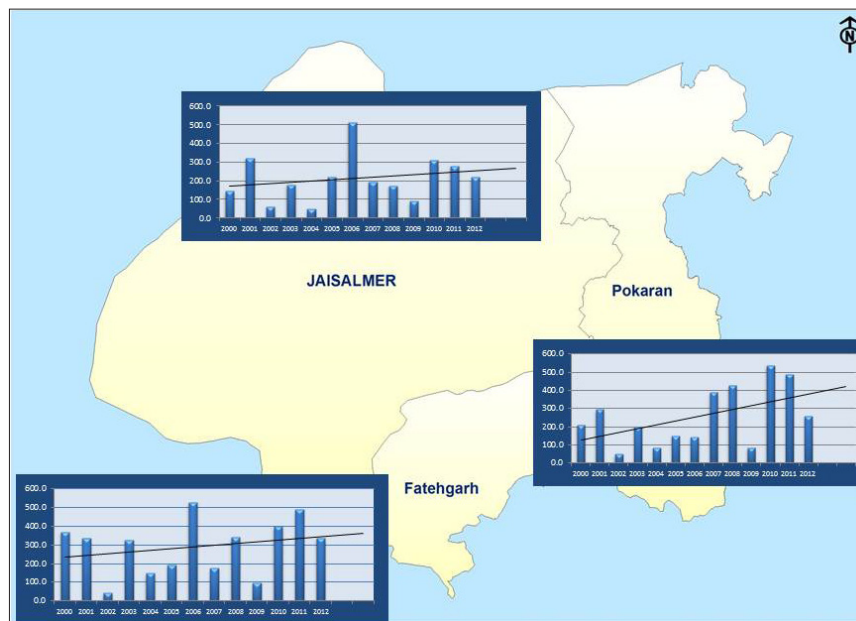


Fig. 2. Rainfall variability in Jaisalmer district from 2000 to 2009, recorded at three rain-gauge stations

- IRS - AWiFs data were used as secondary data for checking vegetated area.
- The data has been downloaded for the years 2000 - 2009. Monsoon period (July, August and September) were selected for observation
- Statistics generation and area calculation for each class
- Analysis of rainfall pattern of the study area from 2000 to 2012.

Preprocessing

- Conversion of MODIS NDVI data from 16 bit integer to 32 bit float to get the original values (+1 to -1)
- Since this data did not contain cloud covers and atmospheric disturbances, therefore, the procedures to remove such errors were not followed
- Satellite data in respect of the study area was extracted

Methods

- Generation of yearly Average scenes by raster calculator (July+August+September/3) for each year.
- Visual observation of value range from the year 2000 to 2009. Then we obtained maximum and minimum range of NDVI values (0-0.65).
- On the basis of this range, we have classified all the scenes into three categories (0.65/3) as 0-0.2 (low), 0.2-0.4 (Moderate) and 0.4-0.7 (High) using ArcGIS spatial analysis tool.

Result and Discussions

Assessment of vegetation condition

Distribution of NDVI values, extracted from MODIS terra remote sensing data indicates variation in greenness over the region from 2000 to 2009. The time series analysis of NDVI values for the respective years is presented in Fig. 3. The images present an over view of spatial changes in greenness in the region. Reclassification of this data into low, moderate and high (Fig. 4 & 5 and Table. 1) using GIS indicates condition of vegetation and their spatial extent over the years. Area under high category was only experienced during 2003 (4.8% area) and in 2001 and 2006 with <1% area under high categories. In the moderate situation, during not so good rainfall years, the areas remained at par with 10-12% while in the low categories, the percent area varied from 89 to 100 (2002), except in 2003 (36%) indicating very bad situation of vegetation.

Reclassification of NDVI values (categories)

Therefore our analysis indicates very low distribution of vegetation in Jaisalmer district

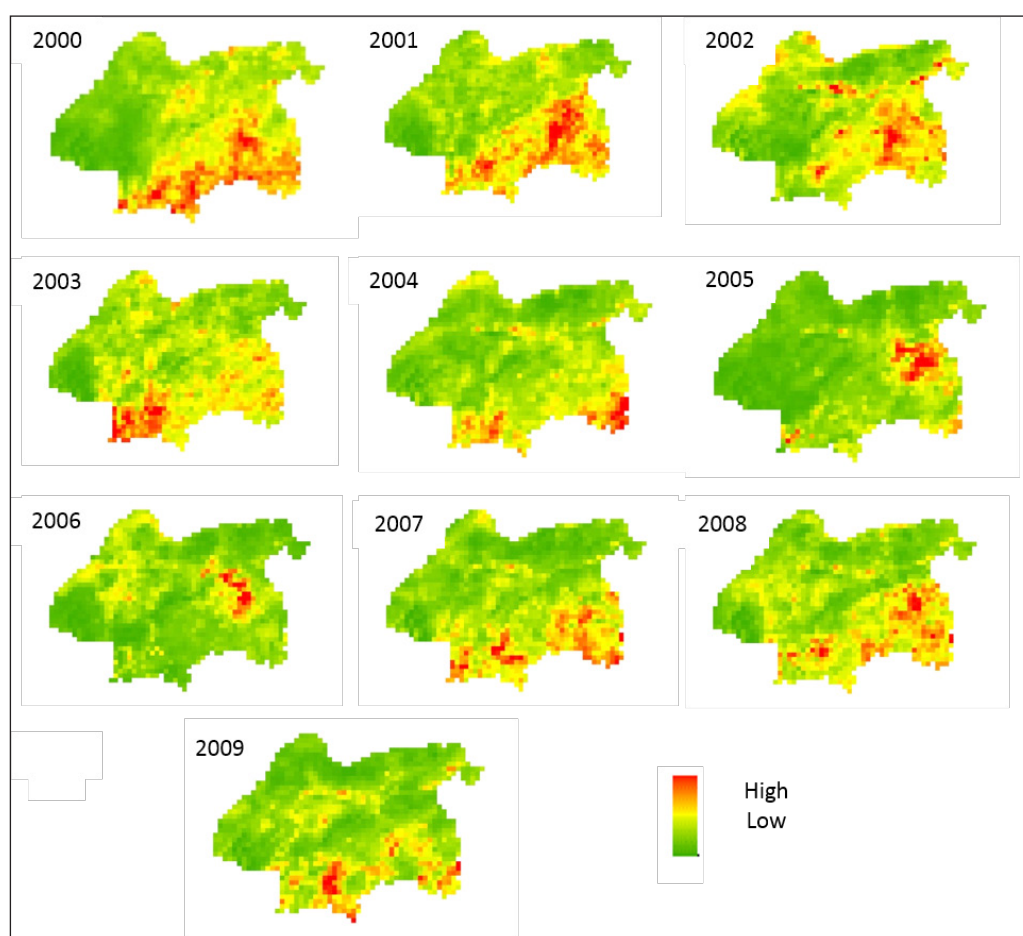


Fig. 3. NDVI derived from MODIS TERRA showing different levels of Greenness over Jaisalmer district from 2000 to 2009.

except in 2001, 2003 and 2006 when the region experienced rainfalls more than normal. A better situation was observed between 2005 and 2009, but the worst of the situations was observed during 2002 and 2004 when the

region experienced acute drought condition. Most of the districts in Rajasthan were under moderate to severe drought during those years. Therefore, situations during 2000, 2007, and 2008 may be assumed as representing

Table 1. Area (sq.km) statistics of different categories of NDVI values over the years in Jaisalmer District

Categories > Years	Low (0-0.2)	Area (%)	Moderate (0.2-0.4)	Area (%)	High (0.4-0.7)	Area (%)
2000	34364.77	89.30	4116.57222	10.70	0.000	0.00
2001	23182.96	60.25	14939.9764	38.82	358.0482	0.93
2002	38481.21	100.00	0.000	0.00	0.0000	0.00
2003	15278.14	39.70	21349.6062	55.48	1853.6172	4.82
2004	38453.6	99.93	27.610274	0.07	0.000	0.00
2005	36968.37	96.07	1512.84349	3.93	0.000	0.00
2006	33293.27	86.52	4940.71273	12.84	247.21639	0.64
2007	33869.49	88.02	4611.95398	11.98	0.000	0.00
2008	34014.08	88.39	4467.40331	11.61	0.000	0.00
2009	38038.81	98.85	442.397466	1.15	0.000	0.00

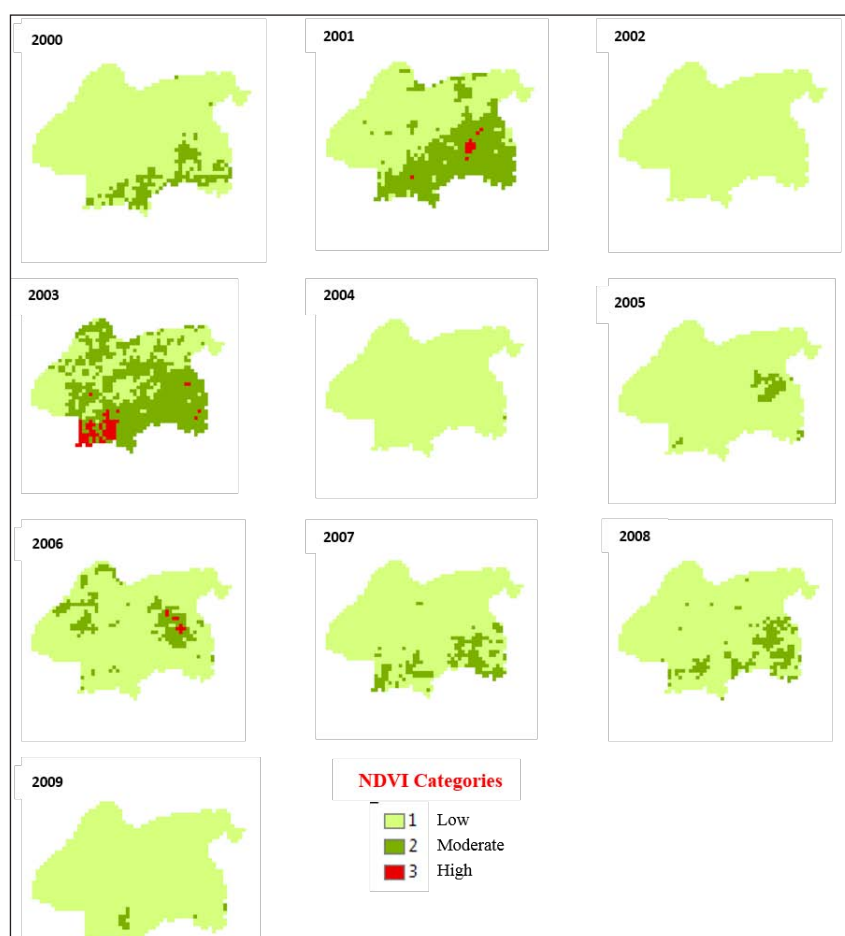


Fig.4. Reclassification of data showing sequential changes in NDVI over the years (2000-2009)

normal years and 2003 and 2006 as better rainfall years for Jaisalmer as a whole.

Discussion and conclusion

Desertification which is defined as a form of land degradation in arid, semi-arid and

sub-humid situation seems to be the right kind of event for this part of Rajasthan. Studies based on natural resources survey in this part by Central Arid Zone Institute, Regional Remote Sensing Centre and few other institutes of the country suggest that

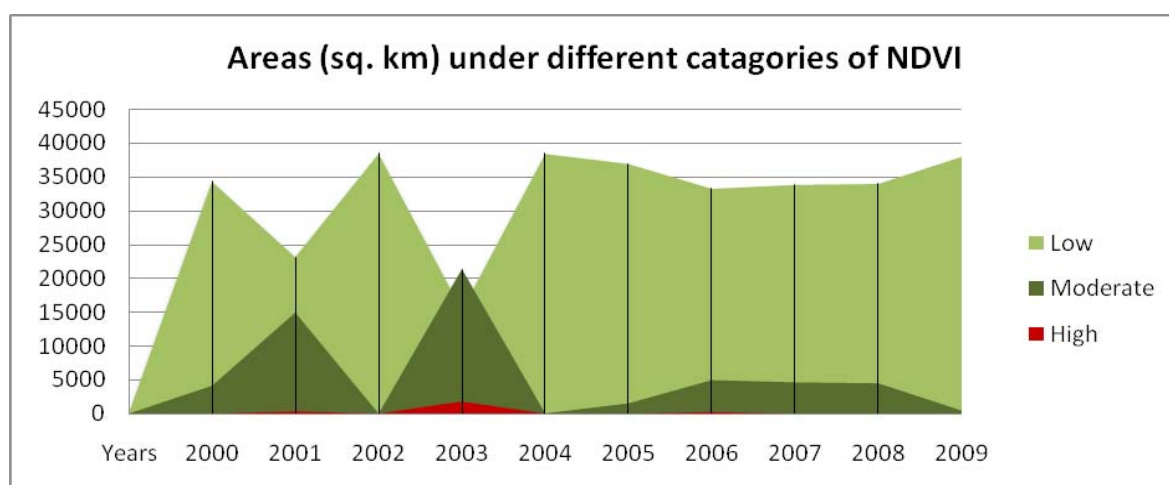


Fig.5. Distribution of classified categories of NDVI over the years in Jaisalmer District

this region because of climatic limitations has a dominant arid ecosystem. Wind erosion is the dominant process of land degradation and is regarded as the major factor responsible for the presence of a vast sandy terrain with various types of sand dunes. As per CAZRI, the region has substantial area (~54 %) under various types of sand dunes, dominant amongst are longitudinal, parabolic and mega-barchanoids. The morphology of such dunes indicates stability as well as some of the recent formations. In the same time, about 40% area around Jaisalmer city is sculpted into a rocky terrain and some of these surfaces present imprints of fluvial signature.

From the results obtained from NDVI re-classification, it was found that the years, 2002, 2004 and 2009, had low distribution of vegetation indicating drought like situations, and in fact, these were under severe drought during those years. As per the concept of EL Nino years which represents a global weather phenomena for dry conditions for region like India, the conditions matched our results. Similarly, the classification also indicated better occurrences of vegetation (all the categories, high, moderate and low) during 2006, which was also a LA Nina year (wetter periods). Analysis of rainfall variability indicated that rainfall was better in the South Eastern part than the rest, particularly over the western part.

As per wind erosion index (Kar, 1993 and Ann. 2000), Jaisalmer district is classified under extremely high value of index (480 and above). Our results (based on NDVI trend and rainfall variability) indicate that in most of the years, the conditions are favourable for higher wind erosion / depositional activities. In the absence of trees the dominant sandy terrain in the west and north-west gets a look of sparse grasslands and are represented by low value of NDVI for all the years. The major grasslands have dominance of *Lasiurus sindicus* type in more than 80% area (Ann. 1992). In the south east, similar habitats support *Calligonum Polygoides*, *Calotris procera*, *Aerva pseudotomentosa* as shrubs and some of the areas are now irrigated with better groundwater. It has been seen that in spite of high vulnerability, the stable dunes can support adequate grass and shrub cover under un-disturbed condition which reduces the aeolian hazards, but situations of sand

accentuations occur only in areas receiving the advantages of canal water and are being utilized for agriculture. The sandy undulating plains or hummocky lands area are at higher risk of Aeolian hazard where grasses and shrub density is low. In the NW part these lands support excellent cover of *L. Sindicus* grass but due to droughts, majority of them are dead or dried up. However, grasslands in this part of arid lands have been found to regenerate with slight improvement in moisture condition as has been seen in NDVI of 2003 and 2006 under better rainfall conditions. Since distribution of NDVI category low is observed in more than 80% area, the state of vegetation in the district can be termed as poor while it is also seen that with slight better rainfall situation, the greenness has improved as depicted in moderate category (38 – 55 % area). Thus, NDVI based technique has been found suitable to get a quick look at the spatio-temporal variability in the vegetation and so as to correlate their status in response to rainfall occurrences and land degradation.

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Green Energy Potentials from Poultry Litter for Reducing Green House Gas Emissions in Atmosphere using GIS

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Keywords: Poultry Litter, Anaerobic Digester, Biogas, Green energy, Green House Gas, Global Warming, GIS, Sustainable Development

Abstract: The increase in use of non-renewable fossil fuels may have increased the amount of carbon dioxide and other Green House Gases (GHG) in the atmosphere to produce climate change and other environmental problems both on local and global scales. The atmospheric carbon dioxide concentrations are calculated to be rising at 2 parts per million a year, the burning of fossil fuels and forests the global level exceeds 385 parts per million. Almost all the countries are now seriously thinking on controlling the fossil fuel use so as to arrest global warming. In this background, there is urgent need for the country to develop a sustainable path of energy development. Biogas is an environmental friendly, clean, cheap, and versatile fuel generating from poultry litter. The main objective of the present study is Geographical Information System to map the biogas energy potential of Namakkal Taluk, Tamil Nadu, India and analyze the variability considering spatial aspects. There is growing interest in installing Anaerobic Digesters (AD) on farms to use poultry litter as a biogas resource for both economic value and environmental benefit. Taking these into account, the present status of the green energy potential is assessed. The study shows that, the green energy potential is 234 megawatt per day available in Namakkal Taluk, Tamil Nadu, India. The biogas potential available in the study area is 84 tonnes per day. This biogas potential is converted to green energy. This technology ensures reducing Green House Gas emissions, sustainable development, energy security and employment generation in the study area.

Introduction

The growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Gupta et al. (2008) stated that the increase in use of non-renewable fossil fuels may have increased the amount of carbon dioxide and other Green House Gases in the atmosphere to produce climate change and other environmental problems both on local and global scales. Venema and Calamai (2000) explained fossil fuels consumption is believed to be the primary factor contributing to serious environmental problems, such as global warming, climate change and acid rain, which are serious threats to the world's ecosystems and the prosperity of human civilizations. The global atmospheric concentration of carbon-dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. Multi-model averages show that the temperature

increase during 2090-2099 relative to 1890-1999 may range from 1.1 to 6.4oC and sea level rise from 0.18 to 0.59 m. These could lead to impacts on freshwater availability, oceanic acidification, food production, flooding of coastal areas and increased burden of vector borne and water borne diseases associated with extreme weather events (Menon, 2010). Efforts to minimize the production of green house gases from all possible sources are needed. An increase in public awareness regarding the negative impact of traditional power-generating methods, especially coal and oil-fired power stations, on the environment has created a demand for developing and using environmental friendly renewable energy (Baban and Parry, 2001). A number of entities have proposed using poultry litter as a fuel source for electricity generation (Ma et. al, 2005). Ramachandra (2008) used a Geographic Information Systems to analyze biogas as one such alternative, which can be obtained by anaerobic digestion

of animal residues and domestic and farm wastes abundantly available in Karnataka State. Humbad et al. (2009) have studied Clean Development Mechanism to reduce the green house gas emissions by monetizing the reduction in emissions and a tremendous potential to earn carbon credits by setting up household based energy substitution or fuel switching projects like biogas plants, solar cookers and solar cells and smokeless chulhas. Palma (2012) attempted to study environmental implications of the disposal of waste from the poultry industry which have created the need for proper waste management. Hanandeh and Zein (2011) attempted to study the energy from waste identified as a source of green electricity and has been used as a way of reducing greenhouse gas emissions. Anaerobic Digestion may yield better results from an environmental and energy generation perspective. Aurich et al. (2012) have emphasized that the production of biogas as a renewable resource has emerged rapidly in Germany and other countries with

the expectation to substantially mitigate anthropogenic Green House Gases. This study analyzes the GHG mitigation potential of using biogas based on cattle slurry and corn to produce electrical and thermal energy. Hence, the main objective of the present study is to use Geographical Information System to map the village wise green energy potential for reducing green House Gas emissions in atmosphere in Namakkal Taluk, Tamil Nadu, India and analyze the variability considering spatial aspects.

Study area

Namakkal taluk is located between 11° and $11^{\circ} 26'$ N latitudes and $78^{\circ} 02'$ and $78^{\circ} 28'$ E longitudes. Namakkal taluk extends over an area of 1513 km² at a mean altitude of about 300 m (Fig.1). Namakkal, the taluk headquarter, is the only town in the taluk which has 117 villages grouped under six development blocks (3). Hills are found on the northern and eastern part of the taluk. Kolli

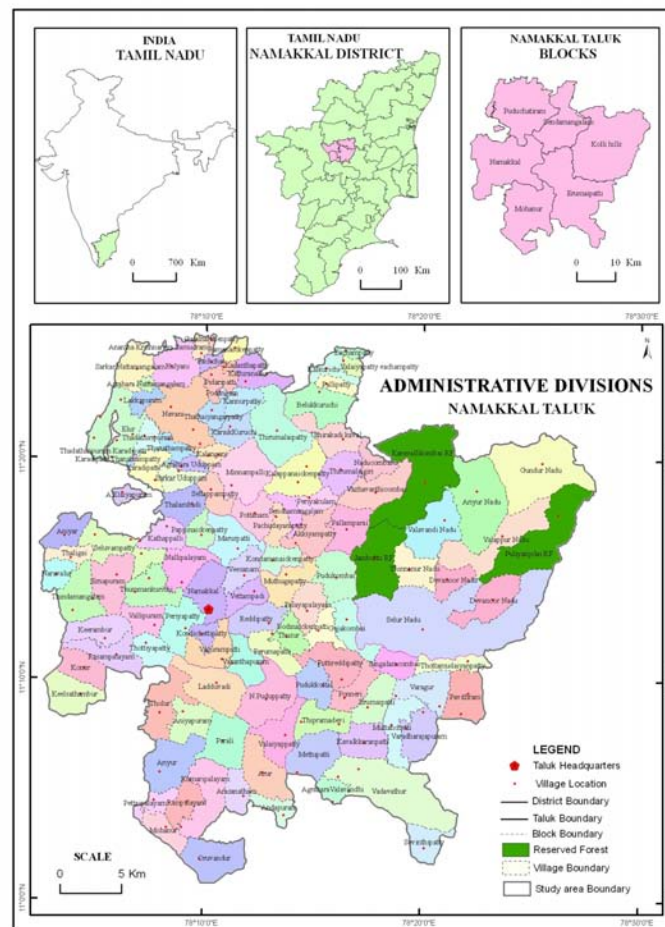


Fig. 1

Hills spreads over an area of 371 km² with peaks rising to 1300 m. The taluk has semi-arid type of climate, and Thirumanimutharu and Kaveri rivers pass through this taluk (11). The maximum temperature ranges from 28.10 to 37.85 °C and the minimum from 20.85 to 25.40 °C. The mean annual rainfall of the taluk is 730.5mm. Paddy is the main crop. Total population as per 2011 Census of the taluk was 5,29,343 with density being 350 persons per km². About 55 per cent working population is engaged in farming activities. The taluk is known for egg production and sends eggs to all over the country. Namakkal is known as Egg City or Poultry Town. It is also known for truck building industry.

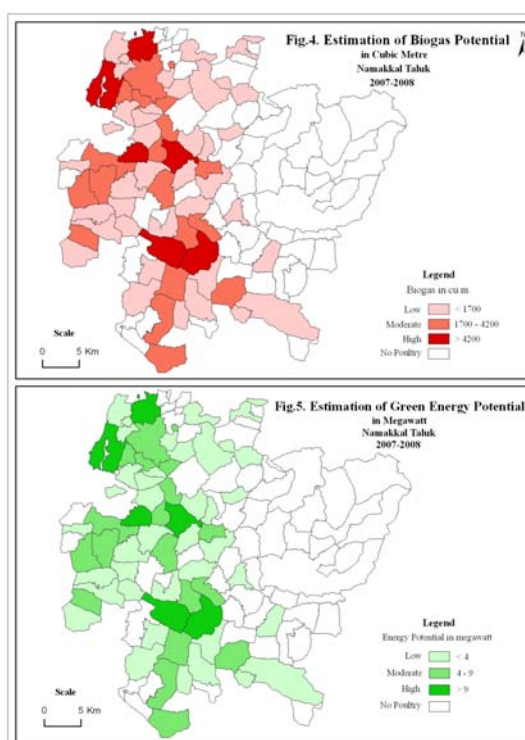
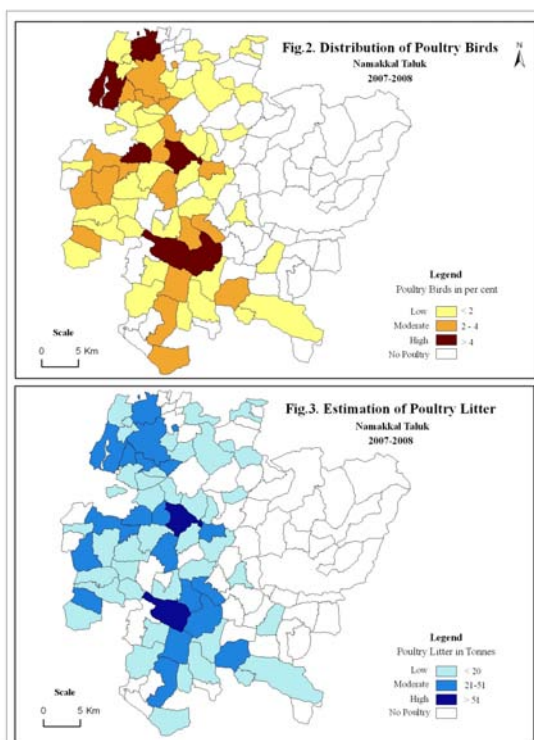
Data and methods

The present investigation is mainly based on secondary data. In accordance with collateral data, the SOI toposheet in 1:50,000 scale and maps from various organizations have been used for preparing various thematic maps. Block map with village boundaries were digitized to generate base layers using vector based software. The village-wise spatial distribution of poultry farms (2007-2008) data was collected from District Poultry Development Office, Namakkal. Simple statistical techniques are used to calculate the percentage of spatial

distribution of poultry birds, estimation of poultry litter, estimation of biogas and green energy potential from poultry litter. The theoretical potential is presented as a thematic map of the total amount of reducing methane gas emissions in atmosphere available in each village.

Poultry birds and poultry litter

In Namakkal Taluk, the poultry farms are located in 64 villages and the total number of birds are 1,30,23,220 in these poultry farms. The poultry farms are not presented in 53 villages. The study shows that, the concentration of poultry birds are at a high level (more than 4 per cent) in six villages (Fig.2). The main reason is very good environment and infrastructural facilities present here. Nineteen villages have 2 to 4 per cent of poultry birds. In thirty nine villages have less than 2 per cent of poultry birds. Most of the poultry farms are located along the transportation lines and are having good connectivity. This will help the rural farmers for increasing the income from poultry farming and increase the socio-economic condition of the rural underprivileged society. The physical quantity of poultry litter produced per day was estimated at the village level, by using the average amount of litter generated per bird.



The average amount of litter generated by a bird was assumed as 90 grams per day. Thus, the total quantity of the poultry litter generated in Namakkal taluk is about 1172 tonnes per day. The highest amount of poultry litter were generated per day was estimated at Marupatty and Ladduvadi villages, which generated 98 tonnes and 72 tonnes per day (Fig. 3). The moderate amount (21 to 51 tonnes) of poultry litter was generated by twenty villages. Forty-two villages generated less than 20 tonnes of poultry litter per day. Poultry litter is a promising sustainable energy resource that can help in reducing the dependence on fossil fuels and minimizing the green house gas emissions to the atmosphere.

Biogas and Green Energy Potential

Biogas energy potential assessment is based on compilation and computation of poultry litter supply for energy generation. Biogas is a product of anaerobic fermentation of organic matters and consists of around 60 to 70 per cent methane and 30 to 40 per cent carbon-di-oxide and traces of nitrogen, sulphur and moisture. Farm wastes locally available are used for extracting biogas from poultry litter. Assuming a production of 0.1 cu.m of biogas from one kilogram of poultry liter, it is estimated that Namakkal taluk can produce biogas of 1,17,214 cu.m per day. Six villages are having highest amount of biogas potential (Fig. 4), the biogas production can totally go up to more than 4200 cu.m per day. In nineteen villages, biogas production is between 1700 and 4200 cu.m per day. Thirty- nine villages have low level of biogas potential. It may be less than 1700 cu.m per day. The estimation of green energy potential was implemented in Geographical Information System to obtain maps showing village-wise variation of green energy potential in the study area. Assuming that one cubic metre of biogas may produce two units of green electricity. The highest amount of green energy potential per day was estimated at six villages. It is about more than nine megawatt per day (Fig. 5). Nineteen villages are estimated to possess 4 to 9 megawatt potential per day. Thirty-nine villages produce low level of green energy potential in less than 4 megawatt per day. Taking these into account, the great alternative green energy potential assessed in Namakkal taluk is 2,34,000 KW (234 MW/day). The

electricity generated would be sold to the Tamil Nadu State Electricity Board (TNEB).

Reducing Methane Gas Emissions in Atmosphere

Every day when the sunrays reach earth, a group of gasses called greenhouse gases (water vapour, carbon-di-oxide, methane, nitrous oxide, etc) absorb heat from the sun's rays and make our planet warm enough for us to survive. If the levels of these gases in the atmosphere increase, they will absorb more heat, and make the earth too hot to live. This overheating of the planet is called global warming. Methane and nitrous oxide have approximately 21 times and 310 times, respectively, the heat-trapping capacity of carbon-di-oxide. Reducing methane by one tonne is equivalent to reducing carbon-di-oxide by 21 tonnes (Westerman, 2008). The average amount of methane gas weight is calculated and analyzed in the study area. There are 0.714 kilograms in a cubic metre of methane gas. Therefore, the total amount of methane gas potential is estimated in the study area is 84 tonnes per day. In the six villages, estimated high level methane gas in more than 3.05 tonnes per day (Fig. 6) and nineteen villages estimated between 1.25 to 3.05 tonnes per day. Thirty-nine villages produce less than 1.25 tonnes of methane gas per day.

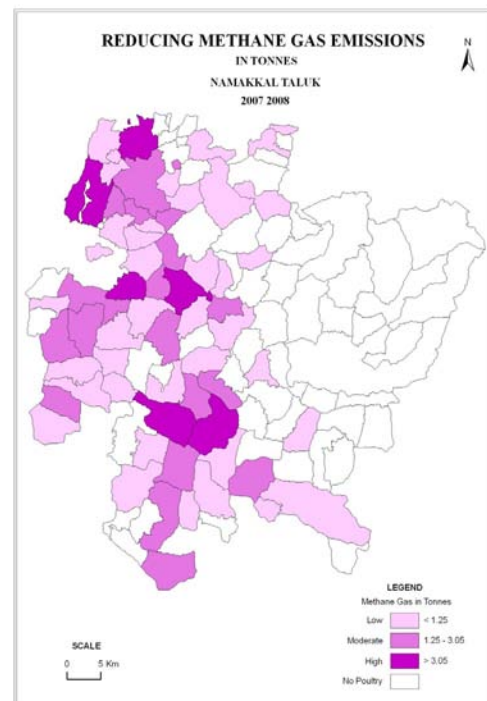


Fig. 6.

The exploitation of methane gas as a source of renewable energy not only provides a steady flow of income to the association but also demonstrates its willingness to reduce the green house gas emissions and to reduce the impact of our modern way of life on the environment.

Conclusion

Climate change, as a result of global warming, is likely to have far reaching effects on every sphere of life including crop and agriculture. Efforts to minimize the production of green house gases from all possible sources are needed. Among all animal protein production systems, poultry happens to be most favoured because of almost negligible enteric methane production vis-a-vis ruminant livestock. Improper handling of poultry manure can be hazardous to soil, air and water. Proper management of manure shall allow use of poultry manure as feed ingredient, fertilizer as well as a safe biofuel with minimal negative impact on environment. Biogas energy is a clean, pollution free and renewable source of energy. The method of generating electricity from biogas resources is one of the most effective ways to reduce global warming emissions. Poultry litter being generated continuously in Namakkal taluk may be profitably used, as it has a potential of generating about 234 megawatt of power per day. Namakkal taluk possesses great biogas energy potential and opportunities are open. The average amount of methane gas weight is calculated and analyzed in Namakkal Taluk. Therefore, the total amount of methane gas potential estimated in the study area is 84 tonnes per day. This biogas potential is converted to green energy. This technology ensures reducing Green House Gas emissions, sustainable development, energy security and employment generation in the study area.

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Remote Sensing & GIS Technique Based Evaluation of Sanitary Landfill Using Indian Parameters - A Case Study of Addis Ababa, Ethiopia

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Keywords: Remote Sensing & GIS, sanitary Landfill, Solid waste management, guideline of Indian pollution control board.

Abstract: Sanitary landfill site selection is a critical issue due to its enormous impact on the environment, health and economy. The wastes are considered hazardous as they may contain substances highly toxic to plants, animals and human, problems have become more pronounced in recent years, as a result of inadequate collection and disposal of wastes. Therefore, Solid waste management is now very essential but optimized sitting decisions have gained considerable importance in order to ensure minimum damage to the various environmental sub-components. The present study focus on evaluating of Addis Ababa's city newly selected Chebe Weregenu sanitary landfill by guideline of Indian pollution control board for conducting environmental impact assessment using remote sensing & GIS technique. The main reason that motivates the researcher to carry out evaluation of the site is that the existing landfill site i.e. Koshe or Reppi is getting full. Selection of landfill site involves integration of voluminous and varied data set of hydrology and geology, topography and transport and socio-economic factors. Finally Chebe Weregenu sanitary landfill scored good on the adopted Indian guidelines for conducting environmental impact assessment and the site is acceptable for landfill development.

Introduction

Waste was an early problem of mankind and now, with the increase in population and amount of waste being generated, it has become a major concern to every nation of the world. According to Yahiya et al., (2010) quoting in Allende, (2009), waste was disposed off in the ground where it would turn to compost to improve soil fertility. The population of Ethiopia from 1984 to 1994 increased by 13.2 million and from 1994 - 2007 the population increased by 20 million, grew at an average annual rate of 2.6 percent between 1994 and 2007, which is by far higher than the world average (URL1). The rapid population growth rate is also resulting in a rise of approximately 5 per cent of urban waste generation (Addis Ababa City Administration, 1998). As an effort to improve dry waste management, the city administration has transferred the service provision of dry waste management to the newly established Addis Ababa City Sanitation,

Beautification and Park Development Agency since January 2003 for green and favourable environment through integrated management and urban recreational area development (Taddese, 2004).

However, in today's society, finding a site to locate undesirable facilities is becoming a significant problem (Yahiya et al, 2010 quoting in Erkut and Moran 1991). According to Lee and Jones, (2008), some of the adverse impact on to public health, aesthetic aspect, economic aspect, on to ground and surface water and decrease in property value is very high. William and Paul, (1997) have also stated criteria for a site proposed as a municipal solid waste landfill. These include zoning, disposal facility siting decision, airport safety, flood plain, wetlands, closure of existing municipal solid waste landfill units, hydrological assessment, proximity to the country boundary, proximity to national historical sites. The results and findings of this study can be used by Addis Ababa City

Sanitation, Beautification and Park Development Agency to carry out similar evaluation for future developing sanitary landfills. This can also serve as an important input to Federal and Regional government for urban planning and environmental protection bodies.

Material and Methods

Data Collection

The secondary data sources like the topographic sheets of Addis Ababa with the scale 1:50,000, the Aster DEM, Google earth image, geologic map, hydrologic map of the study area are obtained from Geological survey of Ethiopia, Addis Ababa water project office, Federal ministry of agriculture and from web sites respectively.

Method of Data Analysis

Based on the nature of the study the analysis was mainly conducted using GIS software to analyze the data. The fundamental analytical functions of a GIS based spatial decision support system include proximity or buffer analysis and overlay analysis. There are two reasons for taking the guidelines from India: first is Ethiopia so far has no National Standard for landfill development and secondly, developing India has more close socio-environmental condition with Ethiopia. The adopted evaluation criteria

consists of three parts these are the first one hydrogeology, the second general information of transport and topography) and the last but not the least socio-economic. Each criterion is rated with a relative value 5 representing excellent, 4 ideal, 3 good, 2 poor and 1 bad.

Study area

The geographical location of the landfill site is between the latitude $9^{\circ}01'22''$.19N - $9^{\circ}02'27''$.52N and longitude of $38^{\circ}55'22''$.12 E - $38^{\circ}55'50''$.70E represented in Fig. 1. The site area lies in the upper part of the Awash River Drainage Basin. It is drained from almost north to south by rivers such as Lege Tafo and Lege Dadi and their tributaries Lege Beri and Secoru into Akaki river and finally into Awash river outside the site area. The elevation of the whole area ranges from 1401 mabsl to 3248 mabsl in the south and south eastern and the north and north western respectively. The total population the landfill development area represents 90 habitation units or families that are between 450 to 550 people. The average family size is 5 persons per household. Addis Ababa city generates a solid waste of 0.4 kg/c/day and more than 200,000 t areas collected each year. The city's major waste generating sources are households 76%, street sweepings 6% and institutions, commercial, factories and hotels 18%.

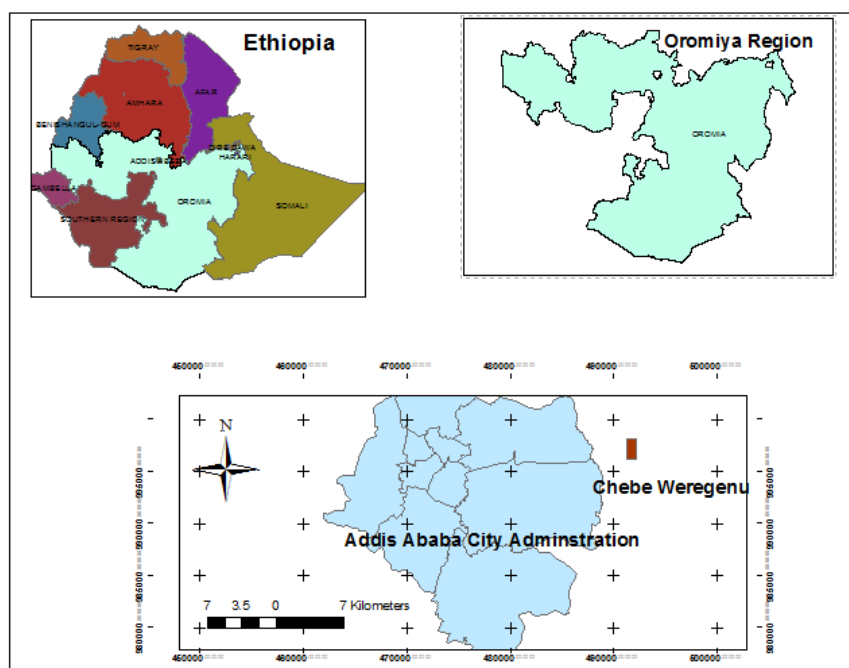


Fig. 1. Map of the study area Buffer Zone.

Results and Discussion

4.1 Hydrological, hydro-geological and geological

Evaluation criteria is adopted from the guidelines of Central Pollution Control Board, India (CPCB, 2003) and that of Central Public Health and Environmental Engineering Organization (CPHEEO, 2000) will be adopted (Sumathi et al, 2000).

4.1.1 Distance from Surface Water Body

Based on the evaluation criteria, the buffer distance for rivers, ponds and lakes are shown in table 1. The buffer distance for the river as depicted on the Fig. 2 by a series concentric circle from outside to inside shows 5, 4, 3, 2 and 1km a buffer distance. In this case the river is within 2 km buffer zone hence its relative value is poor (2). Zeinhom El Alfy et al., 2010, described that surface water (rivers) is very important because of its ecological balance to all the human being activities and as a nature resource. Rivers can be endangered by the landfill because of leachate issue which is dangerous, it can bring a great pollution to the river.

4.1.2 Annual Rainfall

Higher annual precipitation will not only lead to higher leachable generation and therefore more changes of ground water contamination, but also will create problems in controlling surface /contact water at dumpsite. The scales for annual rainfall shown in table 1 were developed for ranking the sites.

The total annual rainfall of Sendafa and its surrounding from 2004 to 2010 with the exception of 2009. This data is obtained from National Meteorological Agency of Ethiopia in May 2012. The average annual rainfall from 2004 to 2010 revealed 1043.47mm, this amount of rainfall as compared to the adopted evaluation criteria is lies in the relative value of good(3). Therefore, the area is good for landfill development based on its annual rainfall distribution.

4.1.3 Groundwater Flow Direction

The sites have to be evaluated as per the distance of downstream flow. The relative value scales have been developed for ranking the sites represented in table 1.

Table 1. Evaluation parameters of Hydrology, Hydrogeology and geology

Evaluation (Relative Value)	Distance from surface water (Km)	Annual Rainfall (mm / Yr)	Distance in downstream (Km)	Soil Permeability Evaluation (1 x 10 ⁻⁶ cm / sec)
Excellent (5)	> 5	< 250	> 5	< 0.1
Ideal (4)	5 - 3	250 - 800	5 - 3	0.1 - 1
Good (3)	3 - 2	800 - 1500	3 - 1	1 - 10
Poor (2)	2 - 1	1500 - 2500	1 - 0.5	10 - 100
Bad (1)	< 1	> 2500	< 0.5	> 100

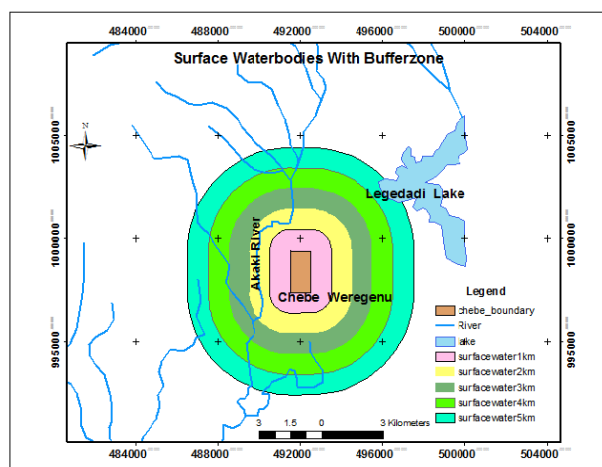


Fig. 2. Surface Water Bodies with Buffer Zone.

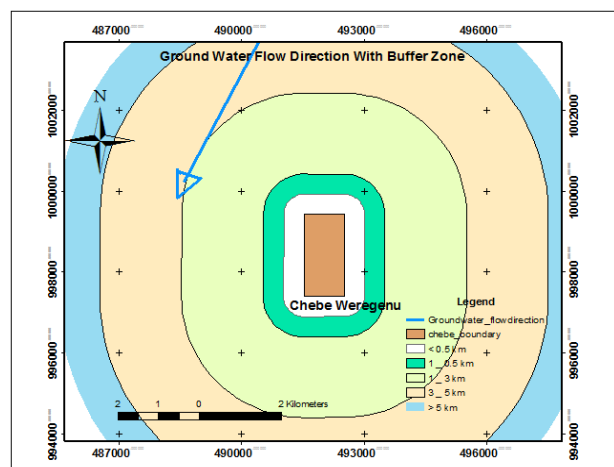


Fig. 3. Ground Water Flow Direction with Buffer Zone.

Based on the adopted evaluation parameter the ground water flow direction as it shown on the Fig. 3, it lies between 3 – 5 km buffer zone. Therefore, it is an ideal (4) position according to the evaluation relative value.

4.1.4 Soil Permeability

The landfill site consists mainly of two soil types of which the vertisols occupy almost the whole part. Landfill should be located where the soil does not allow excessive seepage into groundwater. In an ideal condition, the permeability of the soil should be about 1×10^{-7} cm/sec. The scales have been developed for ranking the sites from permeability of the subsoil represented in Table 1.

The soil permeability of the landfill site is 0.007 cm/sec (Source: Addis clean project phase III). This result according to the evaluation criteria is excellent (5). Therefore, the site has an excellent soil for development of landfill.

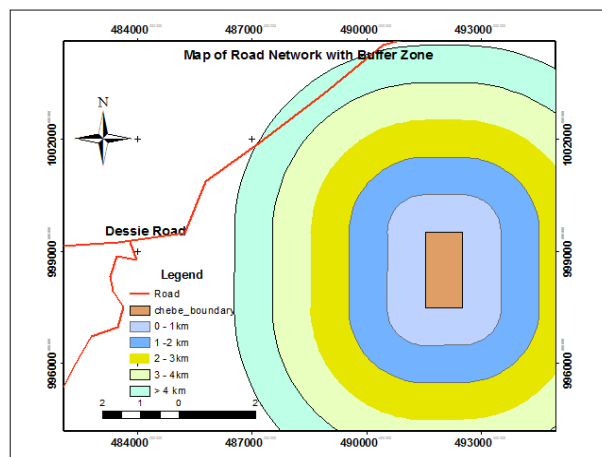


Fig. 4. Map of Road Network with Buffer Zone.

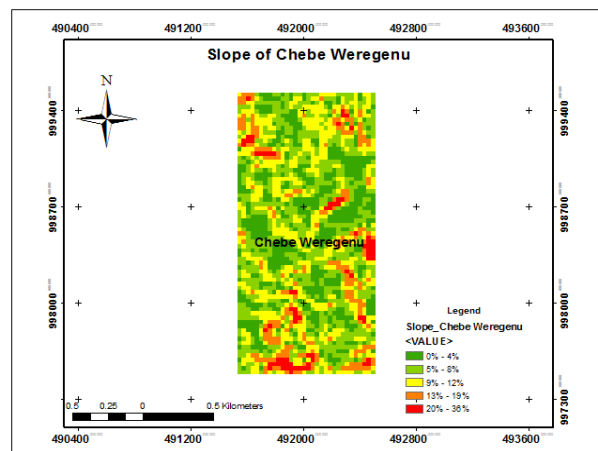


Fig. 6. Slope of Chebe Weredu.

4.2 General information

4.2.1 Distance from Road Network

The road network is an important factor to locate a landfill site. The evaluation Parameter for road network shown in Table 2.

As it is shown on the Fig. 4 the site is situated within > 4 km buffer zone from the closest road network hence it is rated as poor (2) according to the evaluation criteria. Zeinhom El Alfy et al., 2010, quoting in international guidelines for landfill siting has indicated that the suitable distance from road network is within 1000 m buffer.

4.2.2 Distance of the Site from the Transfer Stations

The transportation of waste from the source of waste generation to the disposal site is one of the important factors in order to decide the economic location of site. So the sites for this evaluation have to be given relative value from

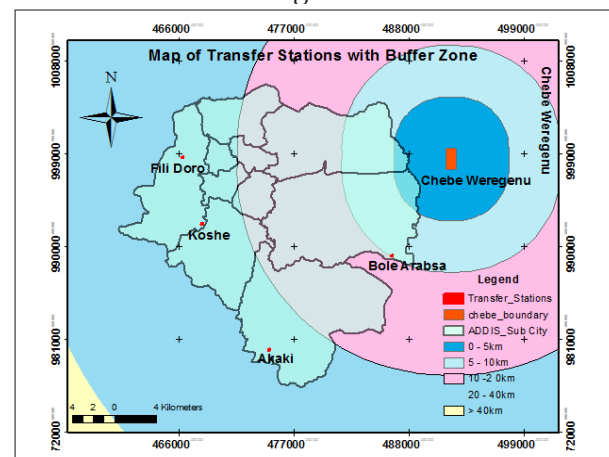


Fig. 5. Map of Transfer Stations with Buffer.

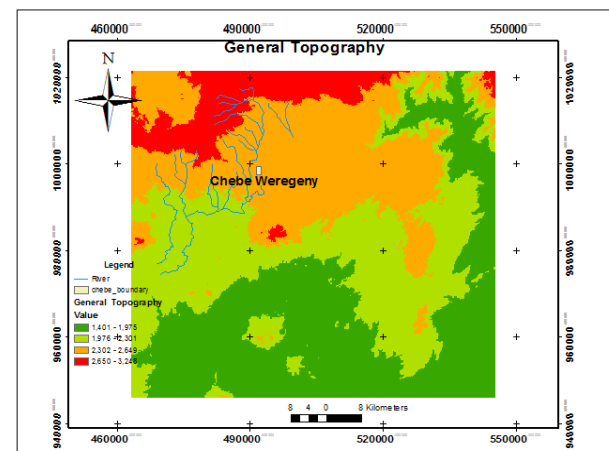


Fig. 7. General topography of the landfill surroundings.

Table 2. Evaluation parameters of General information

Evaluation (Relative Value)	Distance from road networks (Km)	Distance from transfer station (Km)	Scale (Slope %)
Excellent (5)	0 - 1.00	0 - 5	1.5
Ideal (4)	1.00 - 2.00	5 - 10	1.5 - 2.5
Good (3)	2.00 - 3.00	10 - 20	2.5 - 7.0
Poor (2)	3.00 - 4.00	20 - 40	7.0 - 15
Bad (1)	>4.00	> 40	> 15

5 to 2 corresponding to excellent to poor as per their distance from the source of generation (Table 2).

As it shown on the Fig. 5 the concentric circles from outside to inside are indicating the buffer distance of the transfer stations from the site boundary. Bole Arabsa is the only ideal site while Akaki, Fili doro and Koshe are rated poor according to the adopted criteria. Generally, based on the evaluation criteria the location of the transfer stations to the landfill site is too far hence they rated as poor.

4.2.3 Slope Percent of the landfill

Basak Sener, 2004 quoting in Wilson, 1977, the topography of an area is an important factor on site selection because it has important implications for landfill capacity, drainage, ultimate land use, surface and groundwater pollution control, site access and related operations. The scales have been developed for evaluating the slope percent of the sites represented in Table 2.

The slope Fig. 6 shown above is obtained from Aster DEM and hydrological fill has been carried out after this projected to WGS 1884 UTM Zone 37. The output value of the slope is stated in percentage and then reclassified in to 5 natural break (jenks). The mean value of the slope is 7%. Slope with 7% is suitable for landfill development according to the adopted evaluation criteria.

4.2.4 Topography

In general the site topography is to be convex in relation to the surrounding so that the rain-water is drained away from the site naturally. The general topography of the landfill site as it shown on the topographic Fig. 7 above revealed even slope. Therefore, it is rated as good for landfill development according to the adopted evaluation parameters.

4.3 Socio-economic conditions

4.3.1 Existing Land-use

The landfill site is known for its teff production. Teff is a dominant cereal crop which occupies about 45% of cultivated land and followed by wheat 43%, chickpea 5% and others occupy 7% (Fig. 8). Less the economic importance of the site is more suitable of the site for landfill development. Table 4 shows scales that have been developed for ranking the sites from existing land-use.

The landfill site is used for cereal crop production. Therefore, the area based on the adopted evaluation criteria valued good for landfill development. This is because the site dominated by single crop production.

4.3.2 Distance from Residential Area

Population settlement is important factor in choosing the landfill sites. Basak Sener, 2004, landfills may not be constructed on sites within a distance of less than 1000 m to settlements

Table 3. Evaluation parameters of Socio- economic

Evaluation (Relative Value)	Existing Land use	Distance from residential area (Km)	Distance from airport (Km)
Excellent (5)	Wasteland / Saline	> 5	> 5.00
Ideal (4)	Grazing / Fallow	5 - 2.5	3.00 - 4.00
Good (3)	Single Corp / non-irrigated	1.0 - 2.5	2.00 - 3.00
Poor (2)	Double Corp / irrigated	0.2 - 1.0	1.00 - 2.00
Bad (1)	Plantation	> 0.2	< 1.00

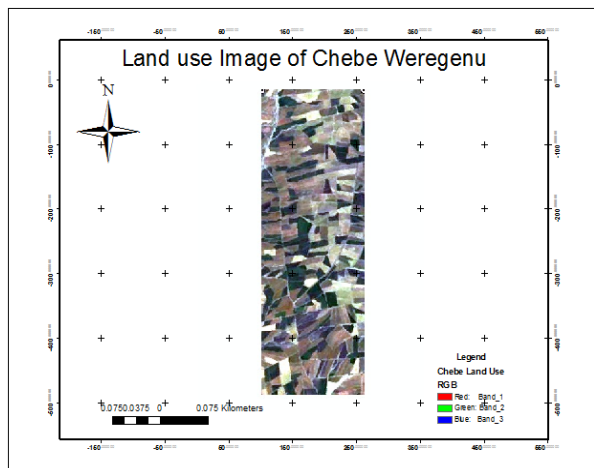


Fig. 8. Land use Image source: Google Earth 2012.

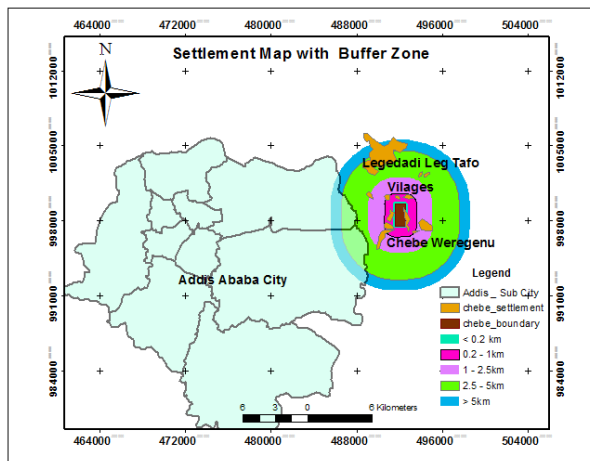


Fig. 9. Settlement map with Buffer Zone.

according to regulation on solid waste control in Turkey. For this reason, the population of villages within 5 km radius and their distances from the site has to be considered (Table 3). As it shown on the Fig. 9 below there are a number of small villages in and surrounding the landfill

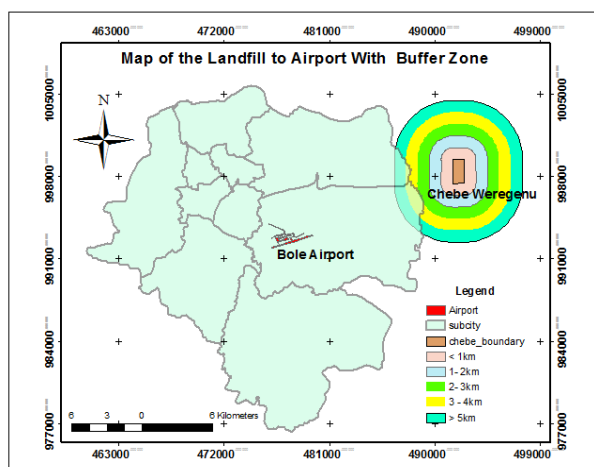


Fig. 10. Landfill to Airport with Buffer Zone.

that account for almost 8 villages within the buffer zone of less than 1km. Therefore, based on the evaluation criteria the area is rated as poor (2).

4.3.3 Distance from Air port

The presence of birds is a real danger for airplanes. Because birds are attracted especially by organic waste, landfills should be located at a certain distance from airports (Fig. 10). The evaluation scale has been set in regard to the safety of the aviation industry shown in Table 3. Hence, it is rated as excellent according to the evaluation criteria.

4.4 Summary

The weight of percentage are hydrology and geology weighting (50%) of the total criteria, general information (25%) and socio - economic (25%).

The sum of the relative value in each section is calculated on the bases of cumulative rating. For instance, the sum of the relative value for Hydrology, Hydrogeology and Geology is 14 and percentage weight is 50% while the sum of the relative value for general information and socio - economic each is 10 and their weight of percentage is 25% each.

Therefore, Cumulative Rating = 50% of the sum of the relative value of hydrology, hydrogeology and geology + 25% of the sum of the relative value of general information + and 25% of the sum of the relative value of socio-economic

Cumulative Rating = 50% of 14 + 25% of 10 + 25% of 10 = 7 + 2.5 + 2.5 = 12

Final Relative value = $12/5 = 2.4$ (divided by 5 as it has to be scaled on a scale of 5).

Based on the adopted evaluation scale the final result will fall into good class. Therefore, the site is suitable for landfill development.

Conclusion

This study is focused on appropriate site selection for land filling is a problem in waste management. This location must comply with the requirements of governmental regulations, adopted guidelines and at the same time must minimize economic, environmental, health and social costs (Zeinhom El Alfy et al., 2010). The transportation of waste from the source of

waste generation to the disposal site is one of the important factors in order to decide the economic location of site (CPCB, 2003).

The study revealed that the GIS software is a powerful element for decision makers to make important decision like accepting and rejecting the already selected sanitary landfill sites. Besides, the adopted evaluation parameter has also equal importance to the GIS software for this project work. As a result of this Chebe Weregenu sanitary landfill has got good in the redefined relative value and therefore, the site is good for the development of landfill site.

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Methane Gas Potential from Municipal Solid Waste for Vehicular Use

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Keyword: *Municipal Solid Waste, Anaerobic Digestion, Methane Gas, Vehicular Use, Sustainable Development*

Abstract: In recent years, there has been a steadily increasing in the amount of municipal solid waste due to the increasing human population and urbanization. Since the generated MSW represents a loss of both raw materials and energy resources, it is necessary to improve MSW management system. The purpose of this study is to propose the integrated MSW management system. The system has achieved the intended aim of reducing the amount of landfill, increasing waste recycling, production of methane gas and reducing Green House Gas emissions in atmosphere. The average amount of municipal solid waste generated in Coimbatore Corporation is around 850 Tonnes and bio-degradable waste is 510 Tonnes per day. The treatment technologies such as conversion of MSW to refuse derived fuel, composting in an anaerobic digester and other waste to energy options, the results were very encouraging. MSW input the usage of anaerobic digestion combined with fuel cell for methane gas conversion to vehicular use. Methane gas can be used in automobiles after its purification. Removing CO₂, H₂S and water vapour and compressing it into cylinders makes it easily usable for transport applications such as three-wheelers, cars, pick up vans and etc. Waste-to-energy technologies convert municipal solid waste matter into various forms of fuel that can be used to supply energy. It is environmental friendly and sustainable development in the study area. Generation of Waste to Energy technologies is emerging which hold the potential to create renewable energy from waste matter. This analysis will give better solution to the existing problem in Municipal Solid Waste Management in Coimbatore Corporation.

Introduction

Rapid population growth, industrialization and urbanization have inflamed the problems associated with management of municipal solid waste. Ineffective and inappropriate solid waste management is responsible for numerous problems such as environmental pollution, low level of sanitation, unhygienic living conditions etc. The improper handling of municipal solid waste during its collection, storage and transportation poses serious environmental and public health effects (Edolmann, 2004). Megacities concentrate large amounts of people, absorb a large quantity of resources and generate vast amounts of waste and sewage, thereby contributing considerably to the use of the environment as a sink. Bani et al. (2009) have explained the development of decision support system for waste management a review integrated with Geographical Information

System, able to give robust prediction despite the inherent uncertainties of waste generation and gives optimal allocation of waste stream for biogas production, recycling, incineration, landfill and composting. Wilkie (2005) has explained the application of anaerobic digestion for waste treatment produces significant benefits that include both energy production and energy conservation. The production of biogas from solid waste materials for using as a fuel source succeeds anaerobic digestion as a sustainable technology for renewable energy source. Chaiprasert (2011) surveyed that the status and potential of biogas production and utilization from biomass and agricultural wastes through anaerobic digestion, the existing biogas technology and biogas utilization, driving forces, and future perspectives in Thailand. Gunasekaran and Ganesh (2008) investigated that the village-wise estimation of biogas energy potential and power generation

from poultry droppings through anaerobic digestion in Namakkal taluk, Tamil Nadu, India. Biogas energy is a clean, pollution free and renewable source of energy. The method of generating electricity from biogas resources is one of the most effective ways to reduce global warming emissions. Chaya and Gheewala (2007) explained that life cycle assessment was performed to evaluate environmental impacts of municipal solid waste to energy schemes currently practiced in Thailand: incineration and anaerobic digestion. Fobil et al. (2005) have explained a study was undertaken in Accra, Ghana, to explore the potential for utilizing municipal solid waste for energy generation in a low income economy and at the same time, address worsening MSW problems in the major cities. Habib et al. (2013) investigated Municipal Solid Waste Management sector has developed considerably during the past century, paving the way for maximum energy recovery and minimizing environmental impacts such as global warming associated in the municipality of Aalborg, Denmark. Kalantarifard and Yang (2012) estimated that the methane gas and carbon dioxide production by LandGem model from Tanjulangsat, municipal solid waste landfill in Malaysia. Methane and carbon dioxide are the major constituents of landfill gas and greatly contribute to the greenhouse effect (Rodica et al. 2006). Kapdi et al. (2005) have explained that biogas is produced by anaerobic digestion of biological wastes such as cattle dung, vegetable wastes, sheep and poultry droppings, municipal solid waste, industrial waste water, land fill, etc. generated huge quantities of compressed methane, a gas with an immense potential and an alternative source of vehicle fuel. Gunasekaran and Ganesh (2011) estimated that the enriched biogas potentials generating from poultry litter through anaerobic digester in Puduchatiram block for production of Bio-CNG to substitute compressed natural gas using in automobile and transport applications. Vijay et al. (2006) have explained the natural gas has 75 to 98% methane with small percentages of ethane, butane, propane while biogas has about 60% methane and 40 percentage carbon dioxide. Biogas can be used in automobiles after its purification. Removing CO₂, H₂S and water vapour and compressing it into cylinders makes it easily usable for transport applications such as three-wheelers, cars, pick up vans and etc. It has lower emission than natural gas and

diesel. Biogas traffic use results in very low emissions of SO₂, NO_x, particles and noise. Taking these into account, the present study is to make ward-wise estimation of enriched methane gas potential from municipal solid waste in Coimbatore Corporation, Tamil Nadu.

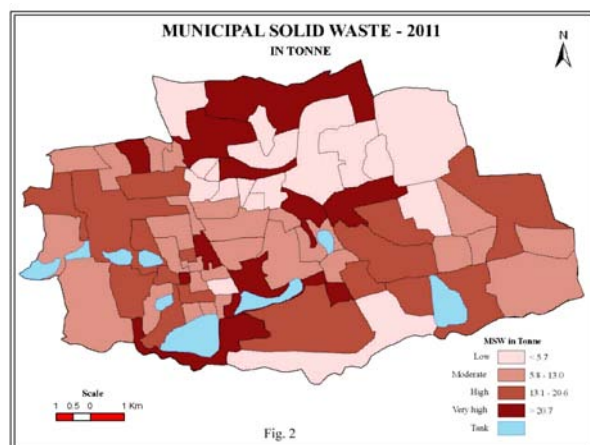
Study area

Coimbatore Corporation is located between 10° 58' and 11° 4' North latitudes and 76°54' and 77° 4' East longitudes (Fig.1). It is located in the northern part of the Coimbatore district at an elevation of 440 m. Municipal Corporation manages delivery of services in 72 wards within corporation limits, covering an area of 105.6 sq.km. As it is exposed to the Palghat gap of the Western Ghats, it enjoys a salubrious climate. The temperature during both summers and winter varies anywhere between 37°C to 25°C. The average normal rainfall of Coimbatore is 623 mm. Major tanks and number of smaller tanks are located in Coimbatore Corporation. The population of the city is 13 lakhs (2011) including a floating population of around 1.5 lakh. Coimbatore is well known for its textile industries and has excellent potential for industrial growth. It has attracted the rural people of the district including the neighboring districts for excellent employment opportunities. Coimbatore City is well connected with other parts of the country by air, railways and an excellent road network. The City is divided into four Zones namely, North Zone, South Zone, West Zone, and East Zone. The average amount of municipal solid waste generated in Coimbatore Corporation is around 850 Tonnes per day.

Material and methods

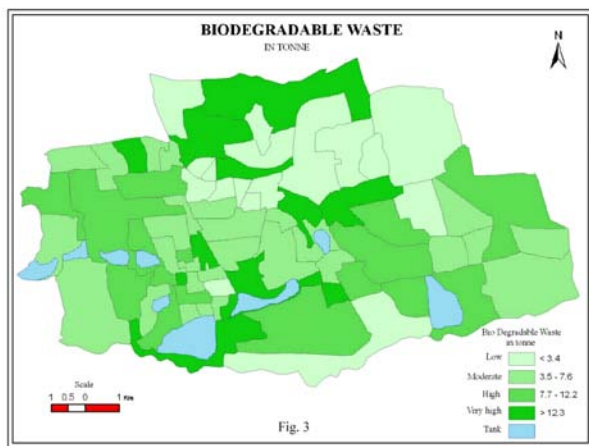
The present investigation is mainly based on secondary data. Data on population and municipal solid waste ward wise data (2011) and base map was collected from the Coimbatore Municipality Corporation. Simple statistical techniques are used to calculate percentage of population distribution, municipal solid waste, biodegradable waste, estimation of methane gas and estimation of bio-CNG resource and suitable cartographic techniques are used to map the same, so as to make a spatial analysis municipal solid waste. In the present investigation the statistical analysis is done using Microsoft Excel® package. The investigator used ArcGIS 9.1® has drawn the maps.

A total population of 13,00,000 persons (2011) is spread over an area of 105.6 square kilometers. Ward wise percentage of spatial distribution of population analysis indicates that, about five wards is having very high population of more than 2.1 percentages. High level population is 1.5 to 2.0 percentages in twenty five wards. Population is moderately distributed in 1.1 to 1.4 percentages in twenty seven wards. Remaining fifteen wards is having low level population distribution. This increasing pressure of population in Coimbatore



The amount of municipal solid waste generated in Coimbatore city has been increased dramatically during the past several years. Disposal of solid waste is by open dumping in Vellalore dumping yard. The waste generated per day within the city is of the order of 850 tonnes per day. The ward wise spatial distribution of Municipal Solid Waste analysis indicates that (Fig. 2) the very high amount of solid waste more than 20.7 tonnes per day is presented in eleven wards. The quantity of waste is higher in 13.1 to 20.6 tonnes per day distributed in fifteen wards. The solid waste is moderate in 5.8 to 13.0 tonnes per day collected in twenty eight wards. Low level of Municipal Solid Waste less than 5.7 tonnes per day is presented in eighteen wards. This study clearly indicated that the population concentrated wards are generated maximum amount of Municipal Solid Waste.

Biodegradable waste is a methane gas resource presented more than 60 percent of the total Municipal Solid Waste. The total quantity



of biodegradable waste is 510 tonnes per day (Fig.3). Very high level more than 12.3 tonnes per day is in eleven wards. The Collection of bio degradable waste is high level in (7.7 to 12.2) in fifteen wards. The quantity of bio degradable waste is moderate level (7.6 to 3.5) in twenty eight wards. Low level quantity of biodegradable waste less than 3.4 tonnes per day is available in eighteen wards. From this observation where is the population is highly concentrated wards are producing more amount of Municipal Solid Waste. Therefore the Coimbatore Corporation total quantity of biodegradable waste is 510 tonnes per day. This quantity may be converted in to methane gas and organic manure through anaerobic digestion for sustainable development in Coimbatore Corporation.

Methane gas is a product of anaerobic fermentation of organic matters. The input materials for the methane gas materials for anaerobic digesters are the wastes that are found locally such as biodegradable Municipal Solid Waste. The MSW are introduced into a

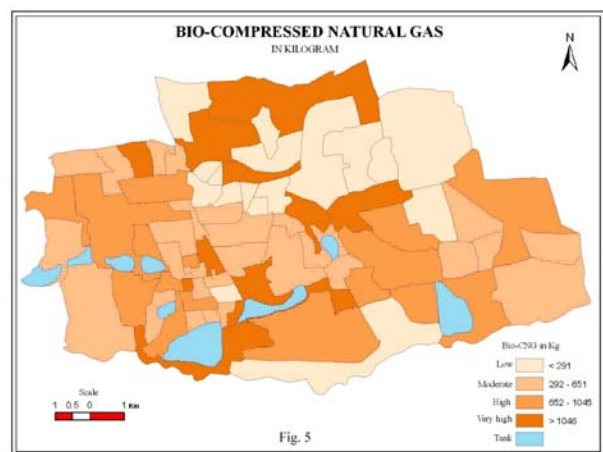
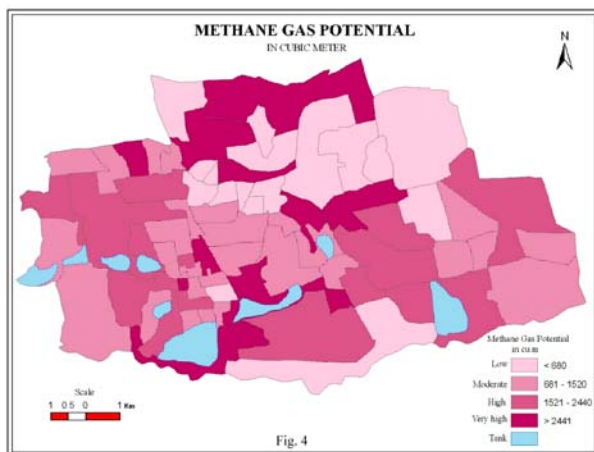
closed digester without the presence of free oxygen. It is estimated methane gas potential that

Coimbatore Corporation can produce 1,02,120 cu.m per day (Fig. 4). In eleven wards are having very high level of potential in more than 2441 cu.m per day. Fifteen wards estimated high level methane gas between 1521 to 2440 cu.m per day. The moderate level of methane gas distribution in twenty eight wards between 681 to 1520 cu.m per day. In eighteen wards are estimated less than 680 cu.m per day.

Compressed Natural Gas

Methane gas can be used in automobiles after its purification. It consists of around 60 to 70 percentage of Methane, 30 to 40 percent Carbon dioxide and traces of nitrogen, sulphur and moisture. Removing CO₂, H₂S and water vapour through Scrubbing Technique and compressing it into cylinders makes it easily usable for transport applications such as three-wheelers, cars, pick up vans and etc. The present status of the enriched methane gas potential 61,272 cubic meter per day is assessed.

Assuming that one cubic meter of enriched methane gas may produce 0.714 kg of compressed methane gas, it is estimated that biodegradable Municipal Solid Waste in Coimbatore Corporation may produce about 43,748 kg methane gas per day. In eleven wards estimated very high level in more than 1046 kg per day (Fig. 5). Fifteen wards estimated high level bio-CNG between 652 to 1045 kg per day. The quantity of compressed methane gas is moderate level (292 to 651) in twenty eight wards. Eighteen wards estimated less than 291 kg of compressed biogas per



day. This technology ensures reducing Green House Gas emissions, sustainable development, energy security and employment generation in Coimbatore Corporation, Tamil Nadu.

Conclusion

Today's idealists promote "zero waste" as a solution and we should reduce, reuse and recycle as much as possible. But zero waste is a practical impossibility. Rather, "zero disposal" should be our goal. We must make waste to energy conversion a priority in order to best protect our environment and conserve our energy resources. Municipal solid waste is a low-cost waste and methane gas resource. It is making it a potentially attractive renewable feedstock for energy conversion. The Anaerobic Digester gasification process offers considerable energy recovery and reduces the emission of potential pollutants. It is considered an interesting alternative to the conventional technology for the thermal treatment of solid wastes. A well designed AD fosters sustainable development since it recovers energy thus reducing fossil fuel use and reducing greenhouse gas sources. There is large potential of enriched methane gas potential 61,272 meter cubic per day and compressed methane gas potential 43,748 Kg per day available in Coimbatore Corporation, Tamil Nadu, India to make it an alternate fuel for vehicle. To conclude, while great strides have been made, and remain to be made in recycling in Coimbatore Corporation, waste as a fuel to produce bio-CNG is yet another form of recycling and reducing Green House Gas emissions.

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Remote Sensing Data for Coastal Mapping & Management: A Powerful Tool - A Case Study

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Abstract: The coastal mapping is very complex and fragile in nature because of the sea which keeps on changing its shape and position due to dynamic environmental conditions. The continuous change in the shore line, deforestation and coastal erosion has not only changed the ecosystem of that region but also has invited many more hazards in the last few decades. Therefore, proper coastal mapping & management system may be thought in the light of vulnerability of the coast to the multi hazard situation. Monitoring changes in shore helps to identify the degree of changes, to assess the human impact and to plan management strategies. The author carried out few case studies along Orissa East Coast using Quick Bird Imageries (0.6m) and attempted to find out the changes on Shoreline, river mouth, wetland and costal geomorphology etc. by comparing maps on 1:50,000 Scale during the period 1972- 2010. The changes due to developmental activities as well as natural processes have clearly been brought out. Further from the present study it can be concluded that high resolution satellite data can be an ideal solution for coastal mapping for periodic review and better planning. It is proposed to use the finer resolution data as very valuable input source for large scale coastal mapping and updating as well in modern mapping arena. Studies further revealed that there are many shortcomings in the existing planning and measure taken by the administration. Only little care has been taken by the administration for safe guarding coast. Therefore, change in coastal line is very alarming condition at both the sea coast. At the end few suggestions have been given for further damage to ecosystem and habitats along the coast.

1. Introduction:

The coastal zone is a dynamic area, prone to natural change. Moreover the increasing population, developmental activities has not only added and pressure on costal land but also has deteriorated the ecosystem of coastal area further more. Though costal area covers less than 15% of the Earth's land surface but it accommodate more than 50% of the world population which needs proper planning to safe guard the coast as well as the habitats and eco system and also from the natural hazards. Moreover, Indian coast is more populated than that of other developed countries. (In one mile 500 people lives). India with a vast coastline of 7,500-km spread over 9 coastal states forms an important economic zone and has lot at stake. More over total 77 cities lie near the coast line including some very important port towns and cities such as Mumbai, Kolkata, Chennai, Cochin, Visakhapatnam, Chandipur,

Paradip and Digha etc. The influence of tides and coastal geomorphology of the East and West Coast of the country is determined by the physical and climatic factors of the central Indian Ocean region. The coasts of India comprise a wide variety of diverse habitats and ecosystems from coral reefs, mangrove swamps, creeks, back waters etc.

2. Why Coastal Mapping

As the existing topographical maps on 1:50,000 / 1:25,000 scale do not reflect the land utility and other coastal flora and fauna to the fullest extent by virtue of the scale, so special design coastal mapping is needed, which can allow to register the potential impacts of climate change and the future for the coastline to be communicated to decision makers and planners to safe guard the coast line and human population and ecosystem in general. The magnitude and rate of change

may be increasing and certain areas will be more vulnerable to climate change than others. The above coastal maps would provide a new perspective and improved understanding of the changes in patterns of risks that may be anticipated along the coastline.

3. Effect of Climatic Change

That the climate change impacts will include sea level rise, increased winter rainfall and more intense and damaging storms a growing threat for many coastal communities already affected by coastal erosion, flooding and instability, and an increasing challenge for the local and regional authorities. Therefore Climate change is a serious and long-term challenge that has the potential to affect every part of the world. Adaptation to the effects of climate change due to both natural and manmade factors is a high-priority for all nations.

Man made factors

A certain amount of climate change is due to the greenhouse gases and air and water pollution from factories. The potential impacts of climate change and sea level rise present a significant challenge to future coastal management and communities. Therefore a comprehensive master plan is must to adapt this challenge. It is anticipated that additional pressures on a variety of coastal zone uses, from tourism and amenity uses, marine aggregate extraction, port and harbor operations etc. other factors responsible for climate change.

Natural factors

All the coastal states and Union Territories of India are to some extent affected by coastal

erosion. About 1,500 km or 26% of the mainland coastline faces serious erosion problems and much of the coastline is actively retreating. Many of the coastal protection strategies employed have been ineffective in that coastal properties and investments remain threatened by erosion, particularly during the monsoon seasons. Furthermore, the extensive use of rock protection structures has contributed to the degradation the beach and the social environment of the coastal zone. Sea level rise in the Indian subcontinent is projected to be between 15 cm and 38 cm by the middle of the 21st century.

4. Coastal Hazard & Disaster

- Hazards pose a threat to a community
- Disasters cause destruction

Coastal Hazard and its impact

India's coastline is highly vulnerable to ecological and geological hazards and hazard line broadly means the maximum distance a wave can reach to shore. The line would be drawn keeping factors like the change in shoreline, high and low tide reach and distance of waves travelled over a period of time and seasons etc. Once hazard line is marked, people who live in the hazard prone can be evacuated to safer zone before any calamities happen. Major factors responsible for coastal hazards (Fig. 1) are Hurricanes, Coastal erosion, Tsunami, Flooding, Drought etc.

If we consider and analyse the global disaster, the graph shows the clear picture about the intensity of disaster mainly Asian and undeveloped countries (Fig. 2).

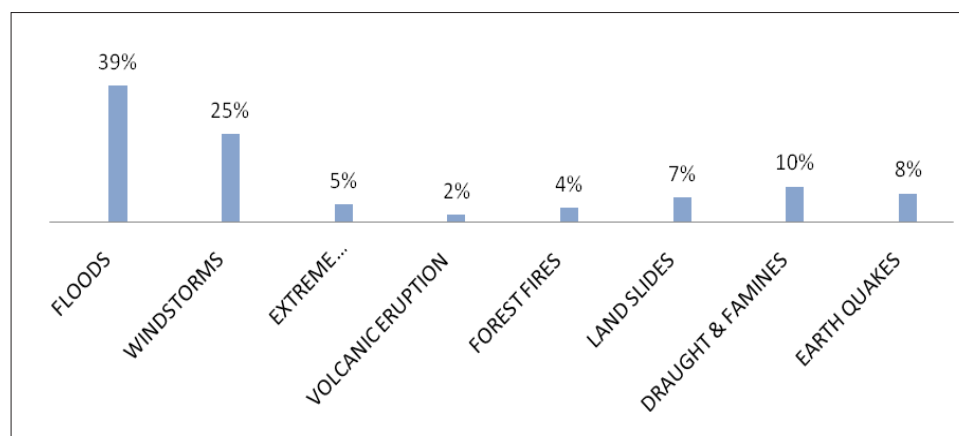


Fig. 1 global natural hazard during the year 1992- 2012.

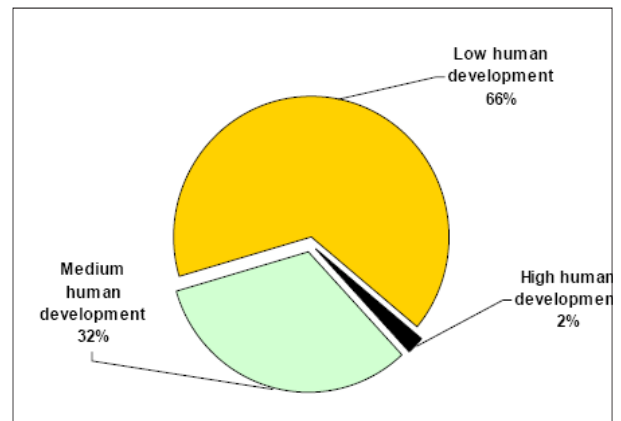
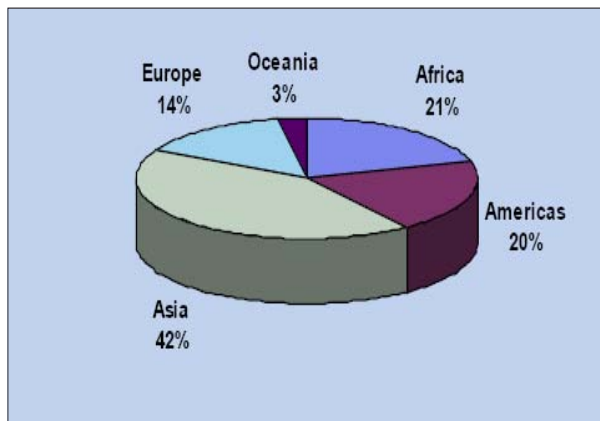


Fig. 2 Global Disaster during Loss of life during 1992 to 2012

Other common factors for Coastal hazards

- (i) High density development of urban and suburban coastal zones
- (ii) Disruption and degradation of environmental pathways from watersheds to the sea (e.g., coastal dune and wetland filling, stream channelization, disrupted sediment flux)
- (iii) Weakened environmental carrying capacity (e.g., inadequate sewage disposal, shore face ecosystem degradation and wetland boundaries)
- (iv) Exhausted natural resources (e.g., over-pumping of coastal aquifers, over-fishing, shore face mining, depleted sediment budgets).

5. The Role of Remote Sensing Data

High resolution satellite data plays a crucial role in costal mapping and updatation. In India, remote sensing data, especially Indian Remote Sensing (IRS) data, having moderate 23m to high spatial resolution 1m, have been used to generate database on various components of coastal environment of the entire country. However, the moderate resolution data provide macro-level information on 1:250,000 and 1:50,000 scale about the condition of habitats, type of landforms and areas under erosion and deposition. The major advantage of remote sensing data is monitoring of change periodically. The classification accuracy one can achieve up to 85 per cent or better. Various zones of coral reef could be identified; however, species level information is not possible to generate using such type of data. The knowledge about bio-optical properties of water is vital for coral reef

and sea grass bed monitoring. The OCEANSAT I (IRS P4) data provides useful information on the phytoplankton and suspended sediments. The information on phytoplankton and sea surface temperature (SST) has been used to predict potential fishery zones routinely.

1. STUDY AREA:

The study area falls under Sheet No.73 O/10, Chandipur of Orissa State. The coast has a great significance in the world map due to strategic defense point and tourist place.

87° 0', 21° 30' & 21° 15', 87° 15' Part of Sheet No. 73O/3



Another study area is Digha of West Bengal State, where it has great significance due to tourist and fishing activities. The study area falls under Sheet No.72 O / 10

Upper Left - 87° 30', 21° 45' Part of Sheet No. 72 O/10



Lower Right - 21° 30', 87° 45'

2. Objectives

The main objective is to study shore line change and river mouth sedimentation and developmental activities and its impact on costal area between the years 1972 to 2010.

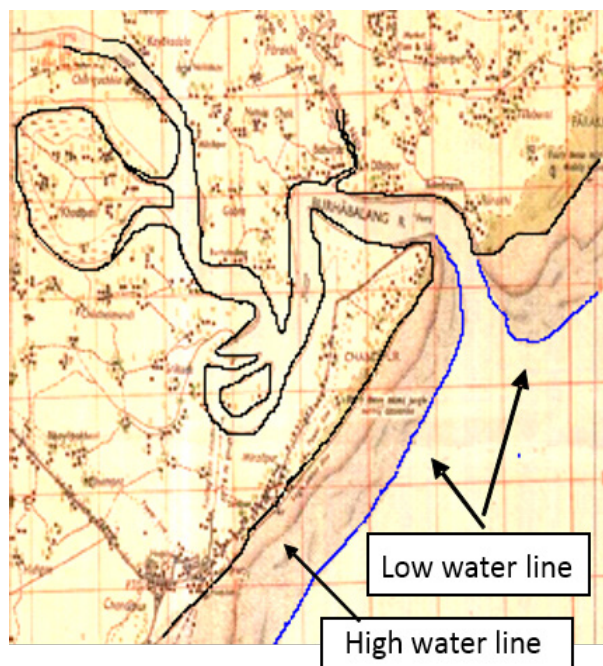
3. Input, Hardware and Software used

1. Topo Sheets of 72 O/3 & 73 O/10 ,Edition 1969-70
2. Open map series map of F 45 P3 of Chandipur, Edition 2009
3. Quick Bird Imagery of year 2010
4. High end Computer
5. Erdas Imagine 9.2 software

Georeferencing of all the Topo Sheets were done using ERDAS Imagine Software and thereafter Satellite Imagery were georeferenced with respect to georeferenced map. Changes were classified by hybrid approach using supervised and visual interpretation methods to derive the change detection of the above sheets of area of interest.

4. Result and Discussion

Case 1: Different year of Topo Sheets of Chandipur area were taken for comparison and latter with Quick Bird Imagery.

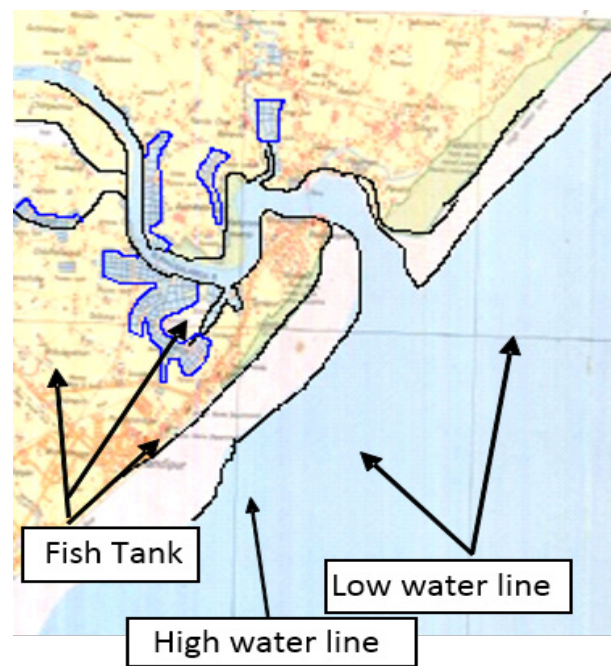


Topo Sheet of year 1969-70

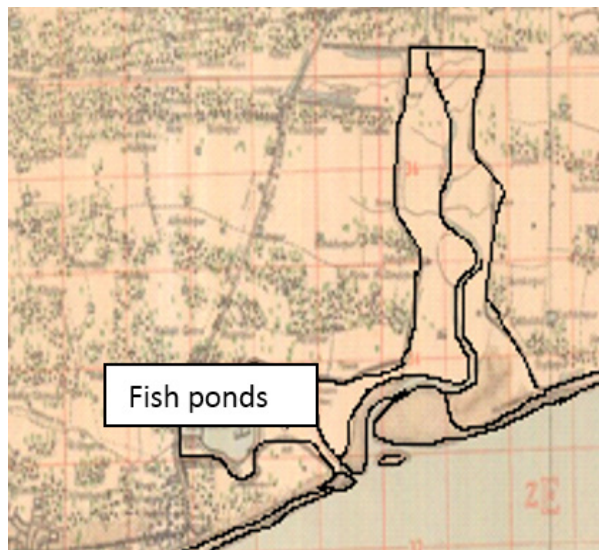
Topo sheet during the year 69-70 does not show any fish pond, but lot of ponds have been established in Topo sheet of year 2009 and Imagery of year 2010 by cleaning the natural habitats. There is a change in low and High water line during last 40 years. In imagery there is a formation of Island near river mouth due to sedimentation. Deforestation shows very clearly in Imagery, even low and high water line is very close in compare to maps.

Case 2: In this case Digha area of Topo Sheet and Quick Bird Imagery were taken for comparison.

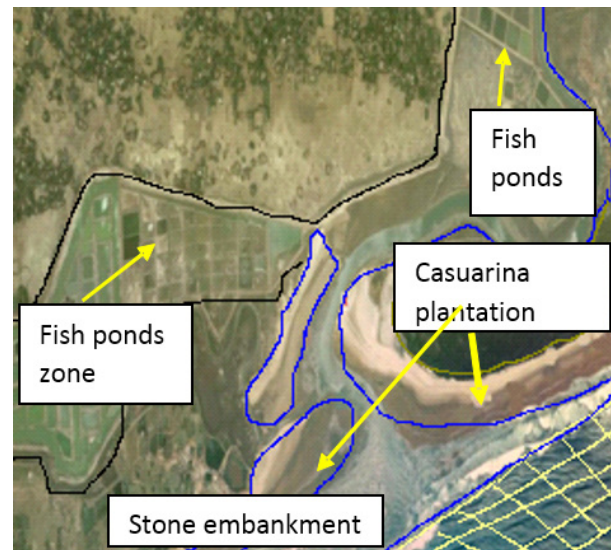
- (i) Earlier fish ponds were very few in nos. as shown in Map (1968-69) but in the Imagery of year 2010, nos. has increased in many folds.
- (ii) The stone embankment along the coast has deteriorated the river mouth area and high water line has gone further inside the land mass.
- (iii) Casuarinas plantation has stopped the further coastal erosion at some places.
- (iv) Large scale fishing activities has cleaned the natural sand dunes at the shore.
- (v) Large scale deforestation has affected the coastal soil degradation at many places of the coast.



Topo Sheet of year 2009



TOPO SHEET OF YEAR 1968-69



QUICK BIRD IMAGERY 2010

DIGHA COAST OF WEST BENGAL

5. Suggestion & Recommendations

- (i) Mangroves are lifeline to coasts as it has potential to minimize damage during natural calamities and stop soil erosion and also can capture carbon particle which restrict the climate change. Therefore emphasis should be given for conservation and restoration.
- (ii) Special attention should be given for conservation of vital & critical habitats such as coral reefs, sea bed grass etc.
- (iii) Reclamation of wetland for agricultural and industrial purposes
- (iv) In high erosion area, buffer zone of 10 km on both sides should be planned for new forestation.
- (v) Identification of vulnerable areas including eroded areas should be restricted for developmental activities.
- (vi) Mapping & monitoring coastal erosion regularly using high resolution satellite Imagery.
- (vii) Emergency response plan to be made for natural disasters such as cyclones, sea level rise, or anthropogenic activities such as oil spills.
- (viii) Coastal mapping should be done on large scale (1:2000 Scale) with low and high tide area demarcation and special coastal features should be shown as special category.
- (ix) In order to ensure sustainable development, it necessary to develop accurate, up-to-date and comprehensive scientific databases on habitats, protected areas, water quality, environmental indicators and carry out periodic assessment of the health of the system. The modern scientific tools of remote sensing, GIS and GPS are extremely valuable in development of databases and to analyse them in the integrated manner and derive management action plans.
- (x) Appropriate site selection should be marked for industries, aquaculture, recreational activities, etc.

Conclusions

Studies carried out in the above selected areas have revealed that there are many shortcomings in the existing planning and measure taken by the administration. Only little care has been taken by the West Bengal administration for safe guarding only the sea beach at Digha only. Therefore, change in coastal line is very alarming condition at Digha. The new city developed at the very close to coast may go inside the sea if proper measure has not taken at the earliest. Similarly defense experiment at Chandipur, Orissa has changed the climatic condition and ecology of the area. Therefore, effective coastal zone management must be initiated not only in planning stage but also proper implementation.

Forest Cover Change Detection using Normalized Difference Vegetation Index (NDVI) : A Study of Reingkhongkine Lake's Adjoining Areas, Rangamati, Bangladesh

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Keywords: Forest Cover Change, NDVI, LandsatTM Imagery, Reingkhongkine Lake, Bangladesh

Abstract: Reingkhongkine Lake is a hilly natural lake in the hill district of Rangamati and is situated in the 9 No. Farua union under Belaichhari Upazila, Rangamati, Bangladesh, which is very close to Mizoram state border, India. It is bounded on all sides by mountain peaks covered with highly dense to moderate natural forest vegetations and thick bamboo bushes. It is a closed, elongated and irregular shaped lake and just nearby in the north-eastern margin there is a high cascading waterfalls along with Jheeri falls into the Reingkhongkine River. Remote sensing technology in combination with geographic information system (GIS) is used to detect the change of forest cover of the areas near Reingkhongkine Lake. For this study Multi-Temporal LandsatTM imageries of the year 1989, 2001, 2003, 2009 and 2010 were used. For vegetation recognition, layer stacking of band (4, 3 and 2) false color composite for TM was performed by using ERDAS Imagine 10 software. Afterwards Multi-Temporal imagery based five individual NDVI Maps (1989-2010) were prepared. The use of the Normalized Difference Vegetation Index (NDVI) was applied to detect areas of forest cover change and also year wise NDVI derived quantitative data were generated and summarized using remote sensing, GIS software and spreadsheet. Finally NDVI derived map of 1989 and 2010 were crossed to generate the change map of vegetation cover and the resultant categories are decreased, some decreased, some increase, and increased. The study reveals that forest cover of the study areas has changed significantly during 1989-2010 due to natural and anthropogenic activities (i.e hill erosion, Illegal forest cutting, jhum cultivation, forest fire, etc.). Out of the total area (2893.59 hectare), decreased category shows 44.40%, followed by some decrease 37.93% and remaining falls under some increase and increasing trend. The area needs special protection because the rate of change is very high (2.02% per year).

Introduction

Bangladesh is a land of beauty and it is blessed with boundless natural objects. Reingkhongkine Lake is popularly known as Pukur para Lake is a hilly natural lake in the hill district of Rangamati. This lake is situated in the 9 No. Farua union under Belaichhari Upazila, Rangamati, Bangladesh. The geographical extent of the study area (Lake's adjoining areas) is in between 22° 0' 0" N to 22° 3' 0" N latitude and 92° 31' 25" E to 92° 34' 25" E longitude. Fig. 1 shows the location of the study area. This lake is a closed, elongated and irregular shaped and just nearby in the north-eastern margin there is a high cascading waterfalls along with Jheeri falls

into the Reingkhongkine River. It is bounded on all sides by mountain peaks covered with highly dense to moderate natural vegetations and with thick bamboo bushes.

The area attracts tourist because of its stunning beauty and surroundings landscape and close attachment to the Indian Mizoram border but it is inaccessible by any means of transport. The authors claim that present research work (NDVI based forest cover change detection) is the pioneer work in the history of of this area.

The use of remote sensing data in recent times has been of immense help in monitoring the changing pattern of vegetation. Change

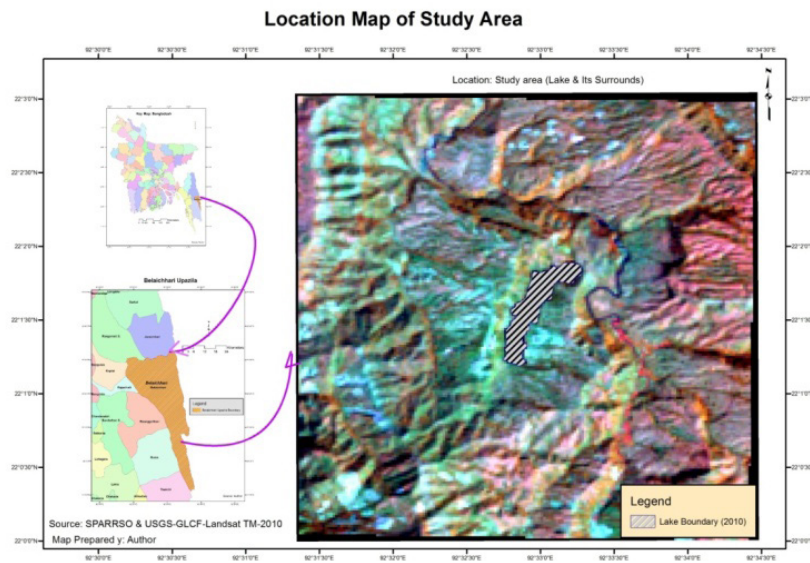


Figure 1: Location Map of Study Area

detection as defined by Hoffer (1978) is the temporal effects as variation in spectral response involves situations where the spectral characteristics of the vegetation or other cover type in a given location change over time. Singh (1989) has described change detection as a process that observes the differences of an object or phenomena at different times.

Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index (NDVI). Data on vegetation bio-physical characteristics can be derived from Visible, NIR and Mid-Infra Red portions of the electromagnetic spectrum (EMS). The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS due to Chlorophyll and other pigment absorption and has high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of green leaf (Campbell, 1987). NDVI can be calculated as a ratio of Red and NIR bands of a sensor system.

NDVI values range from -1 to +1, because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1. Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption quality of water. Bare soil areas represent NDVI values which

are closest to 0 due to high reflectance in both the visible and NIR portions of EMS (Lillesand and Kiefer, 1979, 1994 and 2000). Multi-temporal satellite data effectively improves the temporal attribute and the reliability of multi-data. This paper discusses the methods of change detection of vegetation cover utilizing multi-temporal remotely sensed data.

Objectives

The objectives which are considered for this study are given below:

- Identification of vegetation cover and the spatial distribution
- To produce NDVI and Spatio-temporal change maps
- To analyze the Spatio-temporal change of vegetation cover

Data and Methodology

Multi-temporal satellite data which was acquisition from NASA-Global Land Cover Facility (GLCF) Archive i.e. Landsat (TM) with 30m spatial resolution of different years 02 February 1989, 07 February 2001, 08 February 2003, 06 March 2009 and 05 May 2010 are used in the present study.

Results and Discussion

The remote sensing data is used extensively for large area vegetation cover change monitoring. Typically the spectral bands used

for this purpose are visible and near IR bands. Various mathematical combinations of these bands have been used for the computation of NDVI, which is an indicator of the presence and condition of green vegetation. These mathematical quantities are referred to as Vegetation indices. There are three such indices, Simple Vegetation Indices (SVI), Rational Vegetation Indices (RVI) and Normalized Differential Vegetation Indices (NDVI) (Reddy, M. Anji, 2006). At the regional scales, seasonal weather patterns and green up from logging were the primary driving force of observed increases in NDVI values. It may be said that the vegetation change i.e. positive or negative is mainly due to intense pressure of human population, different economic activities or as a result of anthropogenic activities (Morawitz, Blewett, Cohen and Alberti, 2006).

NDVI calculations using Landsat TM satellite imageries (1989-2010)

Normalized Difference Vegetation Index (NDVI) is used in the present study. NDVI from reflectance images is obtained by mean of channels 3 (0.63-0.69 μm) and 4 (0.78-0.90 μm). The formula for NDVI calculation is shown in equation 1.

$$NDVI = \frac{\text{Band 4} - \text{Band 3}}{\text{Band 4} + \text{Band 3}} \quad \dots \dots \dots (1)$$

Vegetation indices have long been used in remote sensing for monitoring temporal changes associated with vegetation. Soil and rock have a broadly similar reflectance giving NDVI close to '0'. NDVI values little higher than zero, which indicates the presence of vegetation classes, moderate and high values indicate stressed vegetation and healthy vegetation respectively; whereas near zero and negative values indicate non-vegetation class such as water, snow, built-up areas and barren land. Only active vegetation has a positive NDVI being typically between about 0.1 and 0.6 values at the higher end of the range indicating increased photosynthetic activity and a greater density of the canopy (Tarpley et. al, 1984). The following algorithm is adopted to create NDVI map:

- (i) Computation of NDVI values for the entire lake's adjoining areas by conversion of spectral reflectance values into NDVI values.

Conversion of these NDVI values to a scaled channel values by using density-slicing method that measures apparent reflectance to sensor values.

- (iii) Display of image with NDVI and creation of a legend keeping the threshold values.

The greenness range is divided into discrete classes by slicing the range of NDVI values into five ranges by fixing the thresholds for NDVI classification and the method used is Natural Breaks (Jenks). Similar step was followed for all the five (5) different years image classification. A cursory examination of pseudo color image of NDVI and classified output of NDVI image reveals that along the water bodies, built up lands yield negative values, their reflectance being more visible rather than near IR wavelengths.

This technique is applied for comparison of vegetation cover change from multiple dates of Landsat TM derived NDVI imageries. Figure 2 (a,b,c,d & e) shows resultant maps generated from NDVI classification. It shows that high reflectance of vegetation in 1989 image, with an increase in NDVI values but the vegetation reflectance is low in 2010. NDVI image derived statistics for the five different years are shown in Table 1.

The NDVI value based statistics are categorized in the following manner i.e. no vegetation, less vegetation, moderated vegetation, dense vegetation, highly dense vegetation and these NDVI values differ significantly from 1989-2010. The NDVI derived values (0.634-1.00 and 0.383-0.634) of 1989 image shows eastern and south eastern part of the study area was covered by highly dense vegetation and in lakes western part (indicating central zone), southern, northern and north-western areas were covered by dense vegetation (shares 5.11% and 52.06% respectively of total land of the study area) and NDVI value 0.187 - 0.383 represent moderate type of vegetation (shares 35.77% of land) whereas this range was not found in 2001 image. Highly dense forest coverage was found in 2001 image and here the NDVI value reduced to 0.346 - 0.544 (shares 49.29%) which indicate some changes occurred and changed the scenario from dense to moderate coverage and it shares 41.83% of the study area (Table 1).

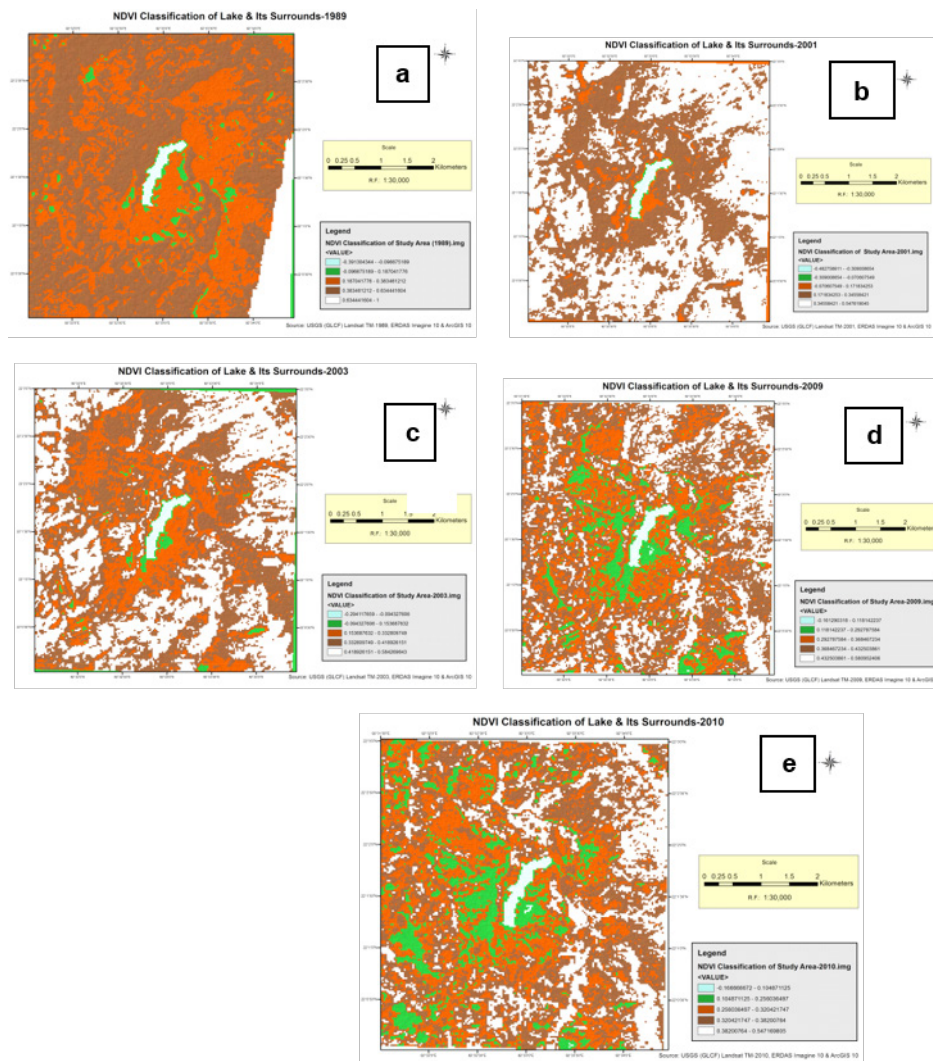


Figure 2 (a, b, c, d & e): NDVI derived classified map of Lake's adjoining areas for five different years (1989-2010)

NDVI values sharply decreased in the year 2001 which ranges from -0.309 to -0.071 and -0.071 to -0.172, whereas in 2003 less and moderate type of vegetation is identified and its share was 5.45% and 19.53% of land respectively. In comparison with the above year, 2009 and 2010 NDVI value of highly dense and dense category shows decreasing trend scenarios which ranges from 22.02% to 18.42% and 38.21% to 35.08% of land respectively. This type of change is observed in the north-eastern, eastern and south-eastern part of the study area (Table 1 and Figure 2: 2d, 2e).

The vacant areas, and lake itself indicate no vegetation category which is represented by negative NDVI values in the year 1989, 2001 and 2003 which shares 0.86%, 0.93% and 0.88% of land respectively. But this percentage of share

increased to 5.11% in 2009 and 5.09% in the year 2010 due to anthropogenic activities (i.e. forest cutting, timber extraction, illegal forest fire, Jhum cultivation and sheet erosion of surface soil as a result of excessive rainfall which was noticed during field survey, November, 2012) growth of large scale long weeds along the lake shore area is observed.

The areas belonging to lake and its surrounding areas represents decreasing trend scenarios of forest cover in between the year 1989-2010. Due to massive jhum cultivation and rapid clearing of highly dense and dense to moderate type of forest, the land is now almost with no vegetation. This conversion started from the year 2001 and continued till now and it is being noticed in the NDVI images of 2001-2010 (Figure 2: 2b-2e) and needless to say

Table 1. NDVI derived changes statistics of the Lake's Adjoining Areas during 1989-2010

NDVI Value based Category	NDVI Value 1989	% of Category	NDVI Value 2001	% of Category	NDVI Value 2003	% of Category
No Vegetation	-0.391 - -0.098	0.86	-0.483 - -0.309	0.93	-0.294 - -0.094	0.88
Less Vegetation	-0.098 - 0.187	6.20	-0.309 - -0.071	0.23	-0.094 - 0.154	5.45
Moderate Vegetation	0.187 - 0.383	35.77	-0.071 - 0.172	7.72	0.154 - 0.333	19.53
Dense Vegetation	0.383 - 0.634	52.06	0.172 - 0.346	41.83	0.333 - 0.419	39.03
Highly Dense Vegetation	0.634 - 1.00	5.11	0.346 - 0.544	49.29	0.419 - 0.584	35.11
		100		100		100
NDVI Value based Category	NDVI Value 2009	% of Category	NDVI Value 2010	% of Category		
No Vegetation	-0.161 - 0.118	5.11	-0.167 - 0.105	5.09		
Less Vegetation	0.118 - 0.293	8.58	0.105 - 0.256	12.27		
Moderate Vegetation	0.293 - 0.368	26.08	0.256 - 0.320	29.14		
Dense Vegetation	0.368 - 0.432	38.21	0.320 - 0.382	35.08		
Highly Dense Vegetation	0.432 - 0.578	22.02	0.382 - 0.544	18.42		
		100		100		

Source: Data computed by author using NASA – GLCF LandsatTM Imagery (1989, 2001, 2003, 2009 & 2010), ERDAS Imagine 10 & ArcGIS 10)

that forest regeneration is quite impossible in this degraded part (Figure 2: 2d and 2e) due to tribal settlement concentration in the western and eastern part of that lake.

Spatio-temporal change detection of vegetation cover

After NDVI image classification, it is necessary to know the overall percentage of change of general land surface based on NDVI derived image value. This kind of change detection helps to detect the areal change of forest cover of an area. Present research highlights the areal forest cover change of Reingkyongkine Lake's adjoining areas in between the year 1989-2010.

The non-changed pixels lie in the NDVI decreased part with low pixel value and NDVI increase part with high pixel value. After preparation of NDVI change category map, the researcher focused on overall forest cover change in the study area which was identified from the image difference map, generated considering two different specific years i.e.1989 and 2010 image (Figure 3a).

Change detection is a good indicator for characterizing and understanding changes occurring during any study period (Figure 3b). The change detection which was performed using ERDAS Imagine 10 (Remote sensing software) are categorize in the following

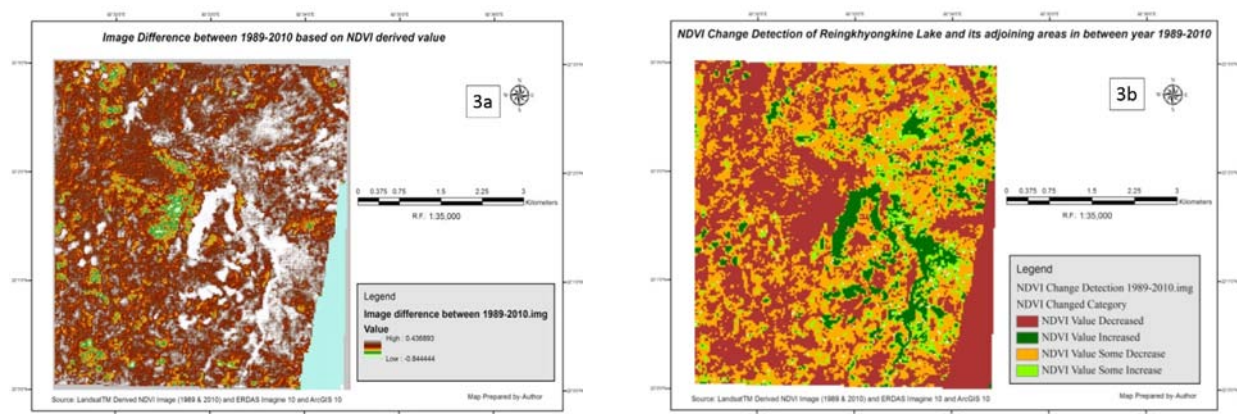


Fig. 3. 3a- Image difference map based on NDVI derived values (1989-2010) and 3b- NDVI value based change detection category map.

Table 2: NDVI Change Detection of Reingkhongkine Lake's adjoining areas in between year 1989-2010

NDVI Change Category (1989-2010)	Area (Hectare)	% of Change between 1989-2010
NDVI value Decreased	1284.84	44.40
NDVI value Some Decreased	1097.55	37.93
NDVI value Some Increase	249.12	8.61
NDVI value Increased	262.08	9.06
Total	2893.59	100

Source: LandsatTM Derived NDVI Image (1989 & 2010) and ERDAS Imagine 10

manner as decreased, some decreased, some increase, and increased (Table 2 and Figure 3b).

Out of the total 2893.59 hectare area, decreased category is in top position, about 44.40% of land surface was changed in between the year 1989-2010, this changes was noticed in the south-eastern, major portion of southern, central (close to lake) and north-western margin followed by some decrease category 37.93% noticed in the northern, central and southern areas and a small percentage of land showing some increase and increasing trend than its previous period which shares 8.61% and 9.06% land surface respectively (Figure 3b and Table 2).

The study area needs special protection because land surface was decreased or changed at the rate of 2.02% per year and some decreased at the rate of 1.72% per year as measured from the NDVI derived change map from 1989-2010.

Conclusion

Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index (NDVI). Data on vegetation bio-physical characteristics can be derived from Visible, NIR and Mid-Infrared portions of the electromagnetic spectrum (EMS). Here in the present study high reflectance of vegetation is observed in 1989 image of the study area, with an increase in NDVI values but the vegetation reflectance is low in 2010.

The change detection helps to detect the areal change of forest cover of an area. Pre-

sent research highlights the areal forest cover change of Reingkhongkine Lake's adjoining areas in between the year 1989-2010. Moreover, the change detection map shows that out of the total 2893.59 hectare area, decreased category is in top position, means 44.40% of land surface was changed in between the year 1989-2010, this changes was noticed in the south-eastern, major portion of southern, central (close to lake) and north-western margin followed by some decrease category 37.93% noticed in the northern, central and southern areas and a small percentage of land showing some increase and increasing trend than its previous time which shares some 8.61% and 9.06% land surface respectively.

Acknowledgement

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Impact of Marble Mining and Processing Industry on Environment (A Case Study of Nathdwara-Rajsamand-Amet Region Using GIS and Remote Sensing Techniques)

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Keywords: *GIS, RS, GPS, Marble, Mining and Processing, Environmental Impact Analysis, Ecological Imbalance. Sustainable Development*

Abstract: The state of Rajasthan is a veritable storehouse of excellent marble. It is the largest marble producing state of India contributing as much as 95 per cent of the country's production. In the state, the study shows that the study region has one of the largest marble deposits contributing 35 per cent production of the country. This region has recorded maximum growth of mining leases in the state as well as in the country during the last two decades, which has resulted in the economic growth and prosperity of the region. Despite the above facts marble mining and processing industry have affected the environment adversely. Therefore, the present study envisages to analyse the adverse impact of marble mining and processing industry.

Introduction

Administratively, the study area is part of Nathdwara, Rajsamand and Amet tehsils (Rajasthan state, India). The study area is located between 73°42'34" to 74°02'47" East longitude and 24°53'29" to 25°19'43" North Latitude. The world famous "Rajsamand Lake" is situated in the study area.

The most advanced techniques including Geographical Information System (GIS), Remote Sensing (RS), Global Positioning System (GPS) along with ArcGIS Desktop, Erdas Imagine, Patch Analyst, ArcHydro software have been used for data collection, processing and impact analysis.

The landscape of the study region has changed largely by converting mixed forest and open scrubland into mining pits, hillocks of marble mineral into ditches and giving birth to new hillocks of overburden. Natural rivulets have disappeared and man-made rivulets have emerged with no apparent benefit. The water, flora, fauna, soil etc. in this region has been affected very badly. Loss of biodiversity from a considerable area has created ecological imbalance and increased the process of sedimentation. Besides, mining and processing of marble affecting the agricultural land; economic conditions of the farmers; quality of

surface and ground water; aesthetic value of the landscape; the growth of natural vegetation; the quality of air, human health etc. adversely.

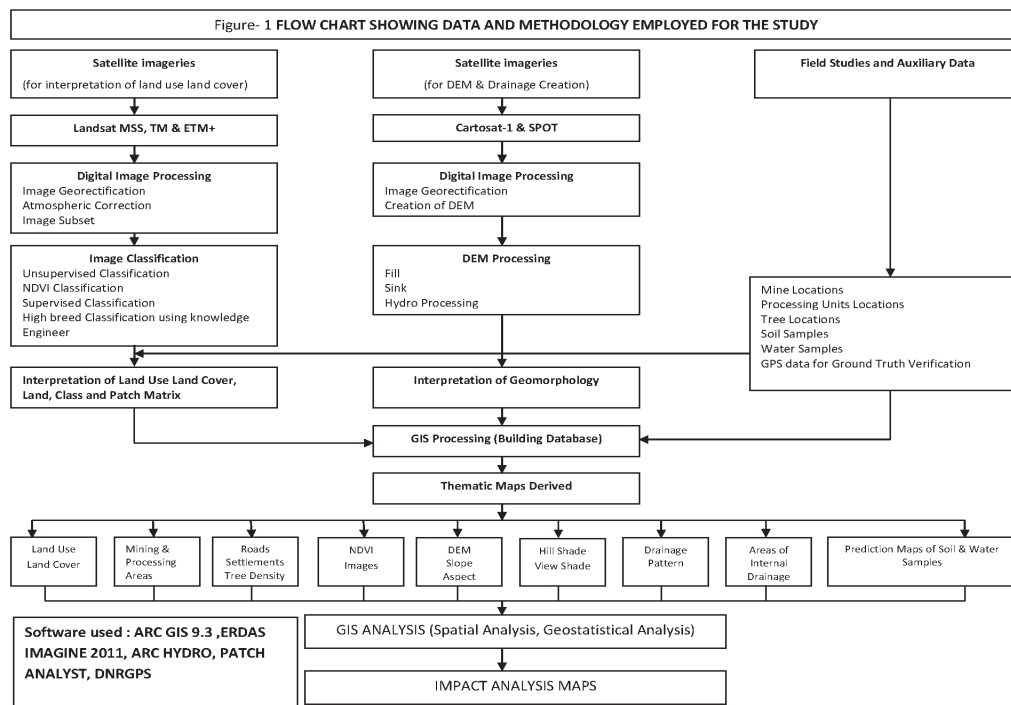
The adverse effect of marble industry can be halted if a practical approach through 'Sustainable Development' is followed meticulously. There shall be logical use of the surface soil, afforestation on the areas having lower slopes, reclamation of abandoned mines, removal of obstacles from the rivulets, channelising the water of water filled mines to the natural course. Use of waste through multivariate techniques and above all the introduction of mechanized mining could minimize or rather restrict & check the adverse impacts of the marble industry on natural resources.

Methodology

The methodology used in the present work has been shown in the Figure-1.

Study Area

The Nathdwara-Rajsamand and Amet Region is part of Rajsamand district. It covers an area of 639 sq km and has the maximum length of 48.04 km from north to south and width of 34.05 km from east to west lying in the southern part of Rajasthan and almost central part of Rajsamand district. Administratively the



study area is part of Nathdwara, Rajsamand and Amet tehsils. (Fig. 2). The world fame Rajsamand Lake is situated in the study area. Besides, National Highway Road No.-8 passes through the study area. Fig. 3 shows the locations of marble processing units and mining areas in the study area. The marble of Rajsamand district is being mined mainly in Rajsamand, Amet and Kumbhalgarh Tehsils. A total of 1198 mining leases of marble are in operation in Rajsamand district, Out of which 1106 mines are in active operation in the study area. The Aravalli hills cover the western and northwestern part of the study area having an

elevation of 621 to 1020 m from MSL. Northeast, east and southeast part is almost plain having an elevation of 520 to 600 m. The study area is a part of bay of Bengal river system. Major part of the study area comes under the basin of River Gomati. Northeastern part of study area is drained by River Chandrabhaga basin. River Gomati is an important tributary of River Banas. It originates from Aravalli hills near Sewantri village located in the northwest of the study area and flows towards southeast direction. The water of river Gomati and its tributaries flows into the famous RAJSAMAND LAKE.

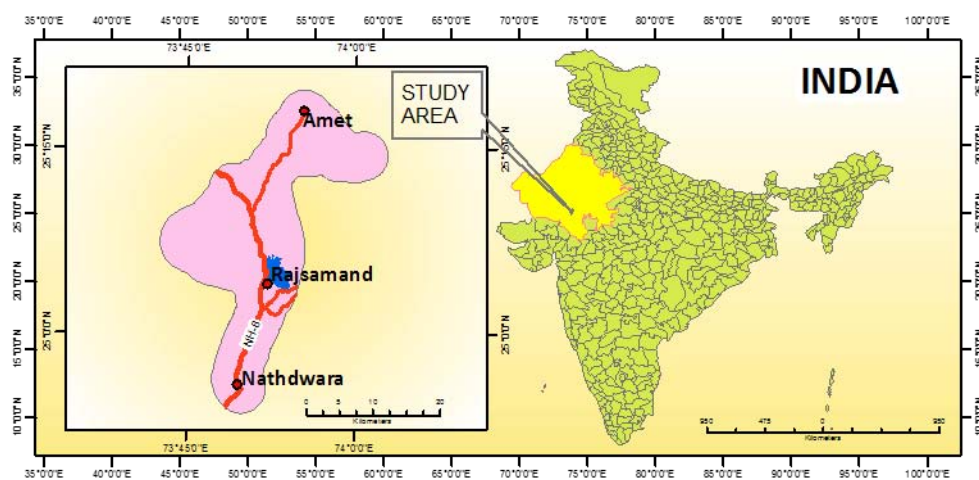


Fig. 2. Location Map of the Study Area.

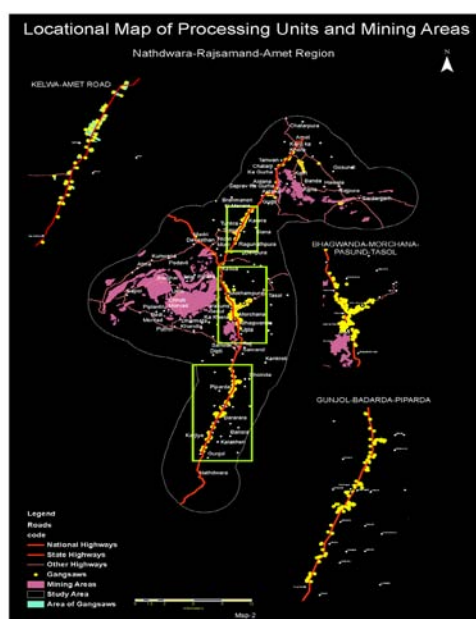


Fig. 3.

Results and Discussion

Mining Activity and Its Impact- In the study region, the minerals are being mined ruthlessly without paying any attention to the environmental protection. Water resources, relief, flora & fauna, land use, human settlements etc. have been very badly affected by mining and processing activities. Billions of rupees are added to state coffers every year at the cost of ecological damage and adverse impact on the welfare of the society. This may lead to incalculable loss in the form of climatic, geological, locational, socioeconomic changes along with massive changes in land use pattern in the area that may be difficult to reverse if the government does not take corrective measures now.

Every day more than 5000 tonnes of marble blocks and equal quantity of waste are mined out. Land degradation, loss of aesthetic appeal (Mouflis.G,2006), loss of vegetation, alteration in drainage system, change in ground water conditions, change in land use, soil erosion, dust pollution, noise pollution etc. are the identified impacts of marble mining in the study region.

Processing Activity and Its Impact- Marble processing industry is one of the most environmentally unfriendly industries. It is estimated that 20 to 50% of marble blocks are converted into powder when they are sawed.

Nearly 264 Gang saw and more than 800 cutters produce 3-4 lacs tons of marble slurry waste each month which is an indestructible waste that create loses to general public. The marble slurry generated during the processing of marble causes the following environmental damage:

- The heaps of slurry remain scattered all around the industrial sector and spoil the aesthetics of the entire region which subsequently has adverse impact on tourism and industrial potential of the area.
- Dry slurry diffuses into the atmosphere causing air pollution and possible pollution to the nearby water (El-Haggar, 2007).
- The porosity and permeability of the topsoil is reduced tremendously and in due course of time it results in water logging problems at the surface and thereby inhibits water infiltration. When and where this happens, the ground water level would be adversely affected and it has gone down to deeper levels (Pareek, 2003).
- The dumped marble waste dries out as a result fine marble dust suspends in the air and slowly spread out through wind into the nearby area and settles down on the crops and vegetation. The fine marble dust also reduces the fertility of the soil by increasing its alkalinity prohibiting any vegetation and severely threatening the ecology of the marble clusters (Vijayalakshmi, 2003; Pareek, 2003).
- The high pH of the dry slurry makes it a corrosive material that is harmful to the lungs and may cause eye sores (El-Haggar, 2007; Vijayalakshmi, 2003).
- It may also corrode nearby machinery (El-Haggar, 2007).

Impact on Topography- The marble mining activity has spoiled extensive area and damaged its topography to a great extent. The huge amount of waste material is being dumped on the just opposite slopes of active mine hills as well as on foothills. The dumps look like small hillocks and have altered the original slope and aspects of the hills. The mining activity takes place on slopes of lower hills that are closer to leveled agricultural land and the overburden is dumped on this fertile agricultural land.

Table 1. Land Use Type and Area Grabbed by Mining Activity since 1976 to 2010

Land Use Type	Total Area Grabbed by Mining Activity (in hectares)
Mixed Forest	9.09
Open Scrub Land	1866.69
Land with or without shrub	520.83
Agricultural Land	258.12
Fallow Land	2.43
Waste Land	23.13
Total Area	2680.29

Impact on Land Cover- Table 1 illustrates that among all land use categories, the mining activity has grabbed a maximum area of 1866.69 hectares of open scrub land. Likewise, mining activities have also grabbed 9.09 ha area of mixed forest and 520.83 ha of land with or without shrub. All these three land categories otherwise were covered with lush green vegetation prior to the onset of mining activity. The removal of vegetation from such an extensive area has been responsible for the migration of wild life, creating the ecological imbalance. The land grabbed has now been converted into the ditches of mining activity and mounds of overburden. It is also apparent from the table that marble mines have been using 258.12 ha of agricultural land even. Though putting rocky waste land in the use of mining activity is no harm, however, only less than 1 percent land of the total mining area is being used for this purpose and remaining 99

percent land belongs to open scrub, land with or without shrub, mixed forest and agricultural land category.

Impact on Water - Fig. 4 illustrates the alterations in drainage system due to mining activity. It is clear that ninety two rivulets from Jhanjhar, Arna, Umti, Sapol, Atma, Morvad, Dharmeta, Nizarna, Dholikhan, SadulkaKhera, Kelwa and Talai mining areas have completely disappeared due to mining activities. All these rivulets are of third order.

The rivulets that have been emerged due to change in slope and aspects of topography have been presented in black in the map. It is evident from the map that forty seven rivulets have emerged from these mining areas and all these rivulets are of third, fourth and fifth order. Despite, flow of these new rivulets the Rajsamand Lake is not receiving sufficient amount of water and remains almost empty because of the obstruction of the rivulets by dumping of mine and processing waste (Fig. 5). More than fifty rivulets have been found obstructed due to dumping of mining waste and slurry. These rivulets are shown in green-yellow color in the map.

The small reservoirs of water locally known as "KUND" and "NALLAHA" also disappeared in the area due to mining activities. The existence of 'JhanjharKund' (Jhanjhar), 'Sheetala Ki Naal' (Morchana), 'MahadeoJikaNallaha' (Talai), 'Rakad-Kakad' (Between Kelwa and Umraya), 'Katiyara Nallaha' and 'Dodira Olla' (Sapol)

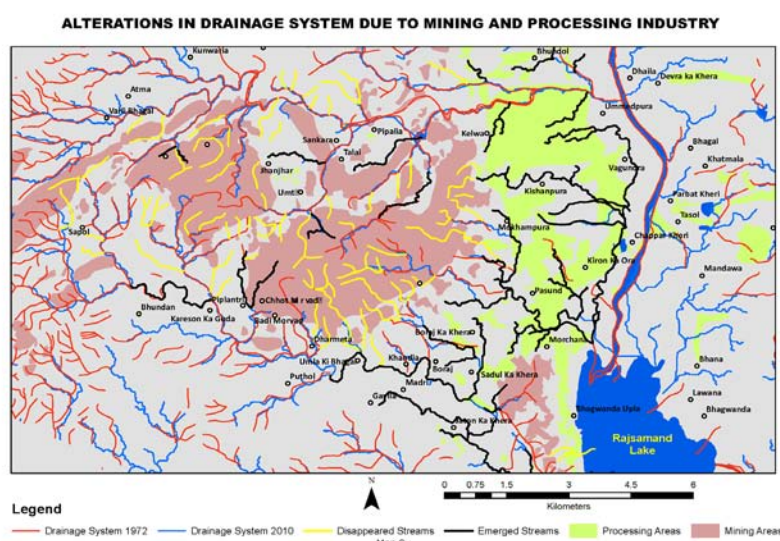


Fig. 4. Alterations in Drainage System due To Mining and Processing Industry.

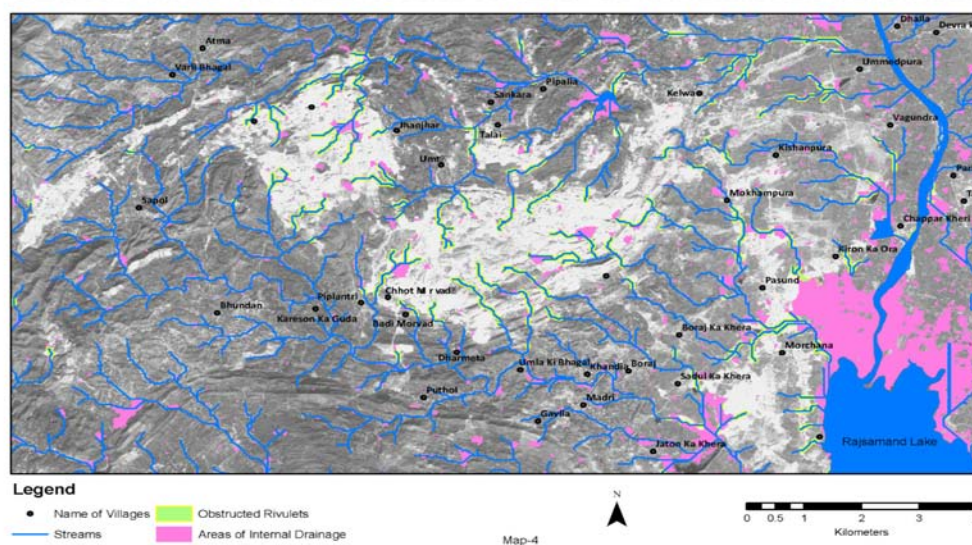
OBSTRUCTED RIVULETS AND AREAS OF INTERNAL DRAINAGE

Fig. 5. *Obstructed Rivulets And Areas Of Internal Drainage.*

have completely disappeared due to overburden dumping. As a result, the amount of water reaching to Rajsamand lake reduced substantially. Several areas of internal drainage have also developed in mining and processing areas of Jhanjhar, Arna, Umti, Talai, Morvad, Menav Ki Bhagal, Dharmeta, Nizarna, Morchana, Kelwa, Sadulka Khera, Mokhampura, Pasoon and Morchana due to change in slope and aspects of topography. These areas are filled in pink color in the map and liable to reduce the amount of water reaching to Rajsamand Lake through river Gomati and Kelwa.

Impact on Flora And Fauna- Many plant species have disappeared in the study area after the commencement of marble industry. Moreover, the composition of flora has also changed due to alteration in geomorphology and hydrology of the area. Native vegetation is gradually replaced by xerophytic vegetation in the area.

Trees including Neem, Peepal, Banyan, Dhok were abundant in the study area before the onset of marble industry. However, their number has been gradually reduced and it is feared that they may also gradually disappeared with time around the mining and processing areas.

Before the onset of mining the study area was covered with dense vegetation and it was teeming with a large variety of animals, birds and reptiles including panthers, leopards, wild

bears, wolves, jackals and striped hyenas. The denudation of vegetation cover destroyed the wild life; as a result the whole area is now devoid of its characteristic faunal species. It is interesting to narrate the experiences of mine owners of Jhanjhar-Umti mining area who used to park their vehicles two to three kilometers away from the mining area in the year 1973 when the mining activity just started. They used to cover the distance between parking and the mining area on foot wearing long shoes to avoid bites from reptiles. Not only this, on several occasions mining activity had to be stopped due to presence of panthers and leopards. Such experiences show the presence of vibrant wild life activity before the onset of mining.

Adverse Impact on Agricultural Land- Agriculture fields near the mining and processing areas are affected in several ways. Most of the agricultural fields in the nearby mining and processing areas suffer adversely by the flying rocks, rolling down of boulders, dust deposition, water logging and siltation. Most of agricultural fields affected adversely are located within the radius of 500 metres, however the major impact is felt within 300 metres radius. Farmers living nearby the industry site said that yield of their agricultural products have gone down significantly over the last few years. Farmers alleged this decline to effects of dusting from blasting, fine particles from mine waste and slurry dumps and truck that transport marble.

Water Pollution- There is no proper planning for disposal of mining and processing waste; it is being dumped on hill slopes, on agricultural land, along roadsides, in the course of rivulets etc. During rainy season, the fine powder is mixed with rainwater that finds its way to rivulets, streams, rivers and lakes, making the water polluted with suspended particles and harmful for drinking purpose. Drainage from mines having fine suspended marble particles along with oil and grease also contaminate the ground water. It has been observed that the fine particles of rocks and minerals along with slurry produced by gang sawing find their way into the lower part of the area and their considerable amount definitely reduce the permeability and cause significant reduction in soil recharge capacity.

Water samples were collected from 42 locations to analyse the quality of water in the area under studied. Results of water quality parameters of 42 water samples are presented in Table 2.

The permissible total dissolved salts for drinking water is 500 mg/L. In the absence of potable water source the permissible limit is up to 2000 mg/L. The range of TDS levels in the study area was 375-6400 mg/L. However, more than half of the water samples showed TDS value beyond the desirable limit of 2000 mg/L. High concentration of TDS may affect persons, who are suffering from kidney and heart diseases. Water containing high solids may cause laxative or constipation effects. Sulphate values were ranging from 21 to 768 and sulphate content was found beyond maximum permissible limit in 12 per cent samples. Fluoride contents were ranging from 0.00 to 4.32 and in 14 per cent samples it was more than maximum permissible limit.

Table 2: Results of Water Samples

Parameter	Within Maximum Permissible Limit			Out of Maximum Permissible Limit			Range (Minimum to Maximum)	Unit
	Value	No. of Samples	%	Value	No. of Samples	%		
pH	<=9	42	100.00	>9	00	0.00	6.8 to 8.9	
E.C.	<=2000	17	40.47	>2000	25	59.53	720 to 10000	µS/cm
TDS	<=1500	20	47.61	>1500	22	52.39	375 to 6400	mg/l
Sulphate	<=400	37	88.00	>400	05	12.00	21 to 768	mg/l
Magnesium	<=100	28	66.66	>100	14	33.33	16 to 254	mg/l
Fluoride	<=1.5	36	85.71	>1.5	06	14.29	0.00 to 4.32	mg/l

Maximum permissible limit or highest relaxable limits are set by W.H.O., I.C.M.R., Govt. of India.

Magnesium was also found more than its permissible limit in exactly one-third samples.

An attempt has also been made to examine the impact of marble slurry on underground water resources using Geostatistical Analyst of ArcGIS desktop software (ESRI Press).

When the layers of active mining areas, dumps of slurry and gangsaws have been overlaid on TDS surface (Fig. 6), it has been observed that the higher Values of TDS is closely associated with the areas where elevation is low, concentration of gangsaws is high and area of slurry is larger. The visualization of the Fig. 6 also reveals that the spatial pattern of TDS values follow the drainage pattern of the study area (i.e. from northwest to southeast). It can be concluded that the higher amount of TDS, Sulfates and Magnesium in the study area is mainly contributed by marble slurry and has spatial relationship with the geomorphology of the area.

Fig. 7 shows that the area of Pasoond, Kelwa, Rajnagar, Bhana and Dhoinda has the highest level of TDS, Sulfates and Magnesium and has unsafe drinking water and need an urgent monitoring system to manage the quality of the water. The Hot Spot covers an area of 70.74 sq. km. and more than 1 lakh population live in it. There are 60 per cent gangsaw, 64 per cent area of slurry dumps and 30 per cent active mining zone of the study area come in this Hot Spot.

Suggestions

Cleaning Up of Rivulets- There are several rivulets passing through the mining areas that flow either from west to east or from northwest to southeast. It is clear from the fig. 4 that these rivulets have been obstructed at more than fifty

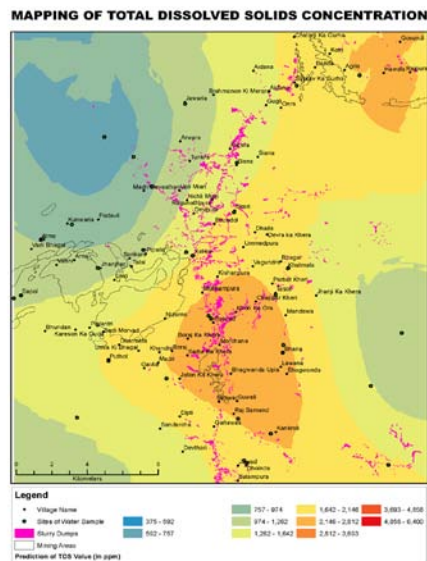


Fig. 6. Mapping Of Total Dissolved Solids concentration.

places. The obstructions in the natural course of rivulets usually diverts the flow of water into several channels leading to soil erosion and water logging problems as well as reducing the amount of water reaching to Rajsamand Lake. These rivulets must be cleaned up especially before the onset of monsoon.

Management of Rain and Mine Water-

The water finds its way into the mines during monsoon period as a result most of the mines are filled with water. Generally, mine owners pump out the water to streamline the mining operations. A large amount of water finds its way in the nearby areas creating water logging problems.

The large amount of water collected in the mines during rainy season cannot reach to its natural destination. i.e. Rajsamand Lake. As a

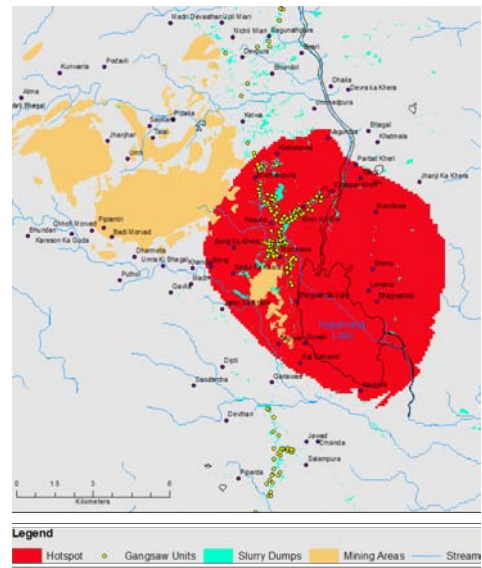


Fig. 7. Hot Spot of TDS-Sulphate and Magnesium concentration.

result of this, the lake does not get sufficient amount of water and remains dry for most of the year. In the normal course, if rain water would not have been collected in the mines, it may have reached to Rajsamand Lake making it to full to its capacity. Mine owners can adopt the following measures to make the best use of rain as well as mine water-

Drainage Control- Mine owners can control the flow of rain water into their mines by constructing garland type of drainage system around the mine that directs the flow of rainwater into the natural rivulets.

Construction of Artificial Drainage- Mine owners can construct artificial drainage in their mining areas leading to natural course of drainage according to the slope aspects of the area. (Fig. 8). The mine water can be pumped

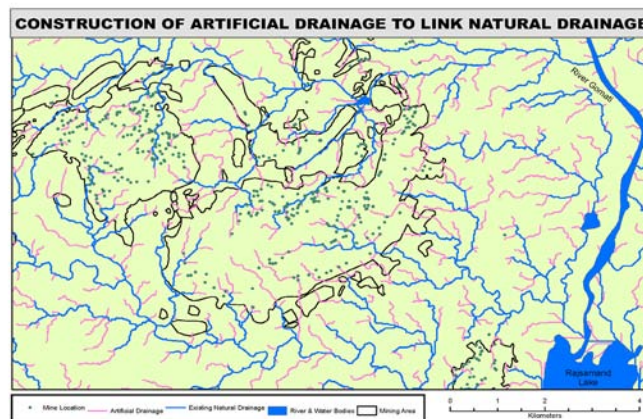


Fig. 8. Construction of Artificial Drainage to Link Natural Drainage.

out into the artificial drainage so that water can find its natural way. This practice will help to enhance the ground water table as well as biological productivity along the both sides of the natural drainage.

Ban on Acquiring Agriculture Land-As stated earlier that mine and processing owners have started purchasing agriculture land at higher prices for dumping their mine and processing wastes. This trend has now become a fashion. However, this trend affects the natural as well as socio-economic environment of the area adversely. On one hand, agricultural land is shrinking rapidly and on other hand, farmers are becoming landless laborers. Thus, mining and processing activities instead of bringing the prosperity in the area is making the local people poor and poorer.

It will not be an exaggeration to state that mine owners have become robbers of the natural resources. It is high time that State Government intervenes and frames laws to impose ban on acquiring the agriculture land for dumping purposes by mine and processing owners.

Conclusion

The adverse effect of marble industry can be halted if a practical approach through 'Sustainable Development' is followed meticulously.

There shall be logical use of the surface soil, afforestation on the areas having lower slopes, reclamation of abandoned mines (Kaliampakos D.C.-2006), removal of obstacles from the rivulets, channelising the water of water filled mines to the natural course. The waste shall be

dumped into the suggested sites. Use of waste through multivariate techniques (UNIDO, 2006) and above all the introduction of mechanized mining could minimize or rather restrict & check the adverse impacts of the marble industry on natural resources.

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Disaster Risk Reduction, Resiliency & Environmental Mapping: A Way of Life to Cope with Natural Calamity

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Introduction

Any disaster need to be viewed seriously and dealt with urgently in an organised and planned manner by the Centre, local Govt., NGOs and more so by the local people. There is no doubt that the first respondent in these scenarios is always the local residents. Except Volcanic eruption (known only in Barren Island), India has witnessed all type of known disasters. In Dec 2004, India for the first time witnessed the devastation from Tsunami at a massive scale along the coastal areas of Chennai, Nagapatnam and Carnicobar Island. Though, India was not prepared for this magnitude of disaster but reached out to the affected people and provided rescue and relief operation on war footing. Indian Navy despatched its Hydrographic survey and Naval ships to East coast and Nicobar islands to provide relief material and act as hospital ship to treat injured people. In the recent cloud burst and landslides disasters in the Kedarnath, Badrinath, & Joshimath area of Uttarakhand the Army, Air force, ITBF and NDRF reached out, to rescue 100s of people stranded in these areas. In spite, there being weather warnings of heavy rains with advisory to evacuate people from these areas, issued by the state Meteorological department. The same was ignored by the local authorities and no action taken in averting massive casualties and damages to the lives and property. It is now estimated that around 10,000 people were evacuated safely, more than 4000 people are still reported missing and close to 900 people confirmed dead. There is no doubt in any one's mind that if concerns of environmentalists, effect of Global warming and its resultant effect like heavy rains, glacier melting, tree top line shifting, landslides and degradation of forest were kept in mind whilst construction of buildings and hotels along the eco fragile river banks of Uttarakhand were allowed to mushroom, this devastation could

have been of lesser magnitude. We cannot fully avert natural disasters but certainly reduce its effect on lives and property by instituting preventive measures and preparing citizens to deal effectively in getting out to safe places and by helping elderly, sick & children, till help from Govt./Administration arrived. In any disaster first 24 hours after the disaster occur, is very crucial and by effective community/local help many lives could be saved. It was only after the experiences of Gujarat earthquake (2001) and tsunami (2004) that Govt. of India set up a National Disaster Management Authority (NDMA) to plan, organise and manage disasters in the country. The NDMA is yet to come up to the desired expectations. I, as past Fellow of the Symposium on South Asia Security (SEAS 2012), sponsored by the US Department of State, was privileged to travel to Honolulu (USA), Manila (Philippines), Yogyakarta & Jakarta (Indonesia) and Ulan Bator (Mongolia) and witness some of the best National Disaster Management Organisation dealing with Floods, Earthquakes, Tsunami, Volcano, Forest fires, Epidemics etc. In this paper, attempt will be made to discuss each country Disaster Risk Reduction, Resiliency and Environment mapping program and draw parallel with our NDMA and suggest way ahead, to cope effectively with such disasters in future.

Background

We all know that the Planet Earth after it separated from the solar nebula has under gone differentiation into core, mantle and crust and then undergone a long mixing and un-mixing of these samples reservoirs by plate tectonics, weathering and hydrothermal circulation. The scientist with radiometric age dating of meteorite material (oldest known terrestrial and lunar samples) has calculated the age of the earth to be $4.54 \pm 1\%$ billion years¹. Further,

due to global warming, manmade infrastructure activities, urbanisation, deforestation, large scale deep mining, hydro carbon exploration onshore and offshore etc. are playing important role in destabilising the natural climate and giving rise to unpredicted natural calamity in the form of heavy rains, floods, landslides, cyclones, earthquakes, volcanic eruptions, severe climate conditions (severe cold, rise in temperature result in heat wave and forest fires, heavy rains (floods) or scanty rains (draught) ; all these affect lives and properties of the civilisation. It is in this backdrop that we need to gear up in advance to face these challenges to see that depending upon the type of calamities likely in a particular region, the people, local Govt. and states are prepared to mitigate and have resiliency to overcome its impact in a shortest possible time.

Major Natural Calamities of the past two Decades (1993-2013)

Like many of Asia-Pacific countries, India has also faced many natural calamities in the past; some has been very intense to severe in the form of earthquakes, Tsunami, floods, landslides etc. I would like to discuss some of the important natural calamities, which took the nation by surprise but we were able to deal with the disaster in a quick and responsible manner, at the same time it was challenge to our system to evaluate our preparedness and shortcomings to better gear up and deal in an organised manner.

Latur earthquake 1993

An earthquake measuring 6.4 on the Richter scale with three aftershocks on the same day with epicentre near Kilari district of Latur shook the entire nation at 0356 hrs on 30 Sep 1993. This caused extensive damage to life and property, wherein 7,928 people killed, 16,000 injured, 15,854 livestock killed, 52 villages raised to the ground, 27,000 houses with all amenities and infrastructure damaged, 30,000 houses collapsed, 2,11,000 houses in 13 districts suffered damages of varying degree².

Super cyclone Gulf of Kachchh 1998

A super cyclone with wind speed of 170 km/hour hit Gulf of Kachchh, wherein more than 900 people were killed, 1800 injured, many ships uprooted from the anchorage/berths

and grounded, many vessels were physically lifted and drifted to more than 5 km on shore. Complete port infrastructure jetties, buoys, moorings and pipelines carrying crude oils were damaged at Kandla and Vadinar ports³. A cyclone at a major port, such as Kandla (Gujarat, India), can not only bring about damage to the port infrastructure but also allied risks such as shortage of essentials, fuel supply for refineries, coal supply for power, etc⁴ One survey ship each from Mumbai and Kochi were despatched by Indian Navy to undertake post cyclone survey of the area and clear port for operation. It was my privilege to command INS Jamuna at that time and undertook operation on a war footing and cleared the Ports of Kandla, Vadinar and Gulf of Kachchh safe for navigation and shipping within one week of arrival on 21 Jun 1998.

Orissa Super Cyclone 1999

On 29 Oct 1999, a very high intensity cyclone (measuring seven on the Beaufort scale) struck the State of Orissa, taking more than 10,000 lives and causing property damages worth US \$1.35 billion. The cyclone referred to as "super cyclone" as per the India Meteorological Department (IMD) classification (i.e. sustained wind speed measuring more than 221km). It was one of the worst ever to strike the region⁵. Here again survey ships from Visakhapatnam were deployed for rescue and relief operation.

Bhuj Earthquake of 2001

The powerful earthquake that struck the Kutch area in Gujarat at 8:46 am on 26 Jan 2001 has been the most damaging earthquake in the last five decades in India. The M7.9 quake caused a large loss of life and property. Over 18,600 persons are reported to have been killed and over 167,000 injured. The estimated economic loss due to this quake was placed at around Rs.22,000 Crores⁶.

Tsunami of 2004

An earthquake in the Indian Ocean close to the Sumatra Island of Indonesia on 26 Dec 2004 generated Tsunami waves, which destroyed lives and properties of Coastal area and islands of Indonesia, Thailand, Malaysia, Sri Lanka and India. Even Tsunami's affected as far as Somalia coast, where 298 people were killed. In India, east coast of Tamilnadu,

Puducherry, Katchall and Car Nicobar Islands were affected very badly⁷. A total of 1,74,296 were killed and 1,08,221 missing; out of which, in India 10,749 people killed and 5640 missing as on 24 Mar 2005⁸. Many coastal towns, cities, fishing harbours and infrastructure including livestock were destroyed. The total cost to India was estimated at \$ 1.6 billion by the Citigroup.

Uttarakhand flash floods and landslides 2013

On 16-17 Jun 2013, flash floods or Glacier Lakes Outbursts Floods (GLOFs) have caused heavy damages and destruction to lives and properties in Kedarnath, Badrinath and Pithoragarh. After 166 bodies were recovered from Rambada on 06-07 Sep, the official deaths have crossed over to 1000 and more than 10,000 are still reported missing. The fact that Uttarakhand is a fragile, new mountain state and vulnerable to various kinds of disasters like high intensity rainfall, cloud bursts, landslides, flash floods and earthquakes. Its geology is ridden with numerous fault lines. Climate change is increasing the frequency of high intensity rainfall including cloud bursts and flash floods, GLOFs with landslides. If a Doppler Radar system was installed in the region to predict cloud bursts, affected people could have been timely evacuation to safe places by local authorities and many precious lives could have been saved. It is sad to know that the State Disaster Management Authority (SDMA) formed in 2007 had not even held its first meeting. Due to lack of coordination among Uttarakhand Govt., CWC, IMD and NDMA, therefore the money sanctioned for Doppler Radar was not spent. Even there have been flash floods, cloud bursts in the past in 1993, 1998, 2008 and 2012, no disaster management plan was in place. Since Uttarakhand was declared an independent state in 2000, efforts have been made by all concerned to carryout rampant construction activities in the valley; by way of roads, hotels, shops, bridges by encroaching on the riversides and valleys.

National Disaster Management Authority (NDMA)

It was the Tsunami of 2004, which shook the nation, in terms of its lack of preparedness and capabilities in weather forecasting, Ocean waves & coastal tide monitoring mechanism, coastal regulation zones, regional information

reporting and sharing system etc. It was Indian Navy in particular Hydrographic survey ships and local people rose to the occasion and coordinated rescue and rehabilitation operation on war footing. Indian Navy dispatched its hydrographic survey ships equipped with helicopters (quickly converted to hospital ships); one each to east coast and Car Nicobar and two ships to Sri Lanka and one to Bandah Aceh, Indonesia. Many other naval ships with relief material were also pressed into service for the disaster mitigation. Devastating effect of Tsunami 2004, made the Govt. and its department responsible for dealing with natural calamities to discuss and debate various options and way ahead to plan, prepare and act in future such disasters in a more professional and organised way. Although, Govt was already planning to have a Disaster Management Authority, but this was put on fast track and on 23 Dec 2005 Disaster Management Act (DMA) 2005 was enacted and the National Disaster Management Authority (NDMA), a statutory body under the chairmanship of PM was set up. As per the DMA, the responsibility to cope with natural disasters is essentially that of the State Disaster Management Authority, under the chairmanship of the CM. At the district level, the Collector/District Magistrate/Deputy Commissioner is the chairperson of the DMA and directs, coordinates and supervise disaster management activities⁹. Initially Gen.(Retd.) NC Vij, former Chief of the Army Staff, was appointed as its Vice Chairman with various technical experts as Members to prepare guidelines for each type of natural disasters, prepare plans for implementation and follow up by centre, state and local administrations. A guideline was issued on "Management of Landslides and Snow Avalanches" in Jun 2009 by the Vice Chairman, NDMA. Similarly, action plans were also drawn to be implemented during 10th five years plan and thereafter, during 11th and 12th five year plans. However, the results of their preparedness and mitigation plans to deal with natural disaster in the country are far from anybody's expectation, experienced during the recent Uttarakhand tragedy.

Disaster mitigation and prevention in some of the Asia-Pacific countries

I had the opportunity to visit Honolulu, Manila, Yogyakarta, Jakarta and Ulan Bator

during Aug-Sep 2012 as Fellow of South East Asia Security -2012 program sponsored by US State Dept. and witnessed some of their preparedness, plans and Risk Reduction measures to deal with natural disasters effectively and the same are discussed in succeeding paragraphs.

Philippines

The country witnessed floods, cyclones, Tsunami, fires, epidemics. In Jul 2012, Manila city was partially submerged due to heavy rains and floods. But due to awareness, active participation and resiliency of the local people to deal with natural disasters and preparedness of the local administration helped in reducing casualties and damages to bare minimum. Philippine have enacted Republic Act 10121 otherwise known as the Philippine Disaster Risk Reduction and Management Act of 2010, which lay down the basis for a paradigm shift from just disaster preparedness and response to disaster risk reduction and management (DRRM)¹⁰. The National DRRM Plan serves as the national guide on how sustainable development can be achieved through inclusive growth while building the adaptive capacities of communities; increasing the resilience of vulnerable sectors; and optimizing disaster mitigation opportunities with the end in view of promoting people's welfare and security towards gender-responsive and rights-based sustainable development. Over the past several years, the country has gained a lot of attention and momentum in the area of disaster risk reduction. Numerous projects and activities have been undertaken by various Philippine stakeholders and agencies in DRRM. However, sustaining the positive results and scaling them up to effect rippling positive changes in the lives of the people have been constant challenges. For years, DRR has focused more on efforts around disaster preparedness and response and not so much in identifying the hazard-prone areas and other factors which contribute to people's exposure to disasters; incorporating risk analysis to development plans; building people's capacities towards sustainable livelihood. Although DRR has been gaining attention among peoples and institutions, complete paradigm shift from "disasters as an immediate product of hazards" to "disasters as a function of people's vulnerability" has not yet fully happened. Lastly, gaps in terms

of increased knowledge, understanding and capacities remain and cause a big challenge for the country in terms of DRRM. The NDRRMP outlines the activities aimed at strengthening the capacity of the national Govt. and the Local Govt. Units (LGUs) together with partner stakeholders, to build the disaster resilience of communities and to institutionalize arrangements and measures for reducing disaster risks, including projected climate risks and enhancing disaster preparedness and response capabilities at all levels. It highlights, among others, the importance of mainstream DRRM and CCA in the development processes such as policy formulation, socio economic development planning, budgeting and governance particularly in the area of environment, agriculture, water, energy, health, education, poverty reduction, land-use and urban planning and public infrastructure and housing among others. The NDRRMP also highlights the need for institutionalizing DRRM policies, structures, coordination mechanisms and programs with continuing budget appropriation on DRR from national down to local levels.

Indonesia

The country was worst affected by the Tsunami of 2004 and prone to floods, cyclones, volcano eruption, drought etc. Indonesia has started with the identification of existing hazards, analysis of the disaster risks and presentation of the programs and priority focuses that will be implemented, including the participation of the national Ministries/Agencies and the related indicative budget needed. The National Disaster Management Plan (NDMP), which subsequently will be called the DM Plan, is the realization of the Govt. effort to formulate effective disaster management programs. The document is formulated based on the mandate of the Law No. 24 Year 2007 on Disaster Management¹¹. The National DM Plan contains data and information related to disaster risks in Indonesia in 2010-2014 and the Govt. plan to reduce these risks through development programs and activities. The DM Plan constitutes a proposal from the Govt. that consists of effective disaster risk reduction efforts, efficient emergency response and effectual recovery. The programs outlined in the DM Plan are formulated based on the vision and mission of Indonesian disaster management and the plan of action according to

risk management. In its implementation the DM Plan was integrated into regular development plans as stipulated by Article 35 of Law No. 24 of 2007 on Disaster Management. The Objectives of the National Disaster Management Plan 2010-2014 are:

1. To identify hazard prone and high risk areas in Indonesia and formulate actions that should be prioritized, including the programs, priority focuses and indicative budget.
2. To provide a reference for government ministries and agencies, and all disaster management stakeholders in Indonesia in order that they could implement their disaster management efforts in a planned, integrated, coordinated and comprehensive manner.

Indonesia's local Govt. and NGOs work in collaboration with the locals to educate train and overcome natural disasters in the region. A right example of resiliency was seen in the Mount Merapi volcano eruption in 2010, during which many villages, houses, people and their cattle were engulfed in the burning hot lava. In spite of great tragedy they helped and fought together to start new life from a scratch.

Mongolia

The country has population of just over 27 lakhs and regularly affected by the extreme cold or heat, snow and dust storms, Dzuds, forest fires, earth quakes. Mostly the livelihood of the nomadic population is cattle, sheep and camel rearing and they move from place to place looking for green pastures for grazing domestic animals. These people need to be given information about likely disaster prone areas and advised to move to safe places. To effectively deal any disaster "State Policy on Disaster Protection", ratified by the Parliament of Mongolia decree No.22 of 2011¹², stipulates that technologies to probe and assess hazards and possible disasters would be introduced, ways and channels to promptly deliver information to the end users would be devised, and the early warning systems would be improved.

By using information from satellites, it is possible to analyze the state of ongoing disasters, evaluate the pre-disaster and post-disaster situations, and constantly monitor and

depict pictorially possible and ongoing hazards and disasters. Mongolia, with its significant nomadic livestock husband dry sector and limited forest reserves that cover less than 10 percent of the total territory, is facing the need to prudently utilize its pastureland, keep the ecological balance, and seek the optimal disaster management strategies to protect against natural disasters. Rapidly progressing remote sensing (RS) and geographic information system (GIS) technologies are suitable for countries with vast territories such as Mongolia in monitoring the coverage and state of national forests and spread and condition of forest and steppe fires. These technologies are also useful in timely and quick assessment of the risks of natural disasters and in determining timely preventive measures. National Emergency Management Agency (NEMA) at Ulaan Baatar is the central agency responsible for implementation of DM policies.

Way Ahead

India has witnessed many disasters and natural calamities of varying magnitudes in the last two decades. We have evolved various strategies and introduced technological warning and monitoring system. The data being collected, need to be integrated from central authorities to local level, to make better judgement on disaster preparedness and management. To start with our warning and evacuation system should be well integrated with IT, Communication, logistics, transportation and medical facilities. Geographic Information Systems and Remote Sensing systems need to be introduced to and expanded at the emergency management institutions to improve prevention from possible disasters, supply decision makers with accurate information during disasters, strengthen the national disaster protection capacities, and to organize appropriate response and recovery measures. There is necessity to train local level officers, NGOs and public at large in using the GIS and remote sensing technologies, increase the number of GIS and remote sensing specialists, expand partnership and cooperation with organizations in the field of geo-informatics, and promote projects and programs in this field. Establishing a disaster geo-database and a Disaster Geo-Database Centre in this era of information and communication technologies would be a huge stride forward in promoting the usage

of the GIS and remote sensing technologies in disaster reduction endeavours. Awareness and dealing to cope with disaster should be the responsibilities of all stakeholders right down from local, village, tehsil, district, state and centre level. The basic and technical information should be disseminated from household, primary school and higher at university stage to all the citizens. As a nuclear state Indian citizens should also be trained to deal with nuclear fallouts and safety measures. It is then only that we will be able to save many lives and properties. Protect environment, be aware of climate change & global warming and work for sustainable development.

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Probabilistic Assessment of Earthquake Hazards in Northeast India and its Adjoining Regions: An Appraisal from Frechet Distribution

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Keywords: *Northeast India, Frechet distribution, Earthquake hazard, Fisher information matrix*

Abstract: In this paper we discuss the application of Frechet distribution for probabilistic assessment of earthquake hazards in the seismically active Northeast India and its adjoining regions. The seismicity of this region is realized from a number of large ($7.0 < M < 8.0$) and great ($M \geq 8.0$) earthquakes during last century. The region falls under seismic zones V (highest), IV (high), and III (moderate) on the seismic zonation map of India (BIS 1893:2002). In view of this, a re-appraisal of earthquake hazard in terms of predicted conditional probability is essential for civil engineers and policy planners for hazard prevention and mitigation. A reliable, complete, and homogeneous earthquake catalog (Yadav et al., 2010) of 20 events ($M \geq 7.0$) is used in this research. The model parameters are estimated from maximum likelihood estimation (MLE) method and the uncertainty in the estimated parameters is evaluated from the Fisher information matrix (FIM) approach. The hazard curves (conditional probability curves) for different elapsed times strongly indicate that the study region is highly seismically hazardous to experience a large earthquake in near time.

Introduction

In recent years, several standard lifetime distributions are being introduced in natural hazard assessment studies mainly to model the phenomenological cyclic pattern of the events. Nevertheless, the modeling suitability of a particular distribution is data dependent. Therefore, use of different distributions on a given catalog has been a regular topic of interest. Keeping this in mind, we frame the objectives of this research work as – (1) to review several properties of Frechet distribution and (2) to study the suitability of Frechet distribution in probabilistic assessment of earthquake hazards of northeast India and its adjoining regions (20° - 32° N and 87° - 100° E). The northeast India and its neighboring regions are considered to be seismically very active and hazardous due to the ongoing collision of Indian plate with Eurasian plate (Bhatia et al. 1999; Bis 2002; Das et al. 2006). It has experienced a number of large ($7.0 < M < 8.0$) and great ($M \geq 8.0$) earthquakes in recent past. So far, 18 years have been passed since the last large earthquake that jolted the region on July 11, 1995. As a consequence, the conditional probabilistic approach for a known elapsed time has become more rational

than the earlier used cumulative probabilistic approach, calculated on the basis of the last rupture time. It has also been realized that the seismic hazard scenario assessed in this manner is dynamic, and requires recalculation from time to time. The conditional probability curves (also known as hazard curves) for a specific region are routinely used in several engineering applications: revising building codes for structural safety, location choice for schools, hospitals, mega structures, highway/railway bridges, hydro/thermal power plants, city planning, and many more. The earthquake catalog in this study is borrowed from Yadav et al. (2010). This complete and homogeneous catalog contains 17 large events and three great earthquake events. The epicentral locations, focal depths, and time of occurrences are listed below in Table 1.

In this study, we accept Frechet distribution to assess the earthquake hazard of the study region. This distribution is frequently used as an extreme value model. It has enormous applications in reliability and demographic studies. In addition, Frechet distribution belongs to the family of Gumbel distributions. The other important characteristic of Frechet distribution

Table 1: List of earthquakes that occurred in the study region for magnitude $M \geq 7.0$ (after YADAV *et al.*, 2010)

S.N.	Date						Location		Focal depth (km)	Magnitude
	Year	Month	Day	Hour	Min	Sec	Latitude (N)	Longitude (E)		
1	1846	12	10				26.00	93.00		7.5
2	1868	6	30				24.50	91.50		7.5
3	1885	1	1				25.40	90.00		7.3
4	1897	6	12	11	5		25.90	91.90	60	8.7
5	1908	12	12				26.50	97.00		7.5
6	1912	5	23	2	24		21.00	97.00	25	7.9
7	1918	7	8	10	22		24.50	91.00	60	7.6
8	1923	9	9	22	3	42.00	25.25	91.00		7.1
9	1931	1	27	20	9		25.60	96.80	60	7.6
10	1943	10	23				21.50	93.50		7.2
11	1946	9	12	15	20		23.50	96.00	60	7.5
12	1947	7	29	13	43		28.50	94.00	60	7.9
13	1950	8	15	14	9		28.50	96.70		8.6
14	1951	11	18	9	35	45.00	30.50	91.00		8.0
15	1954	3	21	23	42		24.40	95.20	180	7.5
16	1961	2	4	8	51		24.90	93.34	141	7.6
17	1976	5	29	14	0	18.50	24.53	98.71	10	7.0
18	1988	8	6	0	36	24.60	25.15	95.13	91	7.2
19	1991	1	5	14	57	11.50	23.61	95.90	20	7.1
20	1995	7	11	21	46	39.78	21.97	99.20	12	7.1

includes heavy tailed property (thicker tail than exponential distribution), which often provides important conclusion in engineering analysis. A review of various applications of Frechet distribution may be found in Murthy *et al.* (2004). In some literature, Frechet distribution is called as inverse Weibull, reciprocal Weibull, and complementary Weibull.

Now we develop the basic probabilistic concept for empirical modeling of earthquake recurrence and conditional probability curves.

Let $T, f(t), F(t), \bar{F}(t), h(t)$, and $P(\tau|t_e)$ be the random variable (RV) of interevent times, probability density function (pdf), cumulative distribution function (cdf), survival function, hazard function, and conditional probability of occurrence (for an elapsed time of t_e years), respectively. For a random variable $T \sim \text{Frechet}(\alpha, \beta)$, the density function is given

as follows.

$$f(t; \alpha, \beta) = \beta \alpha^\beta t^{-\beta-1} \exp \left[-\left(\frac{t}{\alpha} \right)^{-\beta} \right]; t > 0, \alpha > 0, \beta > 0$$

$$= 0; \quad \text{otherwise}$$

The density function is controlled by two positive-valued parameters, namely scale

parameter α and shape parameter β . The shape parameter determines the appearance or shape of the distribution, whereas the scale parameter manages the spread of the distribution. The density function is unimodal with mode at $t_{\text{mode}} = \alpha(1+1/\beta)^{1/\beta}$. However, it

assumes different shapes for different values of β (MURTHY *et al.*, 2004). The cdf and other

functions of $T \sim \text{Frechet}(\alpha, \beta)$ are presented

below.

$$F(t) = \int_0^t f(u; \alpha, \beta) du = \exp \left[-\left(\frac{t}{\alpha} \right)^{-\beta} \right]$$

$$\bar{F}(t) = \int_t^\infty f(u; \alpha, \beta) du = 1 - \exp \left[-\left(\frac{t}{\alpha} \right)^{-\beta} \right]$$

$$h(t) = \frac{f(t)}{\bar{F}(t)} = \frac{\beta \alpha^\beta t^{-\beta-1} \exp \left[-\left(\frac{t}{\alpha} \right)^{-\beta} \right]}{1 - \exp \left[-\left(\frac{t}{\alpha} \right)^{-\beta} \right]}$$

$$P(\tau|t_e) = \frac{F(t_e + \tau) - F(t_e)}{1 - F(t_e)} = \frac{\exp \left[-\left(\frac{t_e + \tau}{\alpha} \right)^{-\beta} \right] - \exp \left[-\left(\frac{t_e}{\alpha} \right)^{-\beta} \right]}{1 - \exp \left[-\left(\frac{t_e}{\alpha} \right)^{-\beta} \right]}$$

Methodology

In this section, we discuss the overall methodology adopted for this research. Recall that the emphasis of this study is to appraise earthquake hazard of northeast India and its surrounding regions from Frechet distribution. We use historical earthquake events (listed in Table 1) for this purpose.

We follow the methodology of Utsu (1984), Parvej and Rm (1997), and Yadav et al. (2010) for our study. It involves three steps: identification of model parameters (α, β) of the Frechet distribution, uncertainty measurement of estimated parameters using Fisher information matrix (FIM), and subsequently finding of estimated mean recurrence interval and conditional probabilities for various elapsed times.

We use maximum likelihood approach for parameter estimation. The estimated parameters $(\hat{\alpha}, \hat{\beta})$ are obtained by finding $\hat{\beta}$ from Eq. and then $\hat{\alpha}$ from Eq.. (4)

$$\frac{1}{\hat{\beta}} - \frac{1}{n} \sum_{i=1}^n \ln(t_i) + \frac{\sum_{i=1}^n t_i^{-\hat{\beta}} \ln(t_i)}{\sum_{i=1}^n t_i^{-\hat{\beta}}} = 0 \quad (3)$$

$$\hat{\alpha} = \left(\frac{1}{n} \sum_{i=1}^n t_i^{-\hat{\beta}} \right)^{-\frac{1}{\hat{\beta}}} \quad (4)$$

Now to realize the uncertainty in the estimated parameters, we construct FIM for Frechet distribution. It is calculated as follows (Hogg et al., 2005).

$$I(\alpha, \beta) = E \left(- \begin{bmatrix} \frac{\partial^2}{\partial^2 \alpha} \ln f(T; \alpha, \beta) & \frac{\partial^2}{\partial \alpha \partial \beta} \ln f(T; \alpha, \beta) \\ \frac{\partial^2}{\partial \beta \partial \alpha} \ln f(T; \alpha, \beta) & \frac{\partial^2}{\partial^2 \beta} \ln f(T; \alpha, \beta) \end{bmatrix}_{2 \times 2} \right) = \begin{bmatrix} \frac{\beta^2}{\alpha^2} & \frac{1}{\alpha} (1 + \psi(1)) \\ \frac{1}{\alpha} (1 + \psi(1)) & \frac{1}{\beta^2} (\psi'(1) + \psi^2(2)) \end{bmatrix}$$

Here $\psi(x)$ and $\psi'(x)$ denote the digamma function and it's first derivate. Digamma function $\psi(x)$ is defined as follows.

$$\psi(x) = \frac{d}{dx} \ln \Gamma(x) = \frac{\Gamma'(x)}{\Gamma(x)}; \quad \Gamma(x) = \int_0^\infty z^{x-1} e^{-z} dz \quad (x > 0)$$

Therefore, the asymptotic variance-covariance matrix for the parameters $(\hat{\alpha}, \hat{\beta})$ estimated from n independent and identically distributed (iid) samples is obtained as

$$\Sigma \geq [nI(\hat{\alpha}, \hat{\beta})]^{-1} = \frac{1}{n} \begin{bmatrix} 1.108665 \frac{\hat{\alpha}^2}{\hat{\beta}^2} & -0.257022 \hat{\alpha} \\ -0.257022 \hat{\alpha} & 0.607927 \hat{\beta}^2 \end{bmatrix}$$

Results and discussions

The estimate of $(\hat{\alpha}, \hat{\beta})$ is calculated as (3.556466, 1.118057). Subsequently, we calculate standard deviations of the estimated parameters from . These are obtained as $(\sigma_{\hat{\alpha}}, \sigma_{\hat{\beta}}) = (0.768384, 0.199992)$. The estimated parameters $\hat{\alpha}$ and $\hat{\beta}$ are negatively correlated;

correlation coefficient is - 0.3130. The estimated mean recurrence interval is found out to be 31.968 years, which is surprisingly very different from the sample mean of the 19 recurrence intervals of the catalog. It is further observed that the standard deviation of the estimated interevent time does not exist, as $\beta < 2$. This is possibly the reason for

getting such peculiar recurrence interval. To verify the model suitability, we re-perform parameter estimation from method of Moments (MoM). The recurrence interval from MoM approach is 7.826 ± 5.795 years. The detailed calculation procedure of MoM

is available on request to the corresponding author. We now calculate the conditional probability values and associated hazard curves for different elapsed times. These curves are presented in Fig. 1.

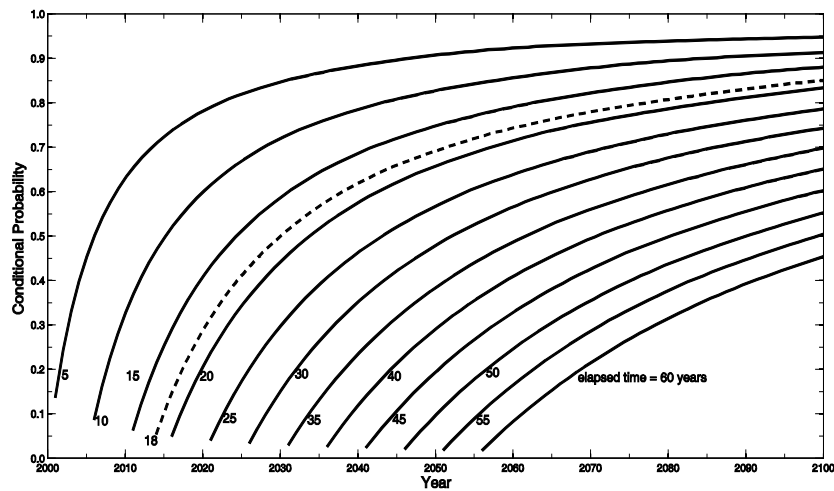


Fig. 1: Conditional probability curves (hazard curves) for elapsed time $t_e = 0, 5, 10, \dots, 60$ years

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A Comparative Analysis of Seasonal Drought Condition Measured from Evapotranspiration Based on Thermal Remote Sensing and Field Survey- A Case Study of Manbazar-I and Puncha Block of Purulia District, West Bengal, India

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Keywords: *Thermal Remote Sensing, Evapotranspiration, Drought, Surface energy balance algorithm*

Abstract: Evapotranspiration is one of the most important determining factors of availability of water in large cultivated areas and forest lands. Remote Sensing can assist in estimation of the geographical distribution of water availability and drought condition. The input data consisted of remote sensing products like land surface temperature, LAI, albedo, Net radiation, soil heat flux, sensible heat flux from LANDSAT-5 and some meteorological data such as wind speed, temperature, rainfall, relative humidity etc are used for this research. It is one type of heat balance. The major principles of the Surface Energy Balance Algorithm for Land (SEBAL) and summarizes its accuracy under several climatic conditions. Pre and post monsoon seasons are highly contrasting in temperature and evapotranspiration. In pre monsoon temperature is high due to heat wave flow and absence of precipitation is expected to increase drought condition and our study area - Purulia district is one of the drought prone areas in West Bengal, India. Thermal remote sensing data provide temperature measurements for fulfilling the requirements of such analysis. It shows seasonal agricultural changes in such application. It show the seasonal evapotranspiration changes in different land use area. High evaporation and transpiration rate cause drought. Some drought indexes for monitoring drought condition are Standardized Precipitation Index (SPI), Normalized Difference Vegetation Index (NDVI) etc. Remote sensing based models generally have the potential to accurately estimate regional ET; however, there are numerous opportunities to further improve them. The spatial and temporal resolution of currently available remote sensing data from the existing set of earth observing satellite platforms are not sufficient enough to be used in the estimation of spatially distributed ET for on farm irrigation scheduling purposes. Spatio-temporal information on actual evapotranspiration (ET) helps user to better understand evaporation depletion and to establish link between land use, water allocation, and water use. The result shows that SEBAL, ET from LANDSAT-5 can be used for estimating ET and drought condition for Manbazar-I and puncha Block, Purulia. Our study shows that evapotranspiration in 2009-10 in post monsoon season is higher than post monsoon season. Investigation into ET variability between pre and post monsoon shows being dry year in purulia district.

Introduction:

Evapotranspiration is one of the most important determining factors of availability of water in large cultivated areas and forest lands. Remote Sensing can assist in estimation of the geographical distribution of water availability and drought condition. Remote sensing is an excellent tool for this monitoring as it provides information related to mass and energy transfers and particularly to evapotranspiration fluxes. Monitoring ET has

important implications in modeling regional and global climate and the hydrological cycle, as well as assessing environmental stress on natural and agricultural ecosystem. The study area in Purulia district which is highly rain fed area and evapotranspiration is high in summer season.

Empirical studies have shown that temperature rise markedly affects the severity of droughts. Although previous year precipitation was lower than normal,

the extremely high temperatures over the purulia during April and May (more than 5°C above the average) caused the greatest damage to cultivated and natural systems and dramatically increased evaporation rates and water stress. Climatic change processes result in two main predictions with implication for the duration and magnitude of droughts: 1) precipitation will decrease in some regions and 2) an increase in global temperature. SEBAL is a thermo-dynamics based model, which partitions sensible heat flux and latent heat of vaporization flux. Semi-empirical relationships are used to estimate emissivity, roughness length from NDVI (Hafeez et al. 2002).

Background of the Study: Purulia district is one of the drought prone districts of West Bengal. The region is characterized by high evaporation and low precipitation. Temperature is very high in summer and low in winter which varies from 3.8 degrees in winter to 45 degrees in summer and causes dryness in air. The study area contains extreme in surface albedo, vegetation cover and surface temperature. The land use in this study area consists of irrigated agriculture, rain-fed agriculture and livestock grazing. Basically Puncha & Manbazar-I are affected by soil salinity, poor land fertility, limited application of fertilizers, the presence of hard or impenetrable soil horizons, the absence of control of diseases and pests and poor soil management which may limit the crop development and reduce evapotranspiration. Other factors to be considered when assessing ET are ground cover, plant density and the soil water content. The effect of soil water content on ET is conditioned primarily by the magnitude of the water deficit and the type of soil. On the other hand, the implication of vegetation changes on evapotranspiration as a consequence of these changes. It was found that an increase in irrigated agriculture and a 60% reduction in the aerial extent of native vegetation have not produced significant changes in the moisture transfer to the atmosphere. The apparent reason for this result is that irrigated agriculture has substituted one actively transpiring surface for another and, therefore, has not significantly altered the transpiration flux of the landscape

Aim and Objectives

- To estimate Evapotranspiration from the remotely sensed data.

- To show pre and post monsoonal changes in evapotranspiration.
- To assess seasonal drought condition from evapotranspiration.
- To show the heat balance from remotely sensed data and field data.
- Comparative study of area under cultivated lands and its change with season.

Location: The study area is located in the eastern part of purulia district (manbazar-1 & puncha block) which is small part of the Chhotonagpur plateau. It is located between latitude: 22°57'36"N to 23°15'0"N and longitude: 86°25'48"E to 86°47'24"E respectively. It covers an area of 684.14 sq km.

Methodology and Data Used: To achieve the objectives of the study, both primary as well as secondary raster and vector data were used. Some Meteorological data collected from Indian Meteorological Department, Govt. of India were also used e.g. min temperature, max temperature, Relative Humidity, Wind Speed, Rain Fall etc. Cover management were derived from 2009 and 2010 satellite imageries of LANDSAT-5, path 139 and row 044. An essential parameter used in the study – slope, was derived from the CARTOSAT DEM that was obtained from Earth Explorer, Global Land Cover Facility (Bastiaanssen et al. 1998).

Methodology

The methodology used to estimate Drought condition through Evapotranspiration by using SEBAL model which have been accepted by researchers all over the world (Fig. 1.). ET calculates from satellite images (Landsat-5, TM) and local weather station data (Manbazar) using surface energy balance equation. The processing of the SEBAL model was done after the standard method described by Bastiaanssen et al. (2005). The ET flux is calculated for each pixel of the image as a "residual" of the surface energy budget equation.....

$$\lambda ET = R_n - G - H \dots \dots \dots (1)$$

Where; λET is the latent heat flux (W/m^2), R_n is the net radiation flux at the surface (W/m^2), G is the soil heat flux (W/m^2), and H is the sensible heat flux to the air (W/m^2). ET is an instantaneous value for the time of the satellite overpass (W/m^2).

Surface Albedo (α): It is the ratio of the reflected radiation and incident shortwave radiation.

Spectral radiance for each band (L_λ) = $(LMAX - LMIN / 255) \times DN + LMIN$ (2)

Reflectivity for each band (ρ_λ): The reflectivity of a surface is defined as the ratio of the reflected radiation flux to the incident Radiation flux.

$$\rho_\lambda = \pi \times L_\lambda / ESUN_\lambda \times \cos\theta \times d_r \dots\dots\dots (3)$$

Where; ρ_λ is unit less planetary reflectance, L_λ calculates from equation (2), $ESUN_\lambda$ is mean solar exoatmospheric irradiances from Table , θ is solar zenith angle in degrees, and d_r is the Earth-Sun distance in astronomical that can be obtained from follow equation:

$$d_r = 1 + 0.033 \cos (DOY \times 2 \pi / 365) \dots\dots\dots (4)$$

Where DOY (or J) is number of day in one year for example DOY of January 1 is 1 hile DOY of December 31 is 365.

$$\text{Net surface radiation flux (Rn)} = Rs\downarrow - aRs\downarrow + RL\downarrow - RL\uparrow - 1 - \epsilon_o RL\downarrow \dots\dots\dots (5)$$

$$\text{Soil Heat Flux (G): } G/Rn = Ts/a \ (0.0038 \ a + 0.0074 \ a^2) \ (1 - 0.98NDVI^4) \dots\dots\dots (6)$$

Where; T_s is the surface temperature ($^{\circ}C$), α is the surface albedo, and NDVI is the Normalized Difference Vegetation Index.

Momentum Roughness Length for each pixel (Z_{om}): Using NDVI and surface albedo databy Bastiaanssen (2000) and modified by Allen (2001)⁴ can be used. In this method, z_{om} is computed from the following equation:

$$z_{om} = \exp[(a \times NDVI/a) + b] \dots\dots\dots (7)$$

Where; a and b are correlation constants derived from a plot of $\ln(z_{om})$ vs $NDVI/\alpha$ for two or more sample pixels representing specific vegetation types. The use of albedo (α) to modify NDVI helps to distinguish between some tall and short vegetation types that may have similar NDVI.

To compute the sensible heat flux (H), the near surface temperature difference (dT) for each pixel needs to be defined. This is given as $dT = T_{z1} - T_{z2}$. The air temperature at each pixel is unknown, along with explicit values for T_{z1} and T_{z2} . Therefore, only the difference dT is utilized. SEBAL computes dT for each pixel by assuming a linear relationship between dT and T_s :

$$dT = b + \dots\dots\dots (8)$$

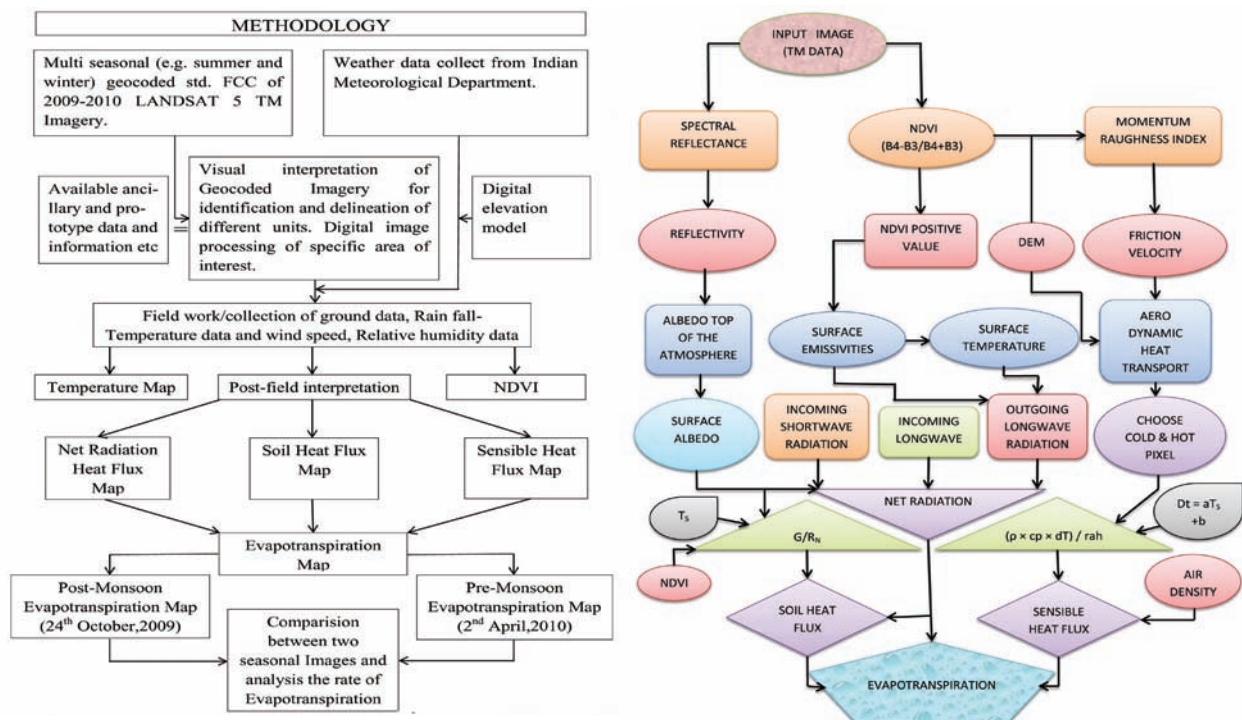


Fig.1 Flow Chart of the Methodology

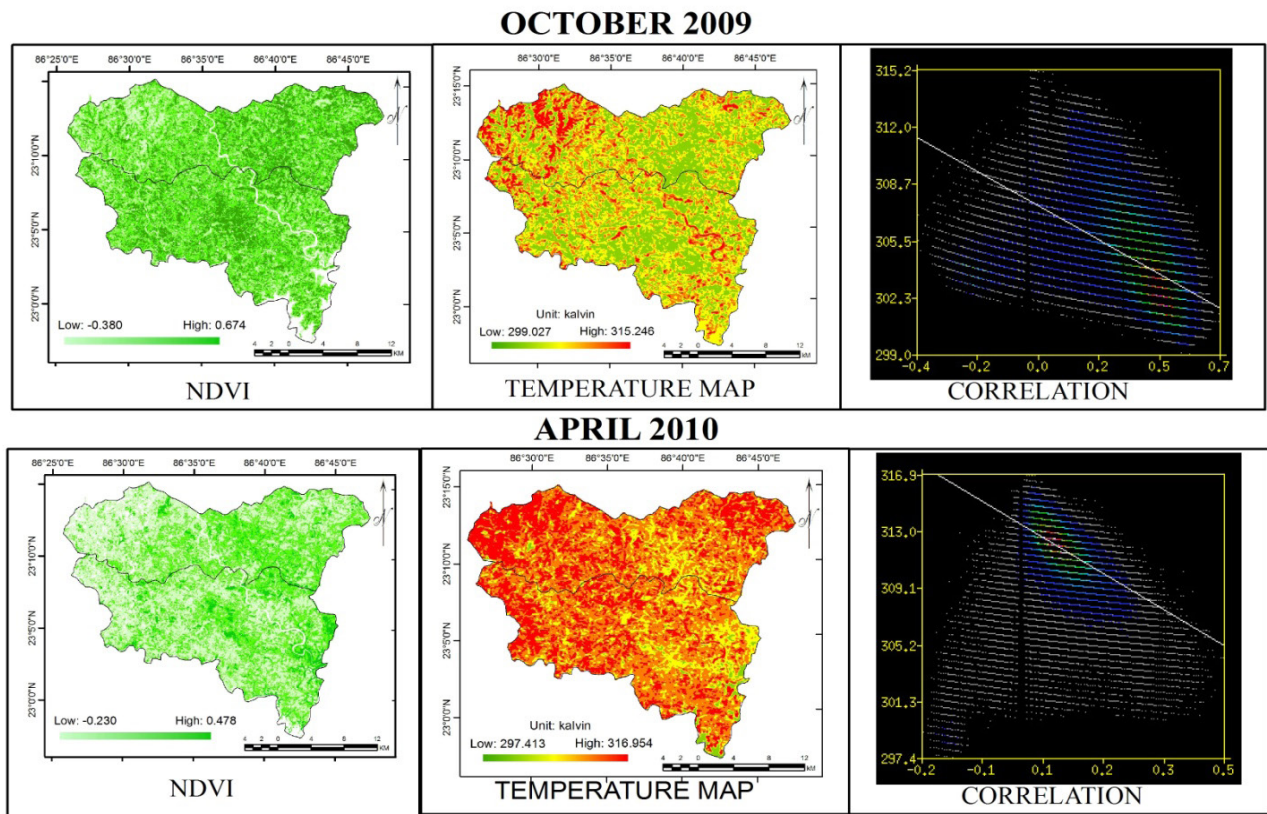


Figure 2: Comparison between NDVI and temperature index

Where; b and a are the correlation coefficients. To define these coefficients, SEBAL uses the two "anchor" pixels where a value for H can be reliably estimated. Values for H and dT at these "anchor" pixels are computed in a spreadsheet format. However, research by Bastiaanssen and others indicate that this assumption appears to fit a large range of conditions.

Comparison between NDVI and temperature index: In this method images of two different season October (2009) and April (2010) were used (Fig. 2). Analysis shows in October temperature is low and vegetation index is high that is normal condition in this study area (Manbazar-1 and Pancha block), in April temperature is very high and vegetation coverage is very low due to lack of soil moisture content. Field survey shows that in this year due to insolation large amount of water vapor content goes out through evaporation and transpiration. We see that the image of NDVI (October and April) difference between two season. A lot of agricultural area in post monsoon season but in pre monsoon season study area where the immediate impact of

drought is felt is agricultural land. With the increased intensity or extended duration of drought prevalence, a significant fall in food production is noticed. The investigation shows correlation between surface temperature and NDVI index and high temperature in the area impact of the soil moisture content and reduced seasonal output of crops & other related production.

Estimated Evapotranspiration

Using the energy balance equation and field data evapotranspiration is calculated (Narsimhan and Srinivasan, 2005). Data consisted of remote sensing products like land surface temperature, albedo (Fig. 3 and Table 1), Net radiation (Table 2), soil heat flux, sensible heat flux (Table 3) are calculated from LANDSAT-5 and meteorological data such as wind speed; temperature data, rainfall, relative humidity shows in pre monsoon season in the study area is under drought condition. In this perspective result of different land use in post and pre monsoon season shows different evapotranspiration rates (Table 4). Evaporation is high due to high temperature and also

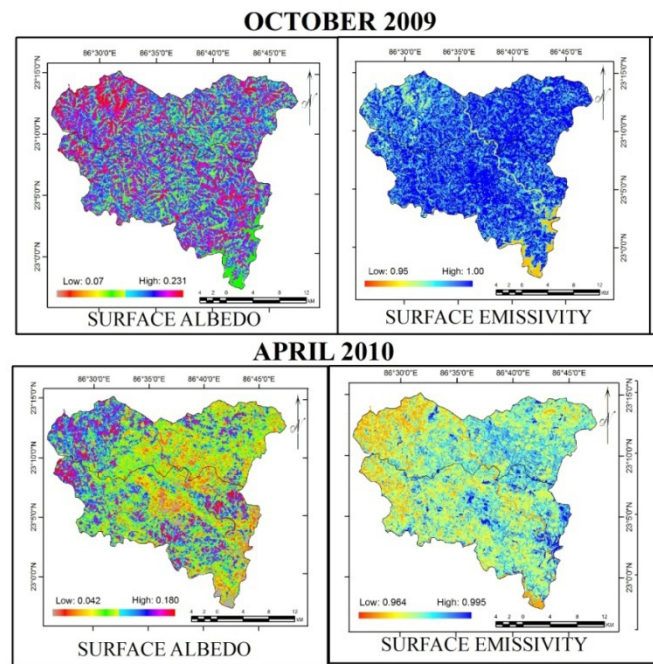


Figure 3: SURFACE ALBEDO AND EMISSIVITY

Table-1. Values of surface albedo

Black Soil	Clay	White-Yellow Sand	Gray- White Sand	Grass or Pasture	Rice Field	Coniferous Forest	Deciduous Forest	Water
0.08-0.14	0.16-0.23	0.34-0.40	0.18-0.23	0.15-0.25	0.17-0.22	0.10-0.15	0.15-0.20	0.025-0.348

Source: George joseph, Fundamental of Remote Sensing (2003)

Table-2. Surface Emissivity Condition.

Object	Grass	Leaves (dry)	Wood	Soil (dry Sandy)	Sand	Water
Emissivity	0.98	0.96	0.99	0.94	0.96	0.99

transpiration is high and probability shows the line diagram of the evapotranspiration in different land use perspective (Fig. 4) and according to field study lack of water in agricultural land it is agricultural drought

and hydrological drought and as well as it is meteorological drought because of high temperature. Observation shows in April net radiation from moist land and water body of the study area (Manbazar and Pancha block) is high and soil heat flux is low. Sensible heat in the atmosphere is very much troublesome in this season. Due to high sensible heat soil moisture is low in the ground surface and soil fertility decreases.

Table-3. sensible heat flux.

	Relative Humidity	Air Temperature	Wind Speed	Air Density	DT	
					a	b
Post monsoon	75 %	25 °C	0.5 m/s	1.129 kg/m ³	-0.7281	16.3811
Pre monsoon	55 %	30°C	3.3 m/s	1.155 kg/m ³	-0.2189	8.1252

Table- 4. Rate of evapotranspiration in Pre and Post monsoon images.

Field	Vegetation	Agricultural land	Fallow Land	River	Reservoir
Evapotranspiration Rate (October)	0.83	0.74	0.66	0.56	0.46
Evapotranspiration Rate (April)	0.72	0.61	0.58	0.55	0.45

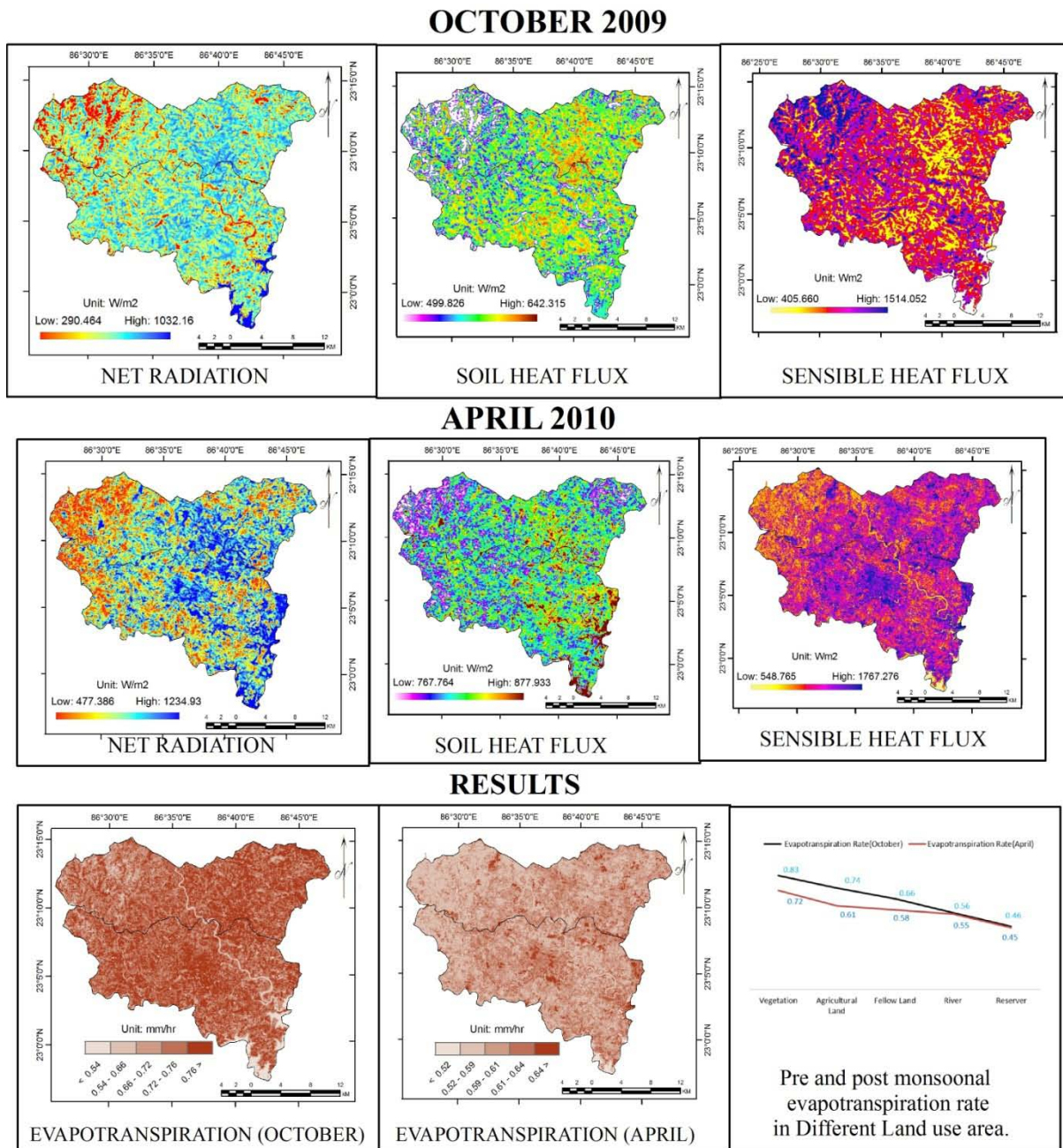


FIGURE 4: EVAPOTRANSPIRATION ESTIMATION

Recommendation

Reducing the risks and therefore the impacts associated with drought in the future requires that much greater emphasis be placed on preparedness and mitigation. Preparedness leads to greater institutional capacity to cope with drought events through the creation of an organizational structure that improves information flow and coordination between and within levels of government (Mishra and Singh,

2010). Drought preparedness coupled with appropriate mitigation actions and programs can reduce and, in some cases, eliminate many of the impacts associated with drought. Provide accurate, timely and integrated information on drought conditions at the level of regions and district. Detect drought early; it allows for activation of the drought management plan and evokes both pro active (mitigation) and reactive (emergency) responses. Immediate steps are needed to make efficient use of

available surface and groundwater in drought prone areas - resorting to drip and sprinkler practices wherever possible. Do not over graze during drought. Rotational grazing increases the ability to make it through a drought.

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Disaster Information System for Mitigation and Management - Greater Mumbai Case Study

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Keywords: *Disaster, Disaster Information System, Hazard, Mitigation, Management, measures, preparedness, GIS environment*

Abstract: Disasters are events that have a huge impact on human and on the environment. Though they are not always unpredictable, but their worst effects can be partially or completely prevented by preparation, early warning, and swift, decisive responses. Disaster management aims to reduce the occurrence of disasters and to reduce the impact of those that cannot be prevented. The focus of the Disaster Management Policy should be on total risk management and vulnerability reduction by strengthening the physical infrastructure, psychological, social and economic status of the people and to make the people increasingly disaster resilient as well. It is essential to identify the processes responsible for the disaster and the natural resources and socio-economic parameters associated with the process. Damage caused by hazards to be assessed and thereby mitigation measures appropriate planning and preventive measures and preparedness should be considered. GIS can be helpful in assessment of damages and management of such tragic events. To develop a Disaster Management Information System (DMIS) data has to be collected and classified from local levels as well as relevant organizations. The DMIS not only collect information on damage but would also support disaster preparedness and prevention activities and identify relief needs. Disaster Information System therefore would be implemented on the basis of identification of hazard prone areas and risk areas, impact zone and preparation of zonation map for query and emergency management problems. The present paper would highlight and project a holistic approach for creation of Disaster Information System for Greater Mumbai for mitigation and for damage forecasting.

Introduction

Disasters cause huge loss to human and animal life as well as human and natural assets. They also cause long run adverse impacts. Disasters are both natural and human causes, and the responses needed could stretch community and government capacity to the limit. Natural and man-made disasters, such as earthquakes, floods, plane crashes, high-rise building collapses, or major nuclear facility malfunctions, pose an ever-present challenge to public emergency services. Disaster management aims to reduce the occurrence of disasters and to reduce the impact of those that cannot be prevented. In order to cope with such disasters in a fast and highly coordinated manner the optimal provision of information concerning the situation is an essential prerequisite. Police, fire departments, public health,

civil defense and other organizations have to react not only efficiently and individually, but also in a coordinated manner. This results in the need for both intra and inters organization coordination at several hierarchy levels. Since coordination requires current information, and such information must be communicated upstream and downstream within and between organizations in real-time, the need arises for an integrated communication and information system for disaster management that provides efficient, reliable and secure exchange and processing of relevant information.

The traditional process of disaster management consists of two phases

1. pre-disaster risk-reduction and
2. post-disaster recovery phase. The first consists of activities such as prevention,

mitigation and preparedness while the second includes the activities of response, recovery and rehabilitation.

The social theories and models are quite contemporary. The systems model of Risk theory can also be incorporated in the present study as it can present the input and outputs or schematics with directionality and feedback loops. These models can contain elements in quite disparate categories, representing an interface of human, ecological, and technological interactions. Generating a model will be important for analyses within the city of Mumbai because it can very well bring out the pattern of the adjustments to disasters especially the natural disaster of flooding in Mumbai. The phases of Recovery in the Aftermath of Disaster are shown in fig. 1.

In other words, to understand disasters we must not only know about the types of hazards that might affect people, but also the different levels of vulnerability of different groups of people. This vulnerability is determined by social systems and power, not by natural forces. It needs to be understood in the context of political and economic systems that operate on national and even international scales .it is these people who decide how groups of people vary in relation to health, income, building safety, location of work and home, and so on. Along

with the systems model of social risk, study of risk governance can also be incorporated in the present study. Risk governance looks at the complex web of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken.

It is useful to differentiate between vertical risk governance and horizontal risk governance. The horizontal level includes the relevant actors in decision making processes within a defined geographical or functional segment such as all relevant actors within a community, region, nation or continent. The vertical level describes the links between these segments (such as the institutional relationships between the local, regional and state levels.) In a city like Mumbai where societies exist and governing choices is seen as interplay between governmental institutions, economic forces and civil society actors, such as non-governmental organizations (NGOs), risk governance will be important for the study as it not only involves risk and risk- related decision- making, but also extends beyond, the three conventionally recognized elements of risk analysis i.e. risk assessment, risk management and risk communication.

Information is fundamental requirement for managing disasters, while most of the

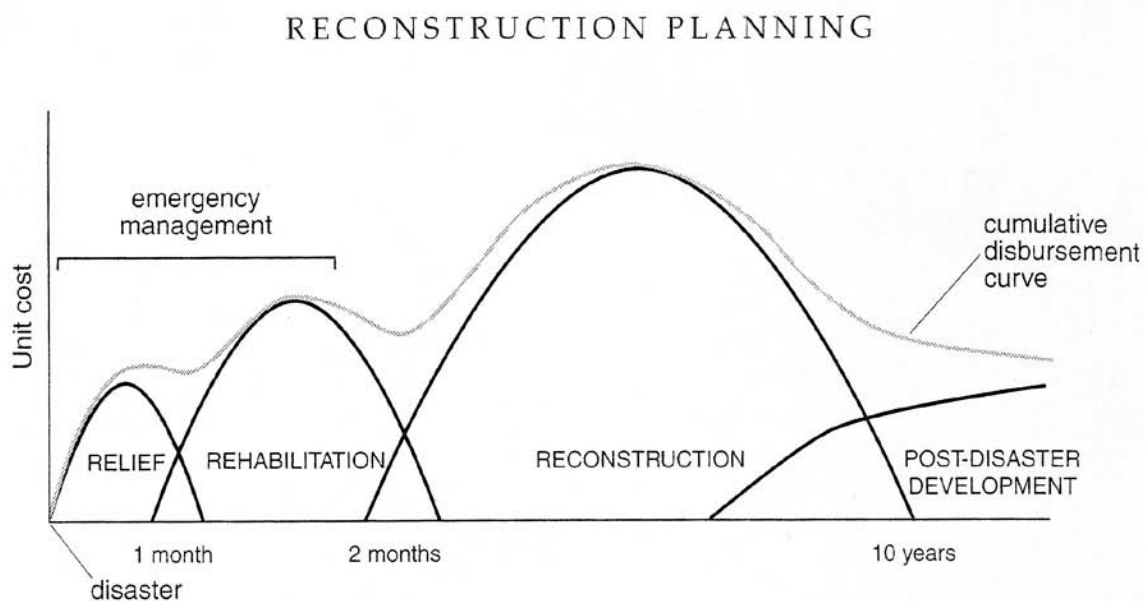


Fig. 1 Phases of Recovery in the Aftermath of Disaster(Alexander 2002)

information required for disaster management has spatial component or location. However, current studies show that there are considerable problems with managing spatial information/data required for disaster management with respect to data collection, dissemination, access and usage). Such problems become more serious during disaster response phase with its dynamic and time-sensitive nature. Disaster response is dynamic and decision-makers need to be updated on the latest emergency situation. Disaster response is also time-sensitive with little allowance on delay in decision making and response operations. Therefore, any problem or delay in data collection, access, usage and dissemination has negative impacts on the quality of decision-making and hence the quality of disaster response. With this in mind, it is necessary to utilize appropriate frameworks and technologies to resolve current spatial data problems for disaster management. Disaster response and recovery efforts require timely interaction and coordination of public emergency services in order to save lives and property. Today, IT is used in this field only to a limited extent, but there is a tremendous potential for increasing efficiency and

effectiveness in coping with a disaster. Fig. 2 shows the flow diagram of disaster cycle.

The paper sketches requirements and innovative technology for an integrated disaster management communication and information system, addressing in particular network, configuration, scheduling and data management issues during the response and recovery phases.

GIS is helpful in identifying the damage and at the same time ensure uniform distribution of emergency supplies at the right place. It is essential to identify the processes responsible for the disaster and the natural resources and socio-economic parameters associated with the process. Damage caused by hazards to be assessed and thereby mitigation measures appropriate planning and preventive measures and preparedness should be considered. GIS can be part of the solution to many emergency management problems. GIS is also helpful in identifying the damage and at the same time ensure uniform distribution of emergency supplies at the right place. Geographic Information System creates integrated geo-database to visualize scenarios for effective

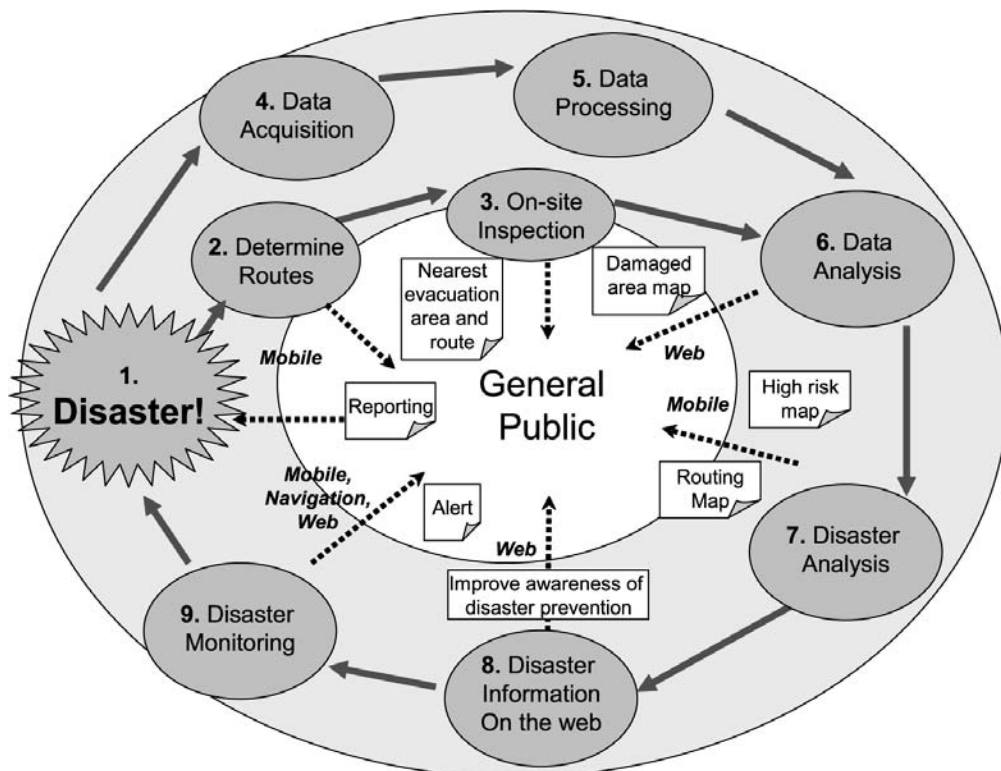


Fig. 2 Flow diagram of Disaster Cycle

solutions. Disaster prone areas could be mapped for vulnerability analysis. Advanced spatial models could be generated for disasters.

Objectives

To develop a Disaster Management Information System (DMIS)

To develop a Disaster Management Information System (DMIS) data has to be collected and classified from local levels as well as relevant organizations. The DMIS not only collect information on damage but would also support disaster preparedness and prevention activities and identify relief needs.

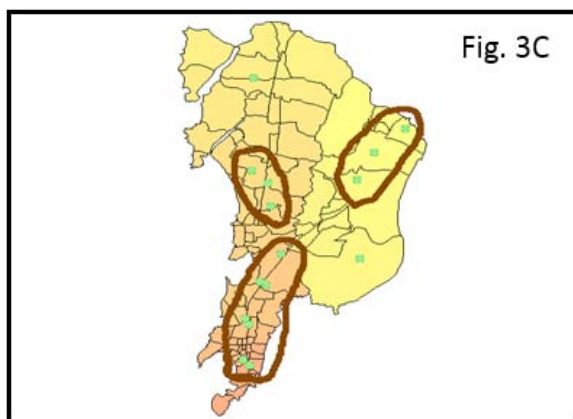
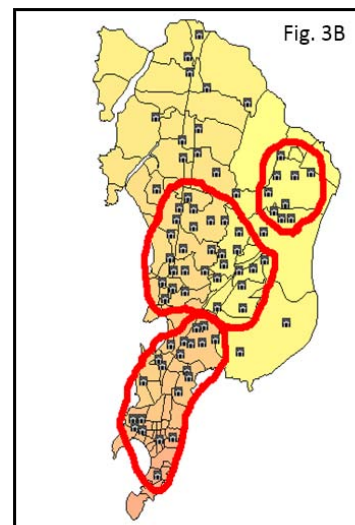
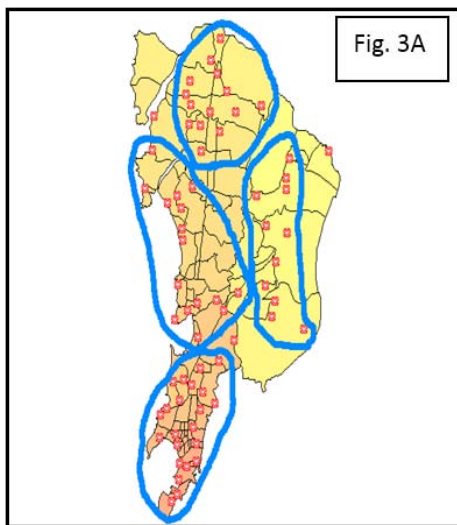
Disaster Information System therefore would be implemented on the basis of:

- Identification of hazard prone areas based on resources map.
- Identification of risk areas based on risk factors which would intensify impact hazard.

- Identification of impact zone and preparation of zonation map for query. Identify emergency management problems with spatial aspects appropriate for GIS.
- Outline an effective GIS process for collecting and analyzing spatial data for emergency management problem solving.
- Evaluate the costs of institutionalizing GIS as an emergency management tool in terms of staffing, training, data collection, hardware and software

Study Area

The city of Mumbai has a vast coastline along the Arabian Sea. The city comprised of seven small islands. In the past few decades, the city has faced severe floods twice. Mumbai is also prone to small annual (monsoonal) flooding. Greater Bombay, the smallest of the districts of Maharashtra is entirely an urban district, that has submerged in itself the former villages



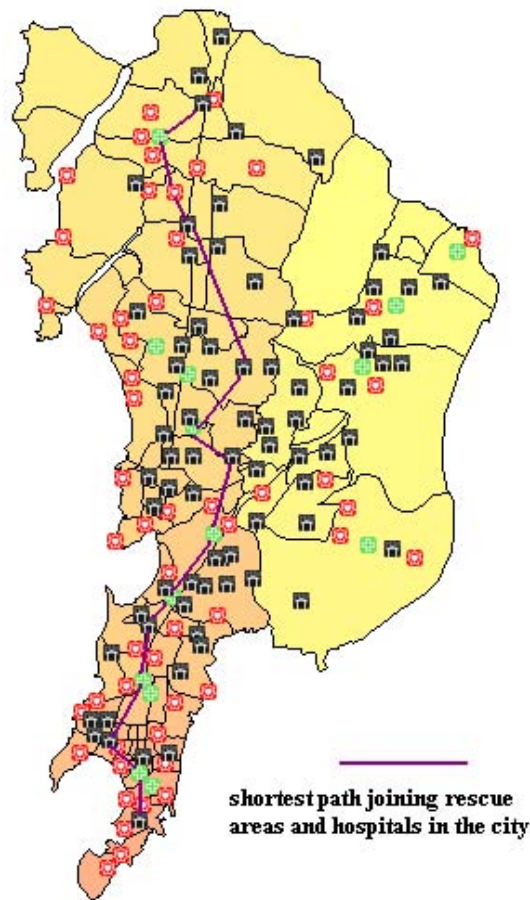


Fig. 4 Map showing hypothetical optimal path joining rescue areas hospitals and police stations in the city.

in the peri-urban fringe. The district, extends between 18°53'N. to 19°20'N. and between 72°45'E. to 73°00'E. It has an east to west extent of about 12 km. where it is broadest, and a north-south extent of about 40 km. The district covers an area of 437.71 sq. km. that constitutes 0.14 per cent of the total area of the State of Maharashtra. The importance of the district is also apparent from the fact that the district supports a population of about 8 millions, sharing 11.5 per cent of the population of the State, which is enormously out of proportion to the size of the district.

Geographically speaking, the district entirely lies outside the mainland of Konkan in Maharashtra in a group of islands separated from the mainland by the narrow Thane creek and a somewhat wider Harbour Bay. The district at present occupies the original island group of Bombay— now practically a southward protruding peninsula of the larger Salsette— and most of the island of Salsette,

with the former Trombay island appended to it in its south-east. A small part in the north of the Salsette Island, however, lies in Thane district. The Salsette-Bombay island complex lies off the mouth of the Ulhas River; the estuary in the Vasai creek and the Thane creek together separate it from the mainland. Thus, the district of Greater Bombay is surrounded on three sides by the seas— by the open Arabian Sea to the west and the south and the Harbour Bay and the Thane creek in the east. Salsette.

Results and Discussions

Mumbai and the Surrounding Region

Maps of the clusters of hypothetical police stations (Fig. 3A), rescue areas (Fig. 3B) and hospitals (3C) in Greater Mumbai are shown below. From the above given maps it can be derived that police stations are not evenly distributed and hospitals are few and far away. However potential rescue areas are evenly distributed and well spread. Fig. 4

shows hypothetical optimal path joining rescue areas, hospital and police stations in the city.

Conclusion

GIS is helpful in identifying the damage and at the same time ensure uniform distribution of emergency supplies at the right place. It is essential to identify the processes responsible for the disaster and the natural resources and socio-economic parameters associated with the process. Damage caused by hazards to be assessed and thereby mitigation measures

appropriate planning and preventive measures and preparedness should be considered. GIS can be part of the solution to many emergency management problems. GIS is also helpful in identifying the damage and at the same time ensure uniform distribution of emergency supplies at the right place. Geographic Information System creates integrated geo-database to visualize scenarios for effective solutions. Disaster prone areas could be mapped for vulnerability analysis. Advanced spatial models could be generated for disasters.

Mapping Agricultural Vulnerability for India Employing Time-series Satellite Data Products

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Keywords: MODIS, AVHRR, NDVI, AESR, SPI, Rainfed Agriculture, Vulnerability, Climate Change

Abstract: Advanced Very High Resolution Radiometer (AVHRR) 8-km Normalized Differential Vegetation Index (NDVI) data and Moderate Resolution Imaging Spectroradiometer (MODIS) 16-day 250m NDVI data product were taken to analyse vulnerability of Indian agriculture to climate change impacts. Predicted higher temperature and altered rainfall patterns accompanied by extreme weather events would impact vegetation growth in natural forest, open scrub, agricultural land and plantations. NDVI derived from 2-band information (Red & Near-infra Red) of multi-spectral imagery of NOAA-AVHRR (1982 to 2006) and from MODIS (2000-2010) were analyzed. CV of Max NDVI from 15-day composites for the total length of study period was used to assess agricultural vulnerability and results were corroborated with Standard Precipitation Index (SPI). AVHRR time-series data helped to identify vulnerable areas at regional scale i.e., agro-ecological sub-regions (AESR) while MODIS data products helped to identify vulnerability at sub-district level. It is estimated that over 263.74 M ha area in the country may be vulnerable to climate change of which over 81.3 M ha are located in arid, semi-arid and dry sub-humid regions. Study indicated that over 12.1 and 1.81 M ha of Kharif cropland would be mildly and severally vulnerable respectively, while 6.86 and 0.5 M ha of Rabi cropland may be adversely affected in a similar manner. Of the remaining agricultural lands, 29.93 and 5.24 M ha would also be vulnerable similarly.

Introduction

Tools and techniques of remote sensing and GIS can help in examining impacts of weather aberrations on bio-physical cover of earth like vegetation, land use, water resource and soils. Weather variables like precipitation and temperature result in change in LULC and they also impact vegetation growth and vigour for which Normalized Difference Vegetation Index (NDVI) are used. Due to perceived increasing variability in climatic conditions in India as a result of frequent drought and flood occurrences in recent past, Govt of India advised the ICAR to study the impact of climate change on agriculture. With this end in view, ICAR launched a large network research program titled National Initiative on Climate Resilient Agriculture (NICRA) in February 2011 to study trends in climate variability in the country in order to develop strategy and adaptation methods to manage climatic disasters. Study was

initiated to identify agriculturally vulnerable regions in the rainfed regions which forms a major chunk of net sown area in the country. NDVI derived from time-series satellite data like NOAA-AVHRR and TERRA-MODIS were downloaded and an assessment was attempted.

GIMMS dataset of NOAA- AVHRR with 8km resolution was used to analyse agricultural vulnerability at a region level namely, State- and AESR- level for 1982-2006 period, while MODIS - TERRA NDVI data product with 250m resolution was used to assess agricultural vulnerability at district-level from 2001 onwards. Standard Precipitation Index (SPI) instead of actual rainfall data was used to corroborate extreme weather events to explain resultant variations in NDVI.

Material and methods

Time-series NDVI data products of AVHRR space-borne sensor of NOAA polar-orbiting

satellites were used for a 27-yr period starting from 1982 onwards. The first two spectral bands of satellite data out of five, i.e., Red (0.58 to 0.68 μm) and Near-Infrared (0.75 to 1.1 μm) essentially useful for mapping clouds and land surface and for delineating surface water bodies respectively, when combined was found useful for monitoring vegetation cover on earth surface (Tucker *et al.*, 2004, 2005). This data product was used for assessing agricultural vulnerability in the country. AVHRR NDVI product which is available for whole of Indian sub-continent was sub-set from the global coverage as one tile for each year starting from 1982. Bi-monthly NDVI images were stacked and pre-processed, followed by identification of pixel-wise Max NDVI for arriving at Maximum Greenness during corresponding year (1982 – 2006). This was followed by estimation of Mean and Standard Deviation of Max NDVI. To assess vulnerability, CV of Max NDVI was calculated which formed the basis for vulnerability analysis at AESR-level. This task helped in estimating spatial extent of agriculturally vulnerable region in India (Kaushalya *et al.*, 2013a). MODIS (16-day 250m) NDVI data product was used to downscale vulnerability analysis to district-level so that it can help in implementing mitigation and adaptation strategies at the local administrative-level. Geo-statistical analysis was used to estimate the extent of vulnerable regions in the country (Kaushalya *et al.*, 2013b).

The source of AVHRR NDVI is the Global Inventory Modeling and Mapping Studies (GIMMS) data set obtained from AVHRR instrument onboard NOAA satellite series 7, 9, 11, 14, 16 and 17 for the period 1981 till 2006. The data has been corrected for calibration, view geometry, volcanic aerosols and other effects not related to vegetation change and hence was found useful for the present study. NDVI values range from - 1.0 to +1.0. The data was downloaded from the Global Land Cover Facility (GLCF) website at www.landcover.org/http://www.glcg.umd.edu/data/gimms/ at 15-day Maximum-Value Composite). MODIS data set was obtained from NASA experiment with Moderate Resolution Imaging Spectroradiometer (MODIS) on board TERRA and AQUA earth observation research satellites. It has a sweeping swath of 2330 km width and covers all parts of the earth in 1-2

days in 36 discreet spectral bands and is thus a great improvement on earth sensing capability over AVHRR (<http://terra.nasa.gov/>). MODIS was found ideal for monitoring large-scale changes in biosphere and hence used for the study. MODIS - 250m NDVI composite data products are freely available from Land Processes - Distributed Active Archive Centre (LPDAAC) website of USGS <<http://mrtweb.cr.usgs.gov/>>. The Indian sub-continent is covered in 13 tiles, i.e., h25v08, h25v07, h24v07, h26v07, h25v06, h24v06, h26v06, h23v05, h24v05, h26v06, h21v07, h27v08 and h25v08 and the NDVI data product is available from February 2000 till date.

Standardized Precipitation Index (SPI) which represents total difference of precipitation for a given period of time from its Climatological Mean and then normalized by Standard Deviation (SD) of precipitation for the same period, provides an improved tool to assess variations in precipitation and its associated impacts (Saikia and Kumar, 2011). IMD provides daily rainfall data of more than 100 years for many stations from its archives. Daily gridded rainfall dataset for 1901–2007 was developed by Rajeevan *et al* (2008). The authors used rainfall data of 1384 stations to generate rainfall data set on regular grids of 1°latitude x 1°longitude. Using this value we estimated SPI using the following formulae:

$$\text{SPI} = \frac{a - A}{sd}$$

where,

a = current precipitation for a given period

A = long- term normal of precipitation for the same period

sd = Standard Deviation of precipitation for the given period

Thus, long-term precipitation record was fitted to a probability distribution which was then transformed into a normal distribution so that Mean SPI for a location and desired period is equal to zero. Positive SPI values indicated greater than Median precipitation, while negative values indicated less than Median precipitation. As SPI is normalized, both wetter and drier climates can be presented in a similar manner, and both wet and dry periods

denoting flood and drought respectively, could be monitored using SPI, thus making it time and space- independent (McKee et al 1993). Accordingly, SPI of ≤ 1.00 for any given period was considered as start of reduced rainfall period which could lead to drought, if prolonged. On the other hand, drought is said to end if SPI is positive. This data was used to corroborate the NDVI variations in the country.

Normalized difference vegetation index (NDVI) which is a contrast –stretch ratio calculated from Red band and Near –Infrared band (NIR) of sensors like LANDSAT – TM; AVHRR; IRS-1B, 1C, 1D, P6 : LISS-3 / LISS-4; and MODIS besides several others was used to take the advantage of typical low reflectance values of vegetation in the Red wavelength range which corresponds with chlorophyll absorption and high reflectance values in NIR range which signifies leaf structure, thereby enhancing contrast between vegetated, un-vegetated and sparsely vegetated areas. Land use and/or Land Cover (LULC) analysis helped in identifying NDVI variations in agriculture, forest and open scrubland. The methodology

used for the present study has been indicated in Figure 1.

At the outset, NDVI data sets were ordered from the respective websites in Geo-tiff format and re-projected in Geographic Projection. MODIS - NDVI data required pre-processing involving several steps like stacking of 16 - day composite consisting of 23 images annually, followed by cloud screening to clean NDVI data. Later the data was multiplied with a scale-factor (0.0001) in order to convert the 16-bit signed integer value (ranging from -3000 to 10,000) to derive pixel- wise Float Point or NDVI value. Cloud screening involved using 8-bit data layer which provides information on quality of pixel-wise NDVI value for pixel reliability ranging from 0-1; similar values meant reliable data. *Savitzky-Golay* filter was used to reconstruct a high- quality NDVI time-series data through smoothening of data using Polynomial - Least-Square Fit method on a 4*4 pixels moving window (Chen, 2004). To analyse NDVI variations, CV of Max NDVI value was calculated as in case of Central, West Asia & North Africa region carried out by ICARDA

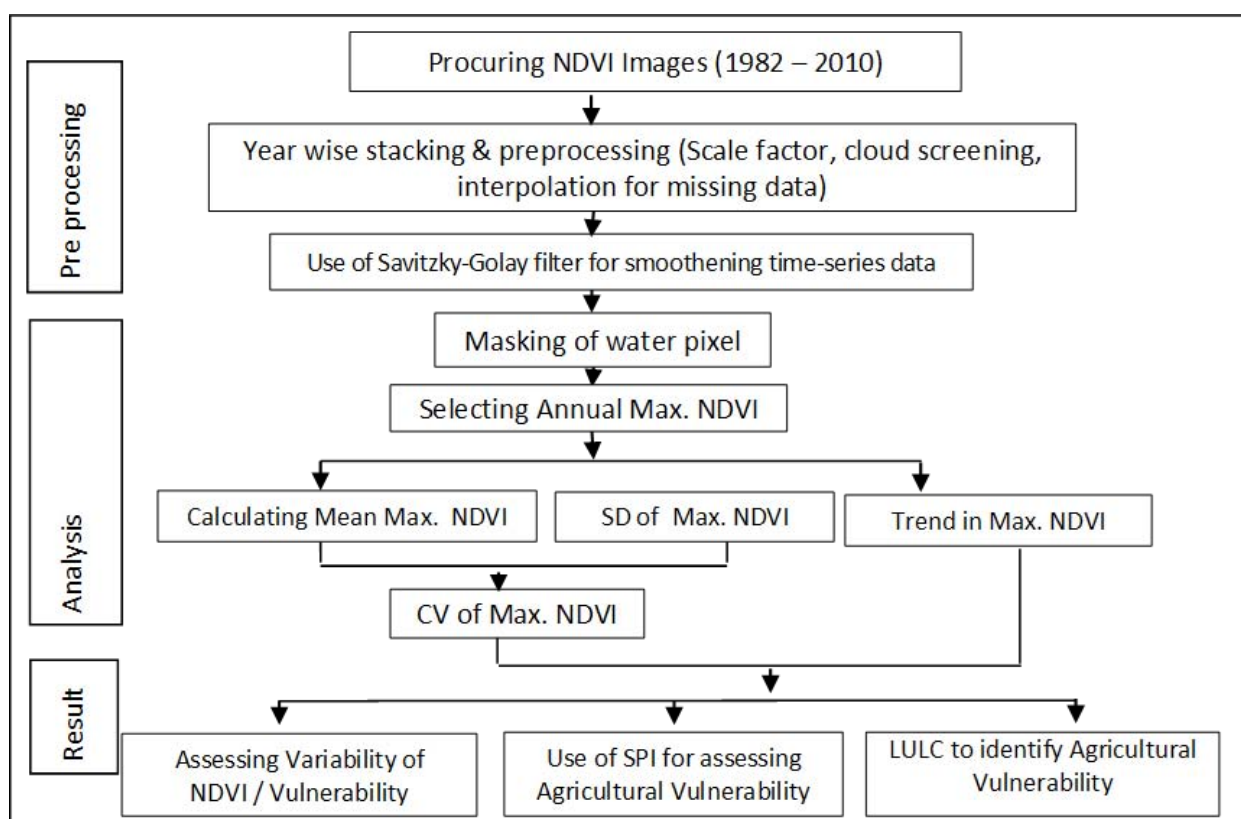


Fig. 1 Methodology

(Celis *et al.*, 2007) and suitably modifications for Indian conditions

Results and discussion

Climate change is an insidious process and hence long-term studies become essential for understanding trends and magnitude of this problem. In India where agriculture is largely rain-dependant, the need to understand slow and scarcely perceptible change in vegetation growth and its dynamics is critical for planning agricultural strategies and adaptation mechanisms, in order to, mitigate or reduce vulnerability to extreme weather events and / or to slow progress of climate change owing to natural and anthropogenic factors.

Climate change leading to aberrant weather conditions can result in reduction in length of crop growing period (LGP) due to early onset or withdrawal of monsoon, increase in intense rainfall events and reduction in number of rainy days, monsoon failure or floods and a general shift in spatial pattern of rainfall. For instance, analysis of rainfall pattern in last 107 years (Rajeevan *et al.*, 2008) has shown an increase in rainfall in drought-prone Anantapur district in Rayalseema region in Andhra Pradesh but a fall in NE region (Ravindranath *et al.*, 2011) which could be disastrous for the country. Even irrigated agriculture may not be immune to climate change as snow cover and glaciers shrink and perennial rivers receive lesser waterflow on one hand, while lower rainfall would cause lesser groundwater recharge.

Large variations were seen in vegetation dynamics in the country owing to climatic variability. While arid regions in W Rajasthan and Gujarat and south-central India in Bellary and Anantapur have sparse vegetation and large livestock population, their dependency on this sparse vegetative cover makes it critical for vulnerability monitoring and evaluation on one hand while implementing adaptation mechanisms on the other. In the semi-arid and sub-humid zones which account for a large proportion of rainfed agriculture region, vulnerability to climate change owing to poor natural resource base and large number of marginal and small farm holdings and over dependence on SW monsoon rainfall, makes the region critical. Humid regions with two or three cropping seasons may be also be devastated due to floods or drought while per-

humid regions like the NE region in India, may suffer due to decline in rainfall.

Study revealed that rainfall was highest during the months of July-Aug. and Max NDVI occurred during the months of Sept. - Oct. annually. Only SW monsoon rainfall data was used for the present study and 1982 was taken as the base year. Mean NDVI ranged from 0.0 to 0.79 while Max NDVI ranged from 0.014 to 0.995. Although the country saw normal rainfall across various ecozones, SPI indicated a moderate drying condition in West Bengal, eastern Bihar and Jharkhand, in a small part in Vidharba and southern Madhya Pradesh and around National Capital Region, south eastern Punjab, southern Himachal Pradesh and south-west Uttarakhand, which is an important agriculture belt in northern India.

To understand the dynamics of weather aberrations, a temporal analysis was carried out for each year during the study period. CV of Max. NDVI from AVHRR (8-km) data was calculated for a period of 25 years (1982-2006) and one CV of Max NDVI value was arrived at which was used to plot Vulnerability Map at pixel-level for each State and AESR in the country (Figure 2). As is revealed in the figure, there is a clear north - south axis to the spatial distribution of agricultural vulnerability to climate change based on AVHRR NDVI data. The vulnerable zones indicated therein correspond with the arid and semi-arid regions which also include the transition belt between semi-arid and dry sub-humid zones.

Vulnerability was analysed with reference to land use / land cover based on LULC Atlas of NRSC (2011). Table 1 indicates that over 1.81 and 12.1 M ha of *Kharif* cropland may be severely and moderately vulnerable respectively, to climate change. Additionally over 0.5 and 6.86 M ha of *Rabi* cropland may be severely and moderately vulnerable. Rest of the agricultural land including double, triple cropped area, current fallow, plantation and orchards in 5.24 M ha would be adversely affected while 29.93 M ha may be only marginally vulnerable to climate change in India.

Analysis of vulnerability at AESR -level indicated that Thar desert and the Kachchh Peninsula besides Malwa plateau, Vindhyan scrubland and Narmada river valley may be

Table 1: Extent of agricultural vulnerability to climate change in India

AESR No.	Geographical region in India	Climate type	Geog. area (M ha)	Soil type	Vulnerability (CV Max NDVI)			
					<10	10 - 20	20 - 30	30 - 40
					Extent (Area in M ha)			
2.1 & 2.2	Thar & Kacchh region	Hot hyper arid	14.3	Shallow - deep sandy desertic; deep loam; saline & alkali	0.82	3.61	5.52	4.02
2.3	Plains of Rajasthan, N Gujarat & SW Punjab	Hot Typic arid	11.5	Deep loamy desertic	3.7	4.3	2.99	0.42
2.4 & 3.0	S Kacchh, N Kathiawar & Karnataka Plateau	Hot arid	7.0	Deep loamy; saline & alkali; mixed red & black	2.72	6.77	1.07	0.30
4.1	N Punjab Plain; Ganga-Yamuna Doab; Rajasthan Upland	Hot semi-arid	11.8	Deep loamy alluvium-derived	9.45	2.17	0.16	0.01
4.2, 5.1, 7.1 & 6.1	N Gujarat Plain (incl. Aravalli Uplands); Kathiawar; S Telangana & N Karnataka Plateau; SW Maharastra	Hot dry semi-arid	21.8	Deep loamy grey brown & alluvium-derived; Shallow loam; clayey; mixed red & black; shallow - medium loam	11.78	9.2	0.66	0.09
5.2 & 5.3	Plateaus & ranges of Central India, Malwa, E Maharashtra, N Karnataka & NW Telangana & E Gujarat plain	Hot moist semi-arid	42.1	Medium - deep clayey black; Deep loamy coastal alluvium; Shallow - medium loam; Deep loamy clay; mixed red & black	29.93	11.59	0.18	0.31
10.1	Malwa plateau; Vindhyan hills & Narmada valley	Hot dry sub-humid	8.1	Medium and deep clayey black; shallow loamy black	0.48	2.09	3.29	2.22

severely vulnerable to climate change followed by central India and northern Gujarat. According to the MODIS data sets used to refine the study further, over 239.14 M ha may

be marginally affected by climate change. Over 55 M ha may be moderately vulnerable while over 8 M ha may be severely affected in the country.

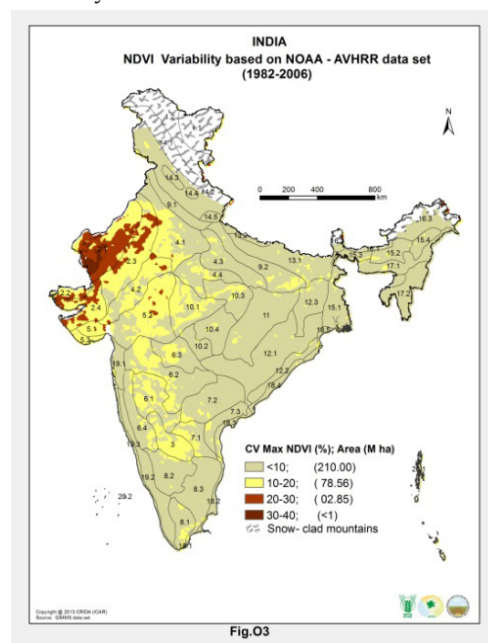
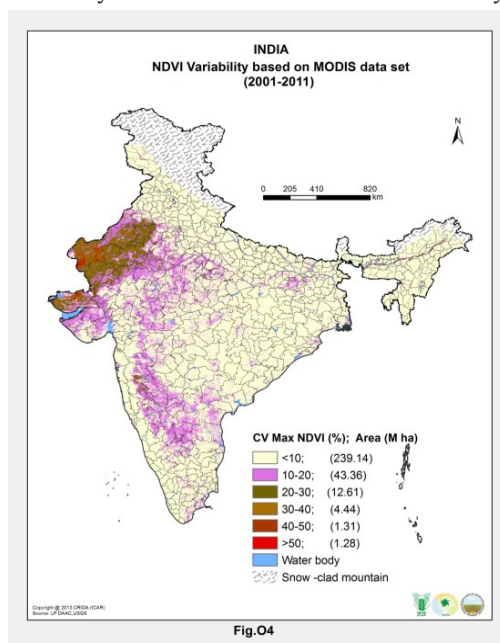


Fig. 2.

In most parts of the country, vulnerability based on CV of Max. NDVI ranged from 10-20% only. However, western Rajasthan was seen to be the most vulnerable with an estimated CV of 30-40%. The snow- clad Himalayan regions were excluded from the study for the present owing to shortfalls in data availability.

Conclusion

Study revealed that AVHRR and MODIS NDVI time-series data are useful for investigating the slow process of climate change as they provide an authentic spatial reference to analysis of agricultural vulnerability. As these datasets are readily available, their inclusion in planning for adaptation and mitigation strategies is recommended. AVHRR 8km dataset was used to acquire a synoptic view of agricultural vulnerability at a regional level due to restrictions of resolution. MODIS 250m NDVI products was used to down-scale the study at sub-district level which would help in actual implementation of mitigation strategies at the local-level. Study indicated that nearly 241 M ha of India may remain unaffected from climate change while over 81.3 M ha may be vulnerable in Rajasthan, Gujarat, Marathwada and Vidharbha regions in addition to semi-arid tracts in Karnataka and Andhra Pradesh where rainfed agriculture is widely practiced. Availability of similar products from IRS data may be very useful for the country.

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Disaster in Uttarakhand - A Real Challenge to Mankind

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Abstract: Natural disaster or man-made disaster a serious disruption of the functioning of a civilized society due to widespread loss of human, material and present status of lively hood. "Natural" disasters happen to be rains, floods, earthquakes and landslides, which are not in controls of individual, involve largely geological and climatic changes. In "manned" disasters, the principal direct causes are identifiable human actions. Uttarakhand state in the Himalayan range is very much prone to natural disaster, due to the neo-tectonic mountain-building process, but in the last few decades the state has under gone a tremendous change in the name of developmental activities. Moreover the spread of unchecked developmental activities has transformed natural disasters into man-made events. Of course, this time flood and mass debris from mountain is not a new happening. Earlier the region suffered one of the worst floods during the year 1970, but the intense of damage and its effects were not as divested as it now happens at Badrinath, Gaurikund & Kedarnath. The unexpected glacial bust proved fatal for thousands of pilgrims, locals and habitats of the region. The author has carried out and investigated deeply into the catastrophic events to find out the cause of such extensive floods and its impact on this region. The recent devastating floods and loss of human life is due to various power projects without considering the environmental impact, blasting of hills & dumping of debris on the river banks, encroachment of dry river bed, glacial outburst floods & heavy rain falls are the root of all causes. Even Govt. agency has not taken any initiative to handle the heavy rush of rain water to the reservoir basin and subsequent release of water to downstream without any warning or information to the public. All crisis are man-made. Nature won't change course. We must find a solution to work in harmony with nature. Further author has identified that the Himalayan glacier is melting in alarming rate and is gradually changing its colour from snow white to blackish white due to air pollution. The more alarming is the increase of black carbon at higher elevation in the atmosphere resulting in quick melting of glacier, which may lead to further divesting in future to the Himalayan state. Black carbon may be responsible for up to 1°C of warming in the Gangotri region.

Introduction

The recent catastrophic of Uttarakhand State is not an overnight phenomena but a disaster induced by nature and further compounded by human factor and an overview of geographical location of Kedarnath will provide a virtual information regarding what caused the worst ever natural disaster. Uttarakhand state in the Himalayan range is very much prone to natural disaster, due to the neo-tectonic mountain-building process, but in the last few decades the state has under gone a tremendous change in the name of developmental activities. Exploitation of nature and ecologically sensitive mountain ecosystem by anthropogenic activities

like construction of hydro-electricity project, settlement activities, tourism has compounded the gravity of disaster. The unexpected glacial bust and heavy rain fall proved fatal for thousands of pilgrims, locals and habitats of the region. Science has advanced in many folds in all direction but the new State has not so advanced and miserably failed to develop any system of early warning, forecasting and disseminating rainfall and landslide related information to the people . The massive floods at Kedarnath have left behind a trail of death and destruction in the entire valley stretching from the temple town to Gaurikund and further downstream. The 1,200-year-old shrine now stands alone amid a sea of debris.

Study area

Kedarnath- A temple town is located in Rudraprayag district of Uttarakhand State. It is located at a distance of 223 km from Rishikesh and at a height of 3,583 m above MSL (Mean Sea Level). Kedarnath town is located in extremities of Central Himalaya in Mandakni river valley with a total catchment area of about 68 sq.km (up to Ramabara), out of which one fourth is covered by glaciers. The catchment area is situated in the "U" shaped valley with an altitude ranging from 2740 m to 6578 m. Mandakini river originate from Chorabari Glacier (3895m) near Chorabari lake and join Saraswati river which originates from companion glacier passing through Rambara and Gourikund. Kedarnath town is located south of Chorabari and Companion glacier. Channels of river Mandakini and Swaraswati meet near Kedarnath town as seen in Fig.1. These streams cut their bank every year. Expansion of the temple town has led to change in course of Saraswathi River. Rambara and Gourikund town in downstream areas is built

on old colluvial and fluvial deposits which are loose and prone to landslides and river cutting.

Materials & Method Used

The following remotely sensed Images of various Images are used in the analysis of data.

- Cartosat-1 imagery (2.5m) 2011, Cartosat-2A imagery (1.0 m) on 20-6-2013
- Resourcesat-1 imagery (5.6 m) on 2013, Landsat (30 m) on 2011, Landsat-8 (15 m) on 22-5-2013, Landsat, 23-6-2013

This study is based on the satellite images of environs of Kedarnath town. To assess the spatial extent and factors responsible for this natural disaster, data was classified by hybrid approach using supervised and visual interpretation to assess the pre and post stages of the disaster with special focus on built up area, road, and blockage of flow of water passages. This process was carried out using Erdas Imagine Remote Sensing Software. During the change detection analysis, new and old water channel was digitised to assess

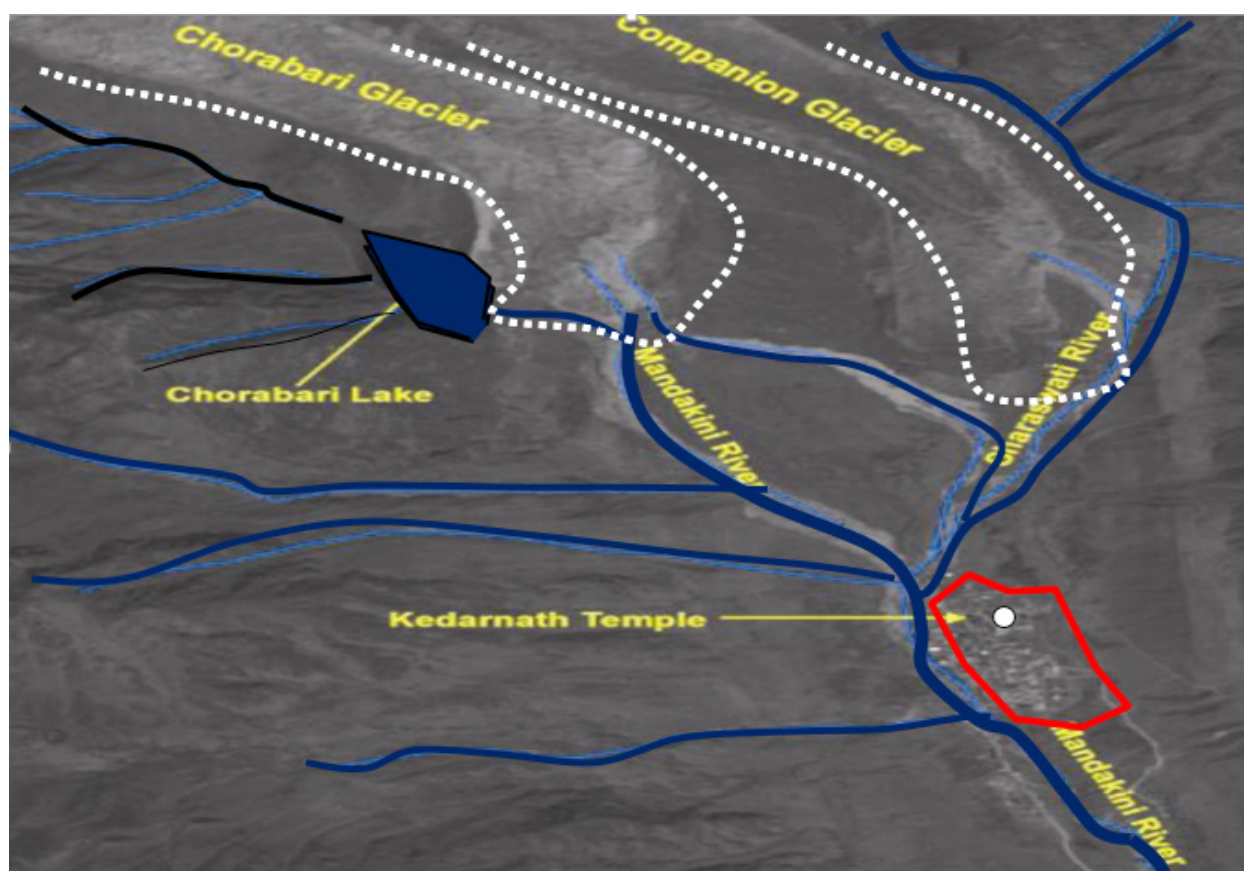


Fig. 1 Cartosat-1 image, 2011 showing drainage system, glaciers, lake and township

the natural calamity. High resolution Indian Satellite data is also used to visualize the changes in the region.

Causes of Kedarnath Tragedy

1. Climatic Factor: Recent climate change has had significant impact on high mountain glacial environment like that of Uttarkhand. According to Indian Metrological Department (IMD) heavy rainfall on the higher parts of Uttarakhand is linked to convergence of south west monsoon trough and westerly disturbances which led to dense cloud formation over Uttarakhand Himalaya.

The atmospheric pressure declined from 15th June and reaching a low of 832.4 mbs on 17th June 2013). From 14th to 17th June 2013, Uttarakhand and adjoining area received heavy rainfall (375%) more than normal monsoon. This caused melting of Chorabari glacier at a height of 3895 m which resulted in overflow of Mandakini River leading to floods at Kedardarnath & Rudraprayag (Fig. 2).

This metrological phenomenon has lead to following events which has made the Kedarnath episode a major disaster with following consequences.

1. Rapid melting of snow and heavy rainfall on the 16th and 17th June has resulted in bursting of moraine damped lake like chorabari leading to flooding of Saraswathi and Mandakini rivers in Rudraprayag district. Chorabari lake is a snow melt as well as rainfed lake located about 2 km upstream of Kedranath town. This is about 400 m long, 200m wide with a depth of 15 to 25 m. The bursting of this lake leads to complete draining of its water within few minutes. The metrological lab of records 210 mm rainfall in 12 hrs between June 15th (5 pm) to 16th June (6.00 am) as shown in fig. 3.

2. Prolonged Heavy Downpour on 16 to 17th June due to cloudburst in Kedarnath valley and surrounding area damaged the banks of Mandakini River between Kedarnath and Sonprayag leading to flooding of towns like Gourikund, Rambara & Kedarnath.

3. Geological Factors

Uttarakhand a seismic prone area is subjected to frequent land slide but on 16th and 17th June landslide have occurred due to heavy rainfall and damage of the slope along the banks of Mandakini River. The landslides have caused heavy damage to the Alkananda River. Floods caused heavy damage in the

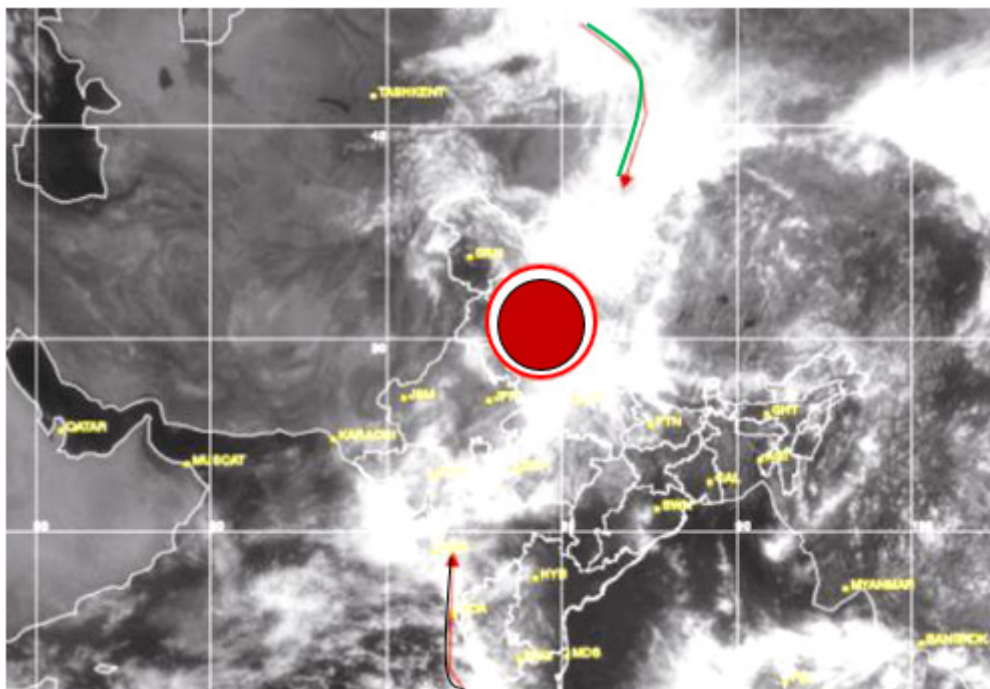


Fig.2 Indian Meteorological Department Image (17 June 2013). Arrows (red colour) on the map indicate the moisture sources of the area.

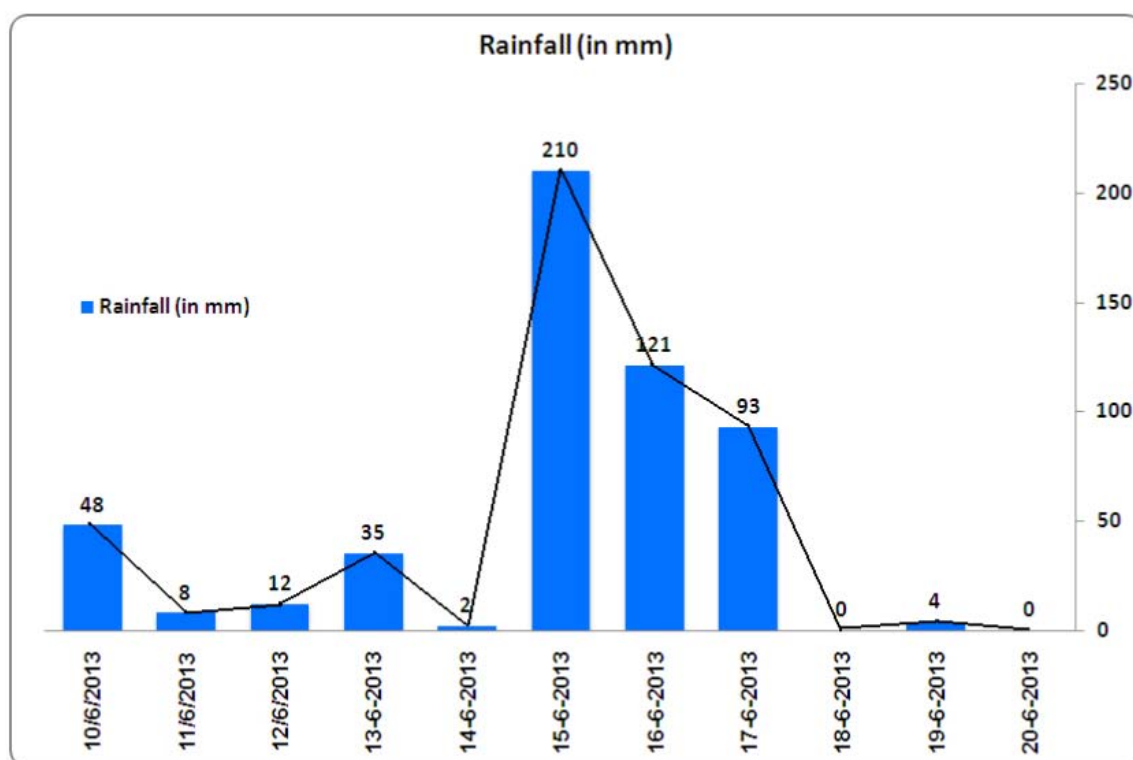


Fig.3 Rainfall observed by Kopardhar observatory near Kedarnath

perennial water stream. The devastation of the settlement is caused not only due to flood water discharge but also due to the moraine deposits which includes huge rocky boulder which is an outcome of bursting of moraine dammed Chorabari Lake. The environs of Kedarnath settlement is located in the flood plain area consisting of loose alluvial deposits, which was easily washed off due to flood water leading to collapse of large number of buildings. The other geomorphic factor attributed is obstruction of natural path of channels due to construction activities resulting in the deviations of the flow path of channels. These features are shown in fig. 4.

4. Construction of River Valley Projects

There are nearly 60 to 70 Hydro Electric Power Projects are either constructed or under construction in this area which also causes the imbalances in ecosystem of the area, even small run-of-the-river projects can cause severe damage to the rivers. They re-route water through tunnels, cutting through mountains to increase the pressure, leaving long stretches of river dry. The striking example is Madhya Maheshwar SHP plant in Uttarakhand uses a

4 km-long tunnel to divert water. Also large number of projects is at very short distances from each other, leaving little space for rivers to regenerate and revive.

River Bank Side Development /Construction Activities

Kedarnath town has developed along the banks of Mandakini River. It is one of the oldest settlements which have expanded rapidly. Due to bank side developmental activities the natural flow of the river is impacted leading to colossal loss of damage to life and property. The channel of the river will not be able to hold the water discharged during the flood time due to the encroachment of flood plain area.

Tourism Activities

Kedarnath town is located in the central Himalayan region surrounded by snow clad mountains, deep gorges. The slope of the mountain is covered by less green forest making this place as one of the most significant tourist place. Basically Kedarnath town has emerged as the tourist place due to religious significance. It is one of the places of religious spot among Char Dham (other places include

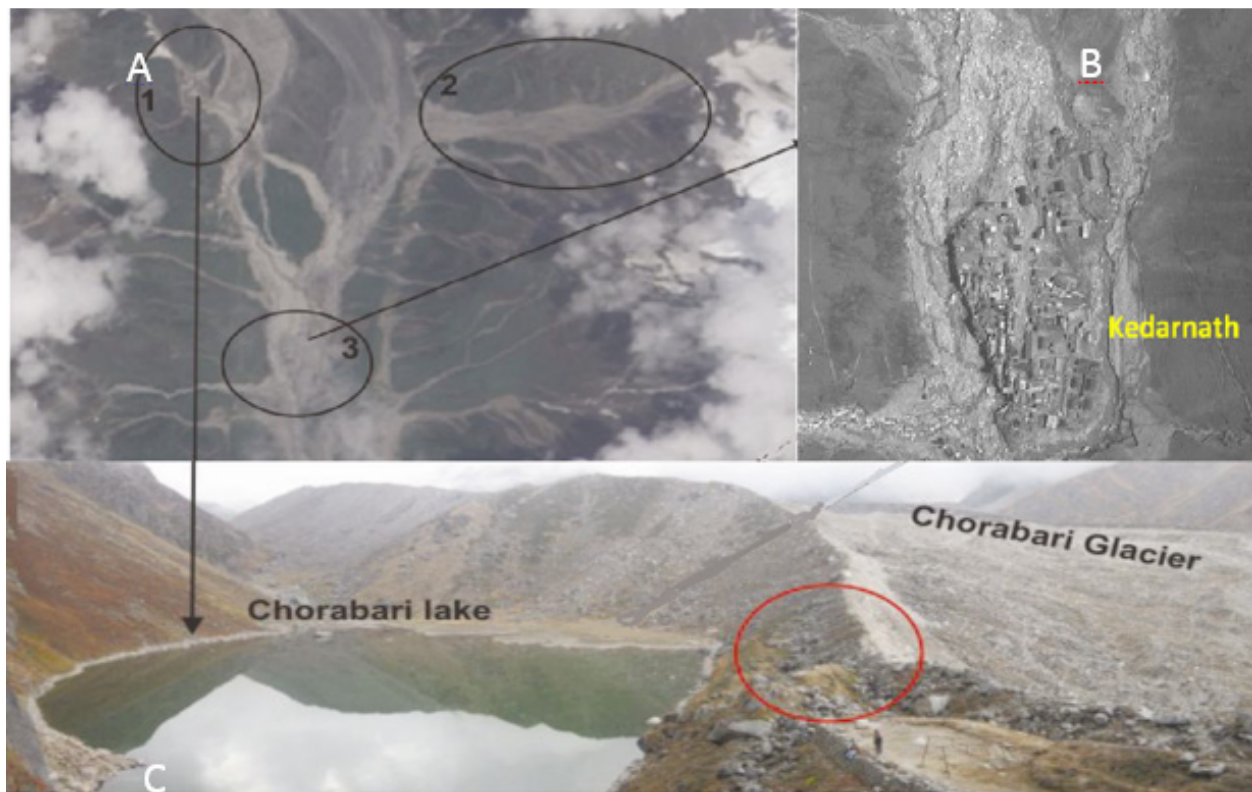


Fig. 4(A) Landsat-8 image on 22nd June 2013(1) showing Chorabari lake weak area (2)maximum erosion area & (3) maximum damage area of temple city.(B) Kedarnath as in Cartosat-2 image(C)Panoramic view of Chorabari lake and red circle indicate the breaking position of lake.

Gangotri, Yamunotri and Badrinath). These places are visited every year by large number of tourists resulting strain on fragile mountain ecosystem.

Slope Modification / Deforestation

Due to large scale anthropogenic activity like construction of settlement along the slope of the mountain, construction of roads by cutting slope of mountains will lead to modification and destabilization of the slope. This will increase problem of land slide and can be easily damaged by the consequence of the flood. Deforestation is linking to soil erosion and increase run-off etc. Soil erosion is responsible for increasing the problem of sedimentation in the river channels, thereby decreasing water carrying capacity by the river.

Increase of Carbon Contents in Air

Recent climate changes have had significant impact on high-mountain glacial environment. Further from the NASA satellite images indicates that the Himalayan glacier is melting

in alarming rate and is gradually changing its colour from snow white to blackish white due to air pollution. The more alarming is the increase of black carbon at higher elevation in the atmosphere resulting in quick melting of glacier. In the Asia chapter of the U.N. Intergovernmental Panel on Climate Change's (IPCC's) 2007 Working Group II report, which claims that Himalayan glaciers "are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035. From the data analysis it is found that Himalayan temperature is increasing at an alarming rate due to deposition of carbon particle on the upper atmosphere.

Change in River path due to sedimentation & heavy landslides

The change in river path due to heavy landslides and deposit of sediments created other passage of water channel. The recent Landsat Image-8 (15 m resolution) shows the additional river course inside the Temple town

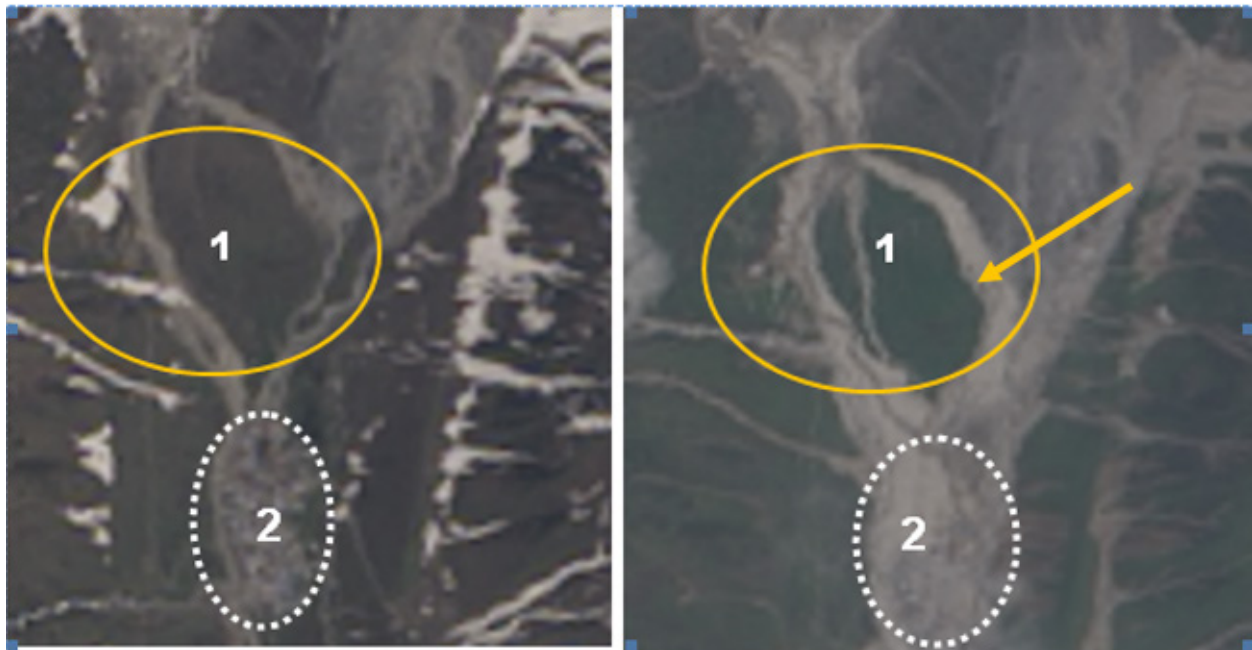


Fig. 5 Landsat-8 Image (Left) taken on 22nd May 2013 and other (Right) 23rd June 2013 after devastation.

which was not existed before the image taken on 22nd May 2013, but was created by heavy flow on 23rd June. The Fig.5, left and right image circle point 1 clearly depicts it. Similarly circle point 2 clearly shows the total washout of temple town in right image. Another is that all of the channels now have fresh sediment in their beds.

Further it appears that there is a large area of erosion, or even a landslide, right up the valley side. This has also transitioned into a debris flow that has struck the temple town. From the right photograph (Fig. 6), it appears

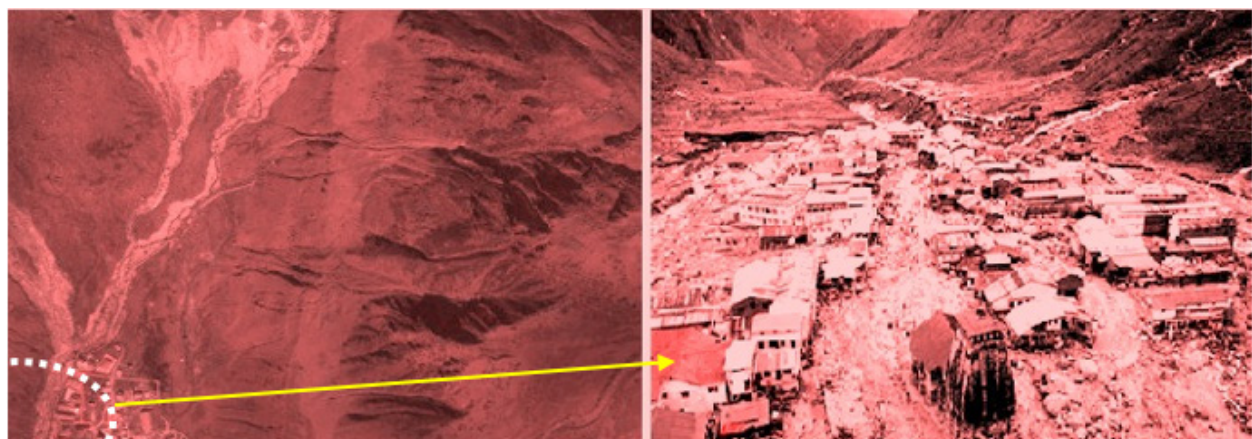
that much of the damage may have been from this flow.

Similarly roads were totally washed out in Rambara area due to heavy flow of rain water and derbies from river flow sediments which is clearly visible in satellite image (Fig. 7). An important road in this region, NH-58 is totally washed out near Jyotirmath

6. Recommendation & Suggestion

i. Pollution Control & Restriction in Tourism

One of the biggest glaciers in the Himalayan range is Gangotri glacier. Gangotri glacier is



Landsat-8 Image

Photograph

Fig. 6



Fig. 7. Rambara area after disaster & before disaster, where road is shown in dotted line. (Resourcesat Image).

located in Uttarkashi District, Uttarakhand, India in a region bordering China. This glacier, source of the Ganges, is one of the largest in the Himalayas with an estimated volume of over 27 cubic kilometers. The glacier is about 30 kilometres (approx) long and 2 to 5 km (approx) wide. Recent climate changes have had significant impact on high-mountain glacial environment. Rapid melting of snow and heavy rainfall has resulted in the formation and expansion of moraine dammed lakes, creating a potential danger from dammed lake outburst floods. Therefore there should be check in pollution from both sides of Himalayas and restriction of tourism in certain extent.

ii. Maintaining right of way of water

One big consequence of poorly planned construction of hydro power projects is reduced ecological flow of rivers. Ecological flow is the water that should be left in the river for ecosystem protection and livelihood purposes at all times.

iii. Assessment of Project and its Impact

Cumulative assessment becomes even more important in case of hydropower projects on a river system to understand the impact of

the existing projects on the ecology and how feasible is it to build new projects in the same basin.

iv. Review Reservoir Limits

This estimation helps in reviewing the reservoir storage capacity of dams so that they are better equipped to deal with the increasing precipitation variability

v. Establishment of Flood Forecasting and Warning System

During last flood in 2012 many scientists from various organizations warned about the possibilities of such calamities in future, but, things were not taken seriously by planners and policy makers at state and central government. No early warning systems were placed in this highly sensitive state Uttarakhand resulting huge loss of property and human lives.

7. Conclusion

Exploitation of nature and ecologically sensitive mountain ecosystem by anthropogenic activities like construction of hydroelectricity project, settlement activities, tourism is bound have adverse impact on the nature and Kedarnath flood is one such virtual example

as to how the disturbance of nature for the exploitation of natural resources can lead to a major disaster. Kedarnath tragedy a pointer towards the repetition of such calamity

elsewhere, if man continues to play with nature for its own greed. It is true to conclude here that Uttarakhand disaster was as "DISASTER WAITING TO HAPPEN"

Climatological Changes and Associated Hazards

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Abstract: Recent observations show that for the past few years some north Indian states like Himachal Pradesh, Uttarakhand, Delhi, Jammu & Kashmir (especially in Leh), Punjab, Haryana are receiving plenty of rainfall that are not common for those areas. In Rajasthan and Gujarat plains heavy rainfall caused sheet flood. These events could be explained by the hypothesis that summer low pressure trough over the subcontinent has a tendency to get shifted from Rajasthan to elsewhere at least for the recent past. It has been observed that during June –July instead of Rajasthan, the low pressure trough is forming over central India causing plenty of rainfall in Odisha, Chhattisgarh, Vidarbha, Central Maharashtra, Konkan, Goa and coastal Karnataka. Saurashtra, south Rajasthan and Kutch also receive moderate rain. Later, it passes over Sind in Pakistan causing heavy rainfall. During early monsoon so called ‘humid’ state of West Bengal is receiving below normal rainfall as the northern part of Bay of Bengal remains insufficiently hot and thus failing to develop a significant low pressure eye over there. Even Sohra (Cherapunjee) in Meghalaya known for super humid climate is not receiving plenty of rainfall. All these factors are indicating about a change in the behavioral pattern of monsoon. Ascending winds bearing plenty of moisture and attending condensation level at a rapid rate cause heavy downpour. When an enormous mass of cloud attends saturation level within a short time span, cloud burst and associated thundershower and sheet flood occur over a small pocket. Recent heavy monsoon rainfall in Uttarakhand, Himachal Pradesh, Leh could be due to mid-latitude excessive hot summer, heavy snowmelt and evapo-transpiration in middle Himalayan region (Nepal) contributing in formation of fresh rain bearing clouds over there. Flash flood in Leh on 6th August 2010 could be explained by this hypothesis. South Pakistan got flooded due to heavy rainfall in the Indus catchment area. Significantly hot weather in the Western Himalayas is causing fast melting of the Amarnath cave ice (Shiva-ling). By late July the height of the holy ice mound has been dropping significantly. Melting of glaciers and ice fields / snowfields and evaporation are contributing in local cloud formation over Uttarakhand, Himachal Pradesh in India as well as over Nepal. In mid-June 2013 devastating flood in Uttarakhand is a combined impact of early monsoon outbreak and associated cloud burst in Uttarakhand, quick melting of glacier at high altitude. At places, within 48 hours 280mm rainfall occurred and five feet of snow was precipitated at higher altitudes. Apart from Uttarakhand, Himachal Pradesh and Delhi are the other areas receiving tremendous rainfall. For Delhi it was an early monsoon breaking the past record of 150 years. In western India heavy rainfall occurred in Gujarat, southern Rajasthan. By and large cloud was contributed by the Arabian Sea branch of the southwest monsoon. Over Uttarakhand it coalesced with the local clouds mostly formed due to evaporation from water bodies, snowfields and glaciers. Much of the casualty in Uttarakhand was due to human interference like construction work within 100 feet from the river channel, deforestation and construction work over fragile geological set up, harnessing of rivers and diverting the river courses for generating hydro electricity. When extra-runoff comes downstream, it denies artificial conduit and tries to follow its original natural course. Hence flooding and casualties happen. Cartography can help in disaster management by mapping these pockets where hazards especially flooding would be frequent due to excessive precipitation.

Causes of cloud burst

Ascending winds bearing plenty of moisture and attaining condensation level at a rapid rate cause heavy downpour. When an enormous

mass of low altitude cloud having significant vertical depth attends saturation level within a short time span, cloud burst and associated thundershower occur over a small pocket. Recent heavy monsoon rainfall in Uttarakhand and

Himachal Pradesh could be due to hot summer, heavy snowmelt and evapo-transpiration in middle Himalayan region contributing in formation of fresh rain bearing clouds. Flash flood in Leh on 6th August 2010 could be explained by this hypothesis; further, south Pakistan got flooded due to heavy rainfall in the Indus catchment area. Melting of glaciers and ice fields /snowfields and evaporation are contributing in local cloud formation over Uttarakhand, Himachal Pradesh in India as well as over Nepal. Heavy rain in Nepal Himalaya accompanied by melting of glaciers are causing flood in northern Uttar Pradesh and north Bihar.

Impact of cloudburst

In mid-June 2013 devastating flood in Uttarakhand was a combined impact of cloud burst in Uttarakhand, quick melting of glacier at high altitude due to beating of ice sheet by raindrops, breaching of natural embankment of Chorabari Tal (north of Kedarnath) due to accumulation of excess surface runoff. Within 48 hours 280mm rainfall occurred and about five feet of snow was precipitated at higher altitudes. Apart from Uttarakhand, Himachal Pradesh, northeast Rajasthan and Delhi are some other areas receiving torrential rainfall. For Delhi it was an advent of early monsoon that broke the past record of 150 years. In western India heavy rainfall occurred during mid-June in Gujarat and southern Rajasthan due to early advent of Arabian Sea branch of monsoon. The monsoon winds were pushed northeastward by an upper air current. On its way towards north northeast the cloud gathered moisture as a result of evaporation from freshwater bodies and irrigated agricultural fields lying on its way. Over Uttarakhand, it coalesced with the local clouds that formed due to evaporation from water bodies (rivers, lakes), snowfields and glaciers as well as evapo-transpiration from forests. It may be mentioned that expansion of built-up area, auto-emission and emission from aircrafts accelerate formation of brown clouds. A polluted overcast sky hinders temperature radiation and cooling of the earth's surface. This causes rising of ambient air temperature that in turn increases the rate of evapo-transpiration. In 2013, Uttarakhand and Himachal Pradesh experienced very early monsoon and heavy precipitation that

were uncommon at least for the past 50 years; the amount of rainfall in Kedar valley was unprecedented since the year 1925. In Himachal Pradesh Shimla district was very badly affected.

Fragile environmental set up

Tectonically northeastern part of Uttarakhand is highly fragile and susceptible to earthquake and landslide. The area recorded 10 significant earthquakes during the past 100 years; horizontal seismic coefficient isoline of 0.08 encircles the region. Further, heavy rain causes soil creep and landslide; landslide is aggravated because of deforestation. Much of the casualty in Uttarakhand was due to human interference like construction activities within 100 feet from the river channel disturbing a fragile geological set up (composed of a variety of metamorphic and sedimentary rocks that underwent intense folding and weathering), harnessing of rivers and diverting the discharge for generating hydro electricity. High velocity of flood water was a result of steep slope – in the affected districts there is a fall of relief from 5000m to 1500m within a short distance. When extra-runoff passes over a steep slope, it denies artificial conduit created for water turbines and it tries to follow its original natural course. Hence flooding happens. Since the creation of Uttarakhand, due to economic development work related to tourism, transport, power generation, etc, natural ecosystem got disturbed. Deforestation, explosion by dynamites for construction of roads, tunnels; building hotels, tourist resorts and parking lot within the catchment area of rivers; construction work related to hydro power projects over Alakananda, Mandakini and Bhagirathi – all contributed in destabilization/disturbance of underlying geological structure as well as river/ surface water flow. In many cases the plinth of the building that was demolished by sheet flood did not have sufficient depth. When soil and debris were washed away the building collapsed. All these factors contributed in landslides, flooding and demolition of structures/ human settlements.

Why flood in Kedar valley?

The sequence of events in Kedar valley was as follows. On Thursday the 13th June 2013 supercomputer of IMD predicted the convergence /confluence of two weather

systems likely to take place by the weekend and likely to deliver copious rainfall. A low pressure system due to early monsoon advection and an upper air trough from western Asia were about to merge over northwest India. It was expected to cause heavy rainfall in Uttarakhand and adjacent areas. India Meteorological Department Delhi office issued a preliminary weather advisory on June 11th and then a second warning of heavy rainfall on June 13th, two days ahead of the torrential precipitation. Around 13,000 pilgrims made their way to Kedarnath region alone between 15th and 17th June. For those thousands in the mountains the forecast did not help.

The low pressure system and the upper air trough had converged over Haryana and Punjab. After their merger over Punjab plain both together moved towards Uttarakhand. It delivered extremely heavy precipitation. According to Shri Singh, Deputy Director General, IMD, convergence of such systems is not unusual during the monsoon season, but the amount of moisture they brought in and the resultant precipitation (280mm in 48 hours) were exceptional. Since the initiation of monsoon season on June 1, Uttarakhand has received more than 410 per cent of the normal volume of rain it was expected to receive during

this phase. Weather stations across the state recorded exceptionally heavy rain between June 15th and 17th, 2013. In Kedar valley on 16th June 2013 at 8-15 AM, sheet-flood transporting large boulders, debris and mud came down the valley when Gandhi Sarovar 3 km up from Kedarnath temple overflowed due to heavy downpour and consequent melting/breaking of a part of Chorabari Glacier further upstream. About 25 m of Chorabari Ridge was demolished under pressure of excess water. This ridge is composed of unconsolidated materials (end moraines); it acted as natural embankment of Chorabari Tal. The sheet flood generated due to heavy shower and snow melt, transported enormous amount of end moraines and fluvial debris. At Kedar, the sheet flood attained about 15 feet height; the discharge was contributed both by the Mandakini (originating from Chorabari Glacier) and Saraswati (originating from Companion Glacier) rivers. The northern and southwestern parts of Kedar settlement got more damaged compared to the southeastern part that was least affected as the run off preferred the westernmost route (in accordance with gradient, lithology and other geomorphologic factors). Further south, volume of surface runoff got accelerated due to contribution from Dudhganga and other east flowing streams debouching in the Mandakini; 14 km stretch of Kedar valley, particularly

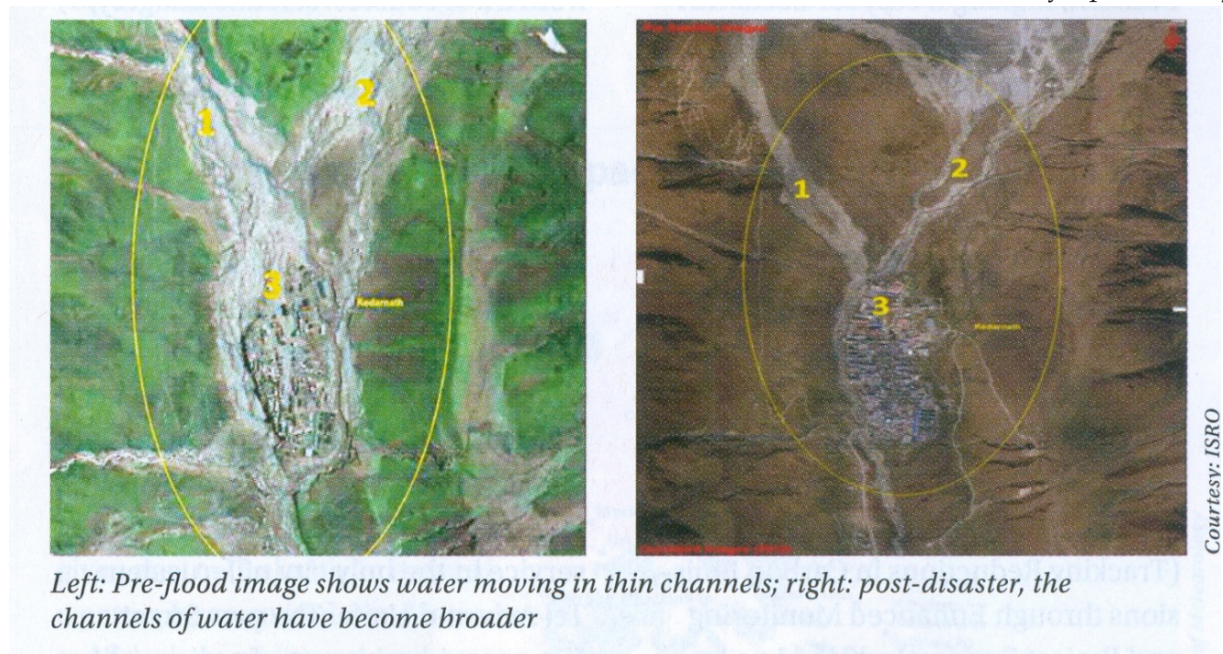


Fig. 1

In the imagery (Fig. 1), item number 1 is Mandakini channel, item number 2 is Saraswati channel and item number 3 is Kedarnath Temple.

from Kedar up to Rambara (7 km away from Kedar) was badly damaged. Kedar Temple was not washed away primarily due to mammoth depth of its plinth, heavy and robust structure. Also, the valley-slope is relatively gentle in and around Kedar temple. Hence the huge boulder transported by the sheet flood got deposited behind the temple; it protected the rear side of the temple from severe damage.

Up in the mountain, trekkers experienced 7 feet of snowfall in 48 hours near Sweta Peak about 50 km away from Gangotri; their tents got buried under snow. Landslides occurred on ways from Bhujbasa (near Gomukh) to Gangotri and Gangotri to Harsil.

Devastation downstream

An estimated 90 rest houses with 1000 pilgrims sheltered there, had been washed away due to flash flood of Mandakini and Alakananda rivers. Several villages of Chamoli and Rudraprayag districts went under water. At least 16 landslides occurred on the road to Uttarkashi. Some affected road routes are Rishikesh-Uttarkashi-Harsil-Gangotri; Rudraprayag - Kedarnath; Joshimath - Badrinath and Dharchhula-Tawaghat in Pithoragarh district. Some immediate casualties are Gourikund to Kedarnath road length of 14 km damaged/ lost due to landslides, Alakananda has changed its course. Border Security Force headquarters (training centre) in Garhwal went under 6 feet of mud and debris. At Shimpur in between Rudraprayag and Rishikesh runoff water rose 40 feet above the normal level of the Ganga, it damaged all the tourist resorts. It was estimated that altogether 5,000 human beings, 12,000 livestock including horse, pony buffalo and cattle died. About 5748 persons are missing. Alakananda Power Project at Srinagar was demolished, 175 bridges were destroyed and about 500 roads have disappeared. Many of the temples at Devaprayag (confluence of Alakananda and Bhagirathi) were demolished. At Gourikund, Gourimata Temple was washed away.

Due to second successive cloudburst on 24th June over Mular village in Pathani-Kasba valley, Pauri district, landslide occurred on Rudraprayag-Badrinath road, metal railings on roadside were squeezed by the virulent force of water; trucks carrying relief materials turned

upside down. Army helicopter deployed in relief operation was thrashed against the valley side slope.

Due to huge accumulation of debris the river Saraswati has lost her downstream track; earlier Saraswati used to meet Mandakini downstream of Kedar; now she meets Mandakini further upstream of Kedar temple. Instead of four hot springs only one hot spring is surviving near Kedar Temple; the hot spring at Gouri kund is no more traceable.

Scope of cartography in geo-hazard management

Cartography can help in disaster management by mapping those pockets where hazards, especially landslide and flooding, could be frequent because of torrential precipitation. Areas prone to earthquake due to fragile geotectonic set up could be marked over the map. Areas to be reforested could be identified. By applying remote sensing technology areas suitable for rehabilitation of the victims could be identified; also new roads could be planned for affected areas. It may be mentioned that not only India but some other Asian countries like Philippines experienced flood during 19th-20th August 2013 due to heavy rainfall; south China was flooded due to heavy rainfall. European countries like France experienced heavy rainfall and flood during this summer. A tornado devastated Oklahoma, USA on 21st May 2013. Last year in April, Kenya experienced flood, eastern Australia received abnormally high amount of rainfall during summer.

The convergence of the upper air trough and the low-pressure system pushed the monsoon line across northwest India well in advance of due date - the monsoon covered entire country about a month in advance of the normal date of July the 15th. If it continues to occur frequently during the coming years, there will be a need for revision of climate maps. For the past few years high and mid latitudinal countries of northern hemisphere are experiencing very hot summer as well as severely cold winter. This indicates rapid warming in summer and rapid cooling during winter; which might be due to a little more tilting of the earth's axis. It is interesting to note that this year on July 20th, southern Canada experienced 41° Celsius temperature; New Jersey (USA) recorded 38°

Celsius temperature; it is happening for past couple of years. On the same day Kolkata, located in the Tropics, was not so hot; it experienced 37° Celsius temperature.

Climate is changing gradually. The districts of Uttarakhand that have experienced flood this year were considered as areas of unpredictable/scanty rainfall 30 years ago. Kheri and adjoining districts of Uttar Pradesh are facing seasonal floods due to heavy rainfall in Nepal Himalaya; these areas are no more drought-prone, but flood prone.

There is a need for revision of natural hazards map with respect to identification of flood prone and drought prone districts. Cloud burst, cyclone and tornado are frequent in these days. Keeping in mind the possibility of early monsoon outburst and associated disaster, the period of tourist influx in Uttarakhand could be restricted since the second half of June. Tourists wouldn't be allowed to trek or travel after 10th June if weather satellite shows signs of early monsoon advent and possibility of formation or accumulation of high density low level cloud with significant vertical extension.

Agricultural Drought Assessment at Micro Level – A Case Study in Andhra Pradesh, INDIA

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Keywords: NDVI-Normalized difference vegetation index, NDWI-Normalized difference water index, MAI Moisture adequate index

Abstract: Extreme natural events become disasters when they affect human settlements, economic and social activities. Droughts are one of the most devastating natural hazards in the world, claiming more lives and causing extensive damage to agriculture, vegetation, human and local economics. The Remote sensing and GIS technology significantly contributes to mitigate these types of problems. Andhra Pradesh is one of the drought affected states in India. Out of 23 districts nine (Rayalaseema, Telangana and Coastal Andhra) districts are drought prone. In the present study an attempt has made to estimate the agricultural drought at micro level (mandal) using integrated approach i.e. Crop condition using satellite data, rainfall, no of dry spells, types of soil, reservoir levels etc from June to September of kharif season. These results were compared with the normal rainfall year for assessment the degree of severity of drought. The state is served by south-west monsoon (June-September) receives on an average 602 mm and North-east monsoon (October to December) receives 203 mm of rain during the above periods. The average rainfall of Andhra and Telangana regions are 570mm and 726 mm respectively. Rayalaseema receives rain in both the monsoons and are nearly 368mm and 213 mm. The major crops are Rice, Maize, Cotton, Sugarcane, Pulses, Groundnut, Chillies, Bajra, Sunflower, Castor, Red gram etc. Agricultural situation was monitored at state/district/ mandal level using AWIFS (Advanced wide field sensor) of Resourcesat-2 (56 m resolution), MODIS -Terra 8 day 250 -meter atmospheric corrected reflectance products (MOD09A1) from June to September during the crop growing season. Crop condition has been assessed using satellite derived Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) indices. The derived outputs were integrated with moisture adequate index (MAI) and rainfall (rainfall deviation, number of dry weeks) for assessment of drought situation. Based on the above study the agriculture situation is classified into normal, mild, moderate and severe classes basing on the degree of severity. This study will help the administrators to 1. Preparedness phase where activities such as prediction and risk zone identification are taken up long before the event occurs, 2. Preparation phase where activities such as early warning/ forecasting, monitoring and preparation of contingency plans are taken up just before during the event and 3. Response/mitigation phase, where activities just after the event includes damage assessment and relief management.

Introduction

In general drought monitoring is assessed based on the ground based related parameters such as rainfall, weather, crop condition and water availability. Earth observations from satellite are highly complementary to those collected by in-situ systems. Satellites are often necessary for the provision on the Agricultural drought assessment is essential for taking appropriate remedial measures for

improvement of drought situation. Remote sensing techniques are currently providing the capabilities to obtain resources information rapidly over large areas by means of sensors mounted on aircraft or satellite and operating in several spectral bands of electromagnetic spectrum. These satellites which orbit the earth are able to repetitively cover the same area at regular intervals and thus help in monitoring changes on ground. Earth resource satellites have limitations for drought monitoring due to

their larger revisit cycle (16 to 26 days) and due to high probability of cloud cover during kharif season. In contrast, the daily revisit by National Oceanic Atmospheric Administrative Satellites with advanced very high resolution radiometer (AVHRR) data, though having coarse spatial resolution of 1.1 km at nadir but due to its large area coverage, and daily acquiring data from MODIS, makes it primary data for nationwide drought monitoring.

The crop / vegetation reflect high energy in the near infrared band due to its canopy geometry and health of the standing crops/vegetation and absorb high in red band due to its biomass and photosynthesis. Using these contrast characteristics of vegetation in near infrared and red bands, which indicate both the health and condition of the crops/vegetation; Normalized difference vegetation index (NDVI) is derived by the difference of the measurements and divided by the sum. The vegetation index was generated from each of the available satellite data irrespective of the cloud cover present. To minimize the cloud, monthly time composite vegetation index is generated.

Crop condition has been assessed using satellite derived normalized difference vegetation index (NDVI), Normalized difference water index (NDWI) images. These satellite derived products have been integrated with soil moisture index (derived using soil water balance approach) and rainfall (rainfall deviation, number of dry weeks) for assessment of drought situation.

Study area

Andhra Pradesh is the fourth largest state in India, with an area of 2, 75,068 Sq.km. It is bounded by Maharastra, Chhattisgarh and Orissa in the North, Bay of Bengal in the East, Tamilnadu in the South and Karnataka and Maharastra in the West.

The state of Andhra Pradesh has a population of 84.66 million (2011 census) which is 7.41 % of country's population. Nearly 73 % of the population of the state is rural, which is primarily depending on agriculture for their livelihoods. The state has three regions, coastal consisting of the nine districts, Telangana consisting of ten districts and Rayalseema consisting of four districts which falls in scarce

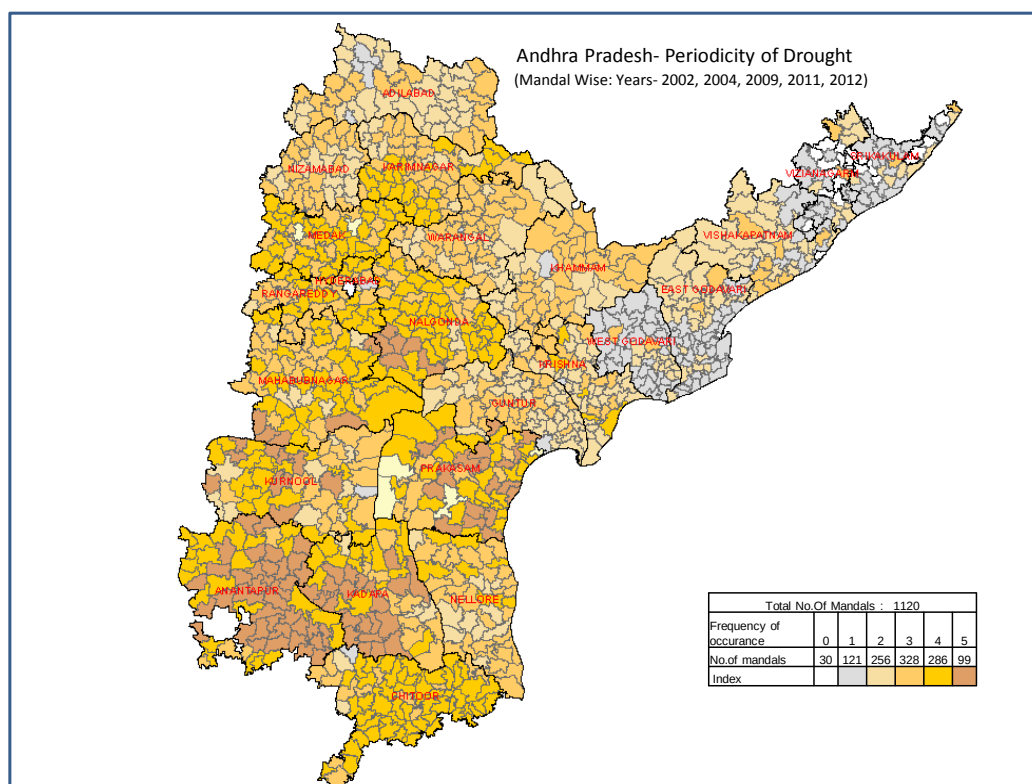


Fig. 1.

rainfall zone. Only 35 percent of cropped area is under irrigation and the rest is under rainfed.

The state is served by south-west monsoon (June-September) receives on an average 602 mm of rain and North-east monsoon (October to December) receives 203 mm of rain during the above periods. The average rainfall of Andhra and Telangana regions are 570mm and 726 mm respectively. Rayalaseema receives rain in both the monsoons and are nearly 368mm and 213 mm. Districts i.e., Nellore, Chittoor, Prakasam, and Kadapa are served by North-East monsoon than by south-west monsoon. The major crops are rice, maize, cotton, sugarcane, pulses, groundnut, chillies, bajra, sunflower, castor, redgram etc.

Material and Methodology

Agricultural conditions are monitored at state/district/ mandal level using AWIFS (Advanced wide field sensor) of Resourcesat-2 (56 m resolution) and MODIS-Terra 8 day 250 -meter atmospheric corrected reflectance products (MOD09A1) data during the Kharif crop growing season (June to October). MODIS has unique capability used in deriving NDVI, NDWI, SASI data sets has used to complement the assessment. Daily/ Weekly/fortnightly/ monthly rainfall (from available AWS stations) is collected for comparative studies.

Generation of Vegetation index image

Among the various vegetation indices, Normalized Difference Vegetation Index (NDVI) using the reflectance of near infrared and red bands is one of the most popular indices used for vegetation monitoring (Tucker et al., 1981) and drought detection (Kogan, 1990; Liu and Kogan 1996; Anyamba and Tucker, 2005). NDVI reflects changes in chlorophyll content and vegetation amount and has proved to be a useful tool for studying vegetation cover change. It is simple in calculation, easiness in interpretation and also its ability to partially compensate for the effects of atmosphere, illumination geometry etc. Normalized difference vegetation index (NDVI) is derived from (NIR-Red/ NIR+ Red) where NIR and red are the reflected radiation in visible and near infrared channels. Various colours in the NDVI image-yellow through green to red-indicate increasing vegetation vigour. Water, clouds and snow have higher reflectance in the

visible region and consequently NDVI assumes negative values for these features. Bare soil and rocks exhibit similar reflectance in both visible and near IR regions and the index values are near zero. The NDVI values for vegetation generally range from 0.1 to 0.6, the higher index values being associated with greater green leaf and biomass.

The fortnightly/monthly vegetation index map for the state with district/ mandal boundaries overlaid are given specific colors for the vegetation index ranges. The various colors in the NDVI map (Fig.1): yellow through green to violet indicate increasing green leaf area and biomass of different vegetation types. Cloud and water are represented in black and blue colors respectively. The bare soil, fallow other non-vegetation categories are represented in brown color.

Time composite NDVI images were generated separately for the total geographic area and for the agricultural area of the state. Non agricultural area comprising forest, fallow lands etc are delineated in each district using sequence of IRS AWiFS images and validated with the land utilization statistics provided by Directorate of Economics and Statistics/ State Agriculture Department. About 80-90 % of non agricultural area was excluded in different districts of the state. The agricultural area mask of the district was obtained after subtracting non agricultural area from respective geographical area. The agricultural area mask thus generated is now being used for drought assessment in current season. The seasonal progression of NDVI compared to that of normal and complementary ground data on rainfall and crop sowing progress are utilized in the assessment of agricultural area.

Surface Wetness Indicators

Gao (1996) introduced the Normalized Difference Water Index (NDWI) using SWIR and NIR bands to retrieve vegetation water content. Shortwave infrared (SWIR) band is sensitive to moisture available in soil as well as in crop canopy. In the beginning of the cropping season, soil background is dominant hence SWIR is sensitive to soil moisture in the top 1-2 cm, as the crop progresses, SWIR becomes sensitive to leaf moisture content. High - frequency temporal data of MODIS instrument having appropriate water absorption bands for

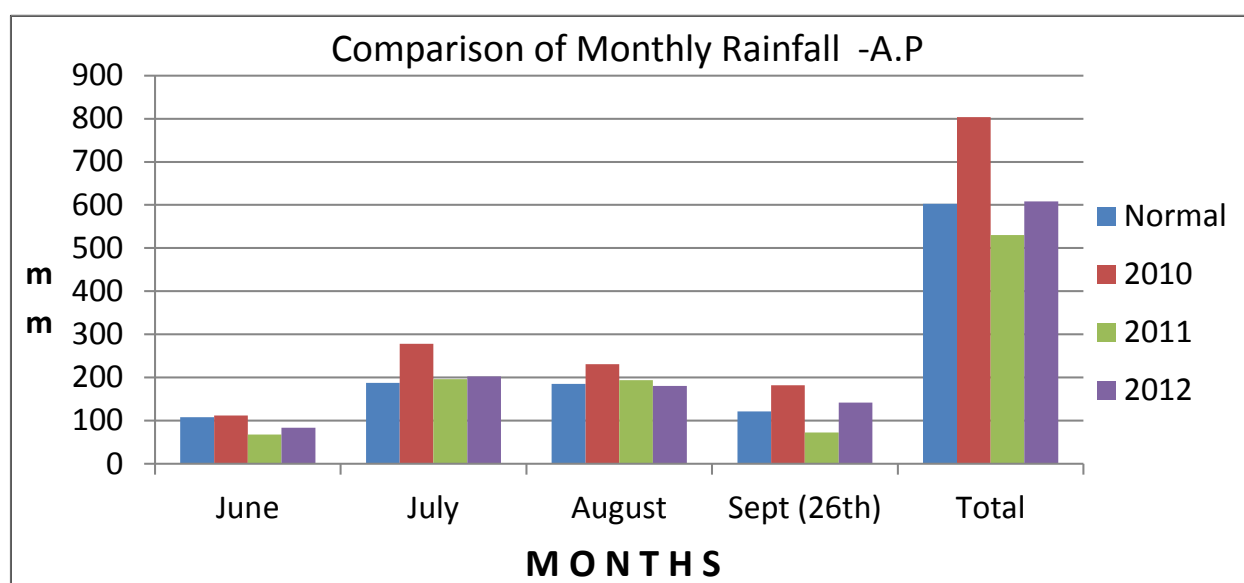


Fig. 2

(Source: Season and Crop coverage Report, Dept. of Agriculture, Govt. of A.P)

retrieving canopy water contents offer a great opportunity to assess the regional and global environmental changes. NDWI using SWIR can complement NDVI for drought assessment particularly in the beginning of the cropping season. NDWI is derived as under:

$$NDWI = (NIR - SWIR) / (NIR + SWIR)$$

Whereas near infra red and SWIR are the reflected energy in these two spectral bands. Higher values of NDWI signify more surface wetness.

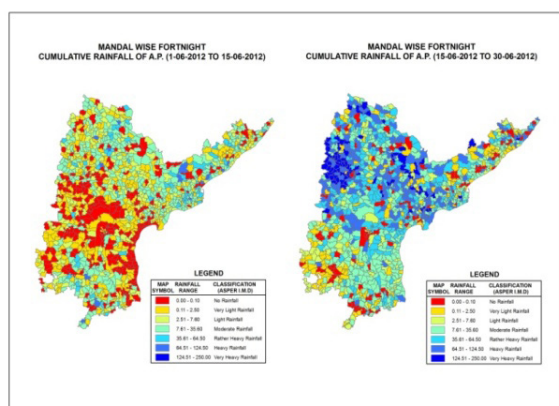


Fig. 3

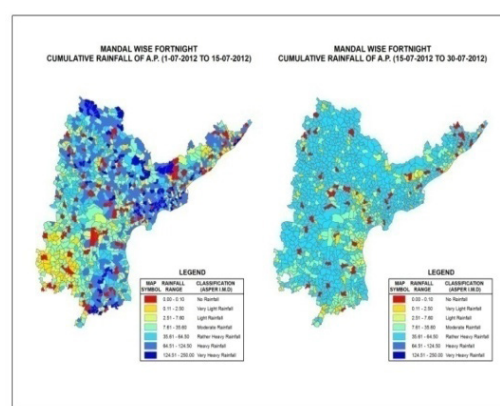


Fig. 4

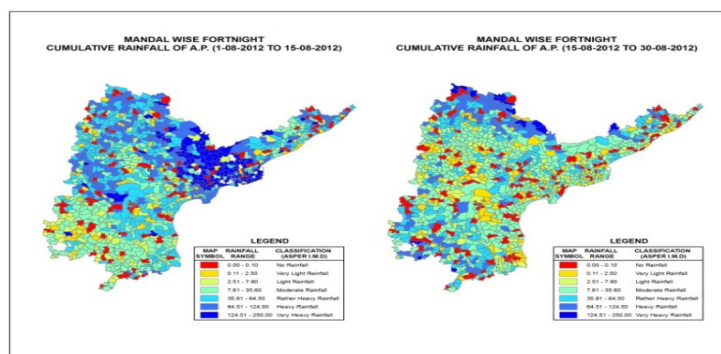


Fig. 5

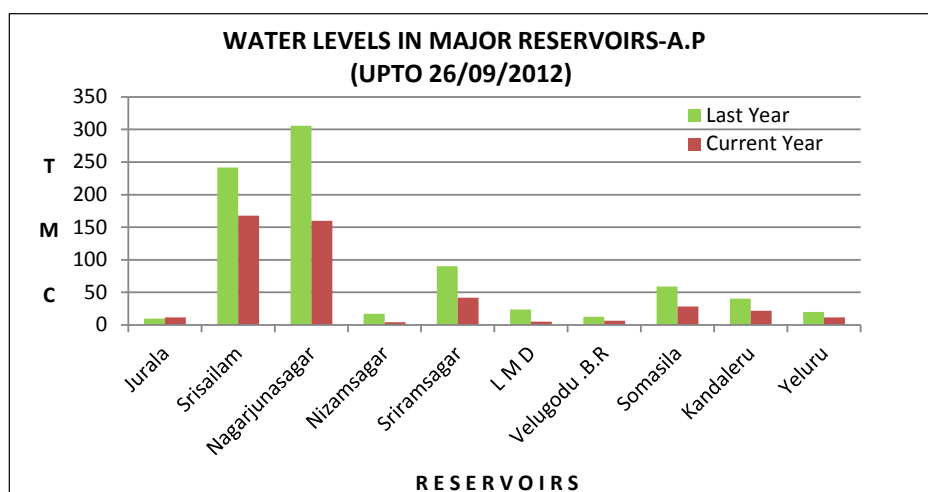


Fig. 6 (Source: Irrigation Department, Govt. of A.P)

Rainfall analysis

Rain is the major causative factor of drought. The Actual rainfall received in the month of June is Deficit (-23%) when compared with normal rainfall of 2010 and in the month of July It is normal (+8%) and deficit (-2%) in the month of August, and it is 21 % excess up to 20th September 2012. Comparison of monthly rainfall is shown in fig. 2. The average rainfall received from 1-6-2012 to 20th September is 580.7 mm as against the normal of as on date is 571.2 mm, 2 % excess than the normal rainfall.

Daily mandal wise rainfall collected through Automatic weather stations (AWS) by APSDMS were collected and cumulative analysis was carried out fortnightly and mapped (Fig. 3, 4 and 5).

Water Levels in Major Reservoirs

Water level of major reservoirs is shown in fig.6. Except Jurala all the major reservoirs of Andhra Pradesh has less water storage when compared with the last year. The storage levels of the current year are 470.06 t.m.c where it

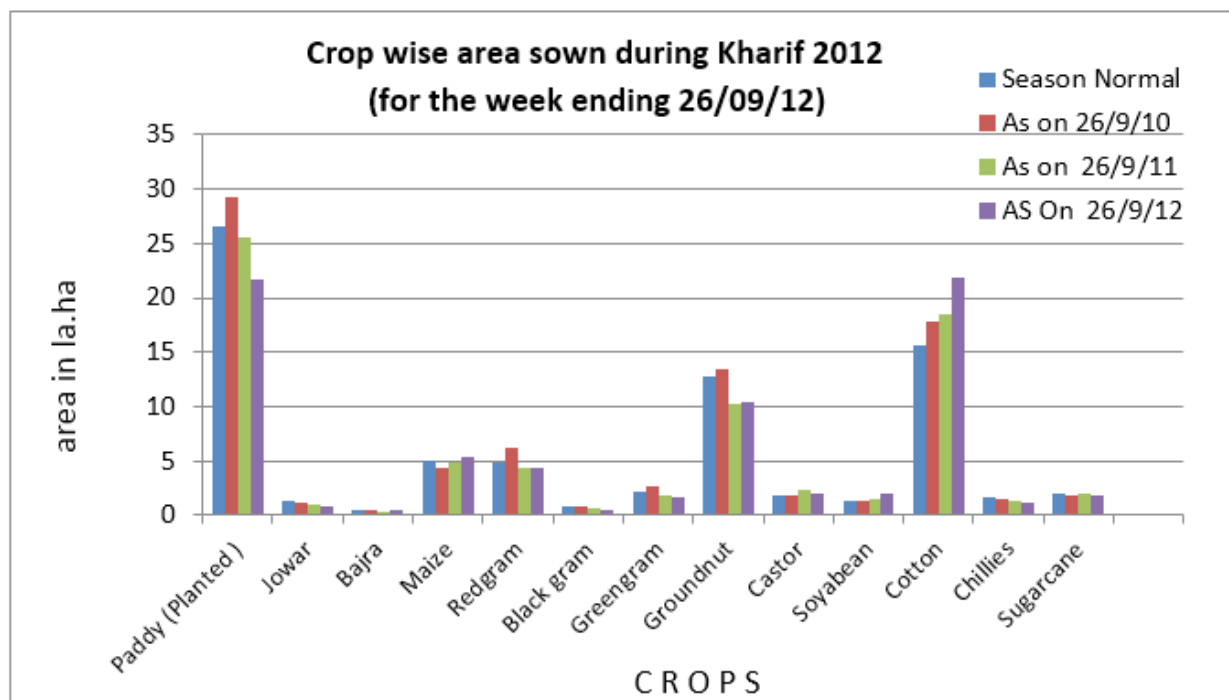


Fig. 7 (Source: Season and Crop Coverage report, Dept. of Agriculture, Govt. of A.P)

is 816.82 t.m.c in last year. This is due to inadequate rainfall received in Krishna basin catchment.

Crop sown Area

As per the reports of Department of Agriculture (ending 26/09/12), Govt. of Andhra Pradesh, an area of 76.25. lakh ha (95% of season normal) has been sown. The crop area sown for the corresponding period of 2011 was 77.00 lakh ha, and in 2010 was 82.68lakh ha. The crop sown area in Coastal Andhra region was 89% of normal for the period and it was 104 % in Telangana and 90 % in Rayalseema region. Crop wise sown area during kharif 2012 is shown in fig. 7.

Results and Discussion

The monthly vegetation index map for the state with district/mandal boundaries overlaid is given in specific colors in the NDVI map: yellow through green to violet indicate green leaf area and biomass of different vegetation types.

The time series of mandal/district averaged vegetation index parameters of 2012 Kharif season has been correlated with ground observations of rainfall, aridity anomaly and agriculture conditions, and the drought interpretation methodology has been validated. The drought assessment reporting is based on comparison of mandal /district VI profile of the previous years. False alarm due to excessive rainfall/ flooding, cloud contamination, poor time composition, difference in seasonal growth cycle is appropriately identified.

Basing on the physiographic, and agro climatic factors the study has taken up ant mandal (group of villages) level to carry out the drought assessment. The satellite data is compared with other factors like, number of dry spells, area sown, damage to standing crops, fall in estimated yields, etc. The satellite data analysis is compared with fortnightly/ monthly rainfall analysis, crop growth and no of dry spells. (Dry spell can be termed, if rainfall received is less than 50 % of its normal value for a consecutive period of more than 20 days in a month during a season. Based on the analysis of satellite derived indices and their anomalies compared to normal, the 317 mandals (Moderate 190, Mild127) are indicative

of less than normal crop condition during current Kharif season as a result of agricultural drought situation Table 1 and fig. 8).

The intensity of agricultural drought situation is characterized as follows:

Severe: Deficit/scanty rains, sown area reduction (>50%), continued poor agricultural crop condition and reduced surface wetness, delayed sowings and reduced crop growth period.

Moderate : The Districts/ mandals are characterized by one or more of the attributes- more than a month delayed sowing time, more than 25 % reduction in crop area, poor greenness/moisture levels of crop vegetation, significant reduction in crop yield, lack of adequate irrigation infra-structure, reduced rate of increase crop greenness/moisture from July-August-September. There is less scope for improvement in the agricultural situation in these districts/mandals in subsequently.

Table-1 Agricultural Drought Assessment - Kharif 2012(Figures Indicate number of Mandals)

District	Normal	Mild	Moderate
Srikakulam	38	0	0
Vizianagaram	34	0	0
Visakapatnam	43	0	0
East Godavari	60	0	0
Westgodavari	46	0	0
Krishna	43	2	5
Guntur	33	18	6
Prakasam	13	17	26
Nellore	46	0	0
Chittoor	32	16	18
Kadapa	6	13	32
Anantapur	0	8	55
Kurnool	4	13	37
Mahabubnagar	29	26	9
Nalgonda	44	13	2
Warangal	51	0	0
Karimnagar	57	0	0
Adilabad	52	0	0
Nizambad	36	0	0
Medak	47	0	0
Khammam	46	0	0
Rangareddy	37	0	0
		127	190

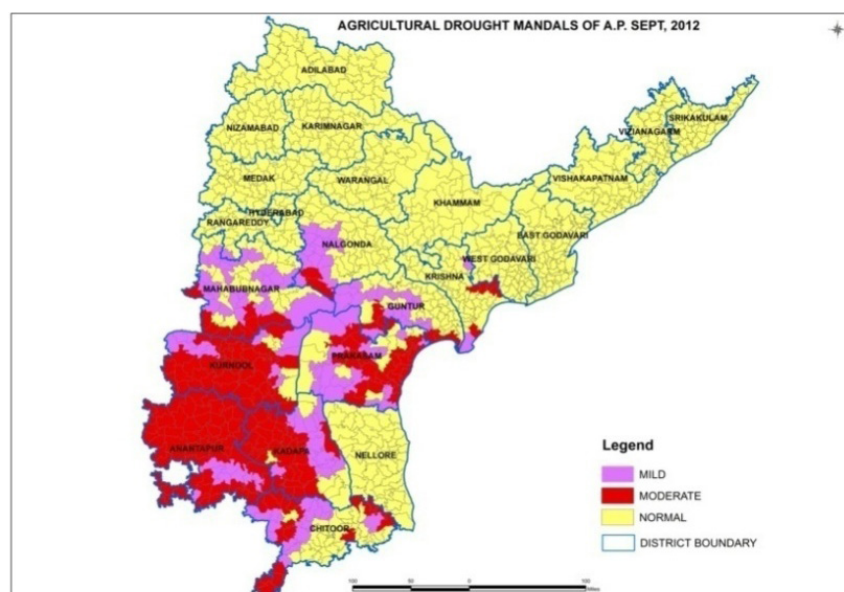


Fig. 8.

Mild: This category was characterized by slightly reduced crop sown area or slightly reduced greenness of crops leading to slight reduction in crop yield. There is scope for improvement in subsequent fortnights in case of long duration crops.

Normal: Rainfall is normal leading to normal crop sown area and crop progression. Crop condition and surface wetness are either normal or better than normal.

Moderate = 127 + 190 = 317 mandals

Conclusions

Droughts are one of the most devastating natural hazards in the world, claiming more lives and causing extensive damage to agriculture, vegetation, human and local economics. The Remote sensing and GIS technology significantly contributes to mitigate these types of problems. The Fortnightly/monthly reports submitted to the government about the of drought situation which helps to (1.) Preparedness phase where activities such as prediction and risk zone identification are taken up long before the event occurs. (2) Preparation phase where activities such as early warning/forecasting, monitoring and

preparation of contingency plans are taken up just before during the event and (3.) Response/mitigation phase where activities just after the event include damage assessment and relief management.

Acknowledgement

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Flood Inundation Modelling in GIS Platform, Integrating Rainfall-Runoff Data: A Case Study in Midnapore-Kharagpur Development Authority of Medinipur District, West Bengal (India)

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Keyword: *Natural Disaster, Flood and Water Logging, Remote Sensing and GIS, Flood Inundation modeling, Real Time Display.*

Abstract: Natural disaster like flood and water logging is a worldwide phenomenon. In India, during intense monsoon, not only the rural areas but the urban areas are also badly affected by water logging. Midnapore Kharagpur Development Authority (MKDA) planning region of West Bengal is not an exception. This research is a fundamental step to assess flood inundation and water logging vulnerability of MKDA and their real time display on map, which can aid the decision making process of MKDA authority during heavy downpour. FLO-2D - a two-dimensional flood routing model, has been used to simulate runoff (channel flow, unconfined overland flow, street flow etc.) over complex topography. Spatial information on land use land cover, elevation, slope magnitude, slope direction, soil condition, and sewerage condition were incorporated in the model design; finally rainfall duration and amount are used as input to get the inundated areas as output. Model generated inundated areas of a real storm have been compared with actual inundated area extracted from microwave imagery (RADAR SAT-1) of the same date and with primary field survey map for validation of the model.

Introduction

Midnapore Kharagpur Development Authority (MKDA) was formed in the year 2003 in West Midnapore district of West Bengal. Basic objective behind the formation of MKDA was to provide better public amenities including construction of roads and streets, open spaces, park and recreational zones, new potential residential and commercial sectors etc. but rapid unplanned urbanization around Midnapore-Kharagpur and its consequent sewerage problem has led to extensive waterlogging throughout the rainy season. Total planning area of the development authority is 596.76 sq. km. consisting of 464 Mouzas (cadastre) with 14 Village-Panchayet Samiti of Medinipur, Kharagpur-I, Kharagpur-II, Salboni block and 54 wards of Kharagpur and Medinipur Municipal area. The general relief of the study area varies between 20m-60m above the Mean Sea Level. Kangsabati is a perennial river passing from west to east dissected the region into two parts north and south and created two converging slope pattern i.e. north west to south east and south west to north east (Anon. 2003).

In the year 2008, annual rainfall in the West Medinipur district was about 2594 mm. Most of the rainfall occurred during monsoon season (mainly in June, July and August) which was 400-500mm above the normal rainfall and most rainfall occurred mainly in three days i.e. 16th-18th June which was about 607mm that badly affected the normal life style of Medinipur-Kharagpur Development Authority (MKDA) as well as the whole district (Anon. 1991- 2011). Many parts of the Midnapore and Kharagpur town were inundated. The above condition is the main motivation behind the study and for that reason some scientific approach related to realtime flood inundation simulation modeling has been adopted to find out the propensity of water logging. There are many factors responsible for this situation viz. 1. poor sewerage condition like absence of drainage, blockage of sewerage system, 2. unplanned development, 3. elevated road network, 4. expansion of settlement in lowlands etc. Application of GIS for real time rainfall runoff modeling is rapidly advancing and soon will be the frame work of a predictive early flood warning system. This research is a fundamental step to assess flood inundation

and water logging vulnerability of MKDA and their real time display on map, which can aid the prioritization process of MKDA authority in their emergency sewerage clearance and mechanical water ejection during heavy downpour.

Study area

Development of a model was targeted at the MKDA region in Paschim Medinipur, West Bengal, India. MKDA region extending between 22°14'40.97" - 22°33'31.65" N and 87°00'45.64" - 87°27'57.84" E. North east, south west and several area of western part are agricultural area; many industries are situated in kharagpur municipal area or in MKDA region. This area is 596.76 sq. km. consisting of 514 mouzas and within 14 gram panchayets of Medinipur, Kharagpur I and Kharagpur II, Salboni block and medinipur and kharagpur municipal area (Fig.1).

General slope of this region is north west to south east and south west to north east. Kasai is a perennial river it enters almost middle of MKDA region. Besides, there is an important streamlet within the town, known as 'Dari Bandh Khal', having a south-easterly course, which joins the river Kasai and forms internal drainage.

The general relief of the study area varies between 20m-60m above the Mean Sea Level.

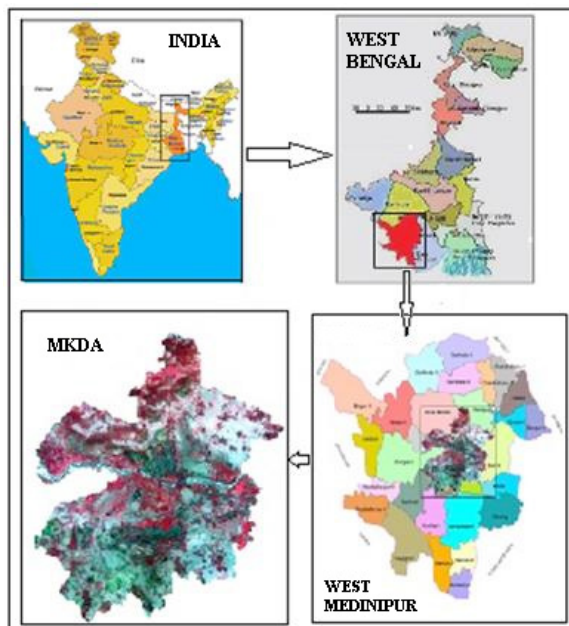


Fig.1 - Location map of the study area

It has an average elevation of 29 meters (95 ft). Several Parts of this area have been flooded in the time of monsoon.

Objectives

The main objective of this study is to assess the water logging propensity of different parts of MKDA and its instantaneous display on map. This main objective can be divided into following sub intents.

1. Estimation of the amount of runoff or total amount of water generation from a single storm.
2. Estimation of the out flows of water through the existing sewerage system.
3. Identification of the direction of water flow and zone of concentration.
4. Real time display of the spatial extension and depth of water logging.

Methodology and Data Used

The first and foremost step of this study was to scan and register all the base maps in digital environment. SOI Topographical sheet No. 73 N/3, 73 N/6 and 73 N/7 at 1:50,000 scales covering the study area were collected from Survey of India office - wood street, Kolkata. District map, MKDA planning map, Block maps are collected from MKDA office, 2nd floor, Sahid Khudiram Zilla Parikalpana Bhaban, Midnapore. Municipality maps of Medinipur and Kharagpur are collected from respective municipality offices. Sewerage condition map of the region is created by primary field survey with GPS. IRS LISS-IV satellite imagery (resolution 5.8m) used for land use land cover mapping, RADAR SAT-1 data (L-band), 2008 (Resolution 102 meter) used to find actual inundation, ASTER DEM (Digital Elevation Model) downloaded from reverb/ECHO website, with spatial resolution 90m is used for slope magnitude and slope direction, Hydrological Soil map of the study area is collected from NBSS & LUP - Salt Lake, Kolkata and rainfall data collected from Directorate of Agriculture, Govt. of West Bengal and Irrigation Department of Paschim Medinipur District.

Inundation Modeling: FLO-2D simplified the process of analytical solution in inundation modeling. It is a two-dimensional flood routing

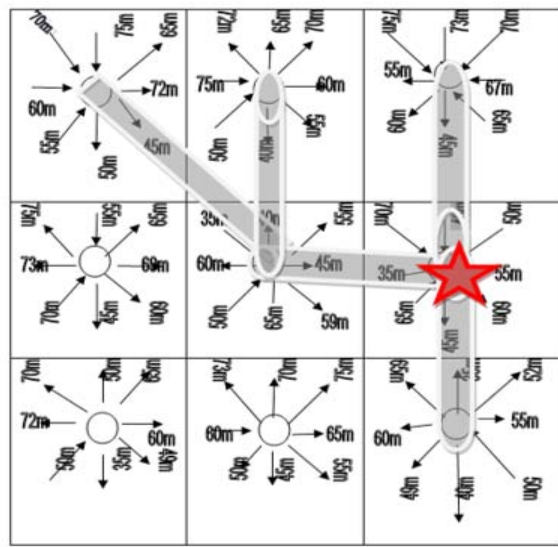


Fig.2 Simulation model architecture

model that has been used to simulate runoff (channel flow, unconfined overland flow, street flow etc.) over complex topography (Anon. 2012). Spatial information on land use land cover, elevation, slope magnitude, slope direction, soil condition, and sewerage condition were incorporated in the model design; finally rainfall duration and amount are used as input to get the inundated areas as output. Shape files for importing results to GIS are automatically generated for most of the Mapper plots. By importing the DTM ground elevation points into Mapper and subtracting the ground elevation from the FLO-2D predicted maximum grid element water surface elevation, flow depths are computed for every DTM point.

Functionality of the Model: FLO-2D routes flows in eight directions as shown in Fig.2. The four compass directions are numbered 1 to 4 and the four diagonal directions are numbered

Pixel co ordinate	Direction	Denoted by No.
X, y-1	North	1
X-1,Y-1	North East	2
X+1,Y	East	3
X+1,Y+1	South East	4
X, Y+1	South	5
X-1,Y+1	South West	6
X-1, Y	West	7
X-1, Y-1	North West	8
XY	Flat	9

Table-1. Table for pixel address and Direction Number.

5 to 8. The grid element boundaries create an octagon shape. For a luciddescription of the model architecture, the inundation model is summarized into 3x3 pixel format and arrows are denoted as slope direction. Firstly model consider first pixel which is XY. Water flows from this pixel to maintain slope height and slope direction to X+1,Y+1 pixel (Table-1). Then model consider next pixel X+1,Y. In this process we get the zone of concentration of water (Anon. 2012).

Results and Discussion

FLO-2D results include the maximum area of inundation (maximum flow depth), temporal and spatial hydraulic results, channel or floodplain cross section hydrographs, peak discharge and other hydraulic output. The 3D MAPPER program has been used to graphically review the model output. The flow depth results have been plotted as shaded contours in MAPPER. This integrated simulation model was used to predict the areas of flooding. For experimental basis we have given the actual rainfall (607mm) the 16th to 18th June of 2008 as input and we have got the 75.376sq km. area of inundation in municipal wards, Village Panchayets and Mouzas.

In Kharagpur municipality ward no. 3, 4, 5, 7, 24, 25, 28; in Medinipur municipality ward no. 1, 5, 6, 9, 18, 19 and Shrirampur, Chherua, Bishripat, Hatiholka and parts of Harispur, Kuldaha in Panchkhuri 6/2 Village Panchayat; Manguchak, Biji and parts of Anandaagar in Tantigaria Panchayat; Ghorachak, Keshpal, Gokulpur, Narayanpur, and part of Barcola, Jinsar in Barkola Panchayat are shown as inundated areas (Fig-3a). In monsoon season due to cloud cover standard FCC images are not available. This model generated inundated areas have been compared with the actual inundated areas extracted from microwave imagery (RADAR SAT-1) (Fig-3c) and primary field survey map (Fig-3b) of nearest date (28th June, 2008). This model validation process is done by calculating the common inundation area using “union” tool of Arc GIS software. Outside this common region there were Juarhati, Paikarapur, Benasol, Tentulia, Maheshpur in Kolaikunda Panchayat; in Kharagpur municipality ward no. 6 and 23; and in Midnapore municipality ward no. 2 and 3 which were actually inundated but not shown by this model. The accuracy level is found to be 67%.

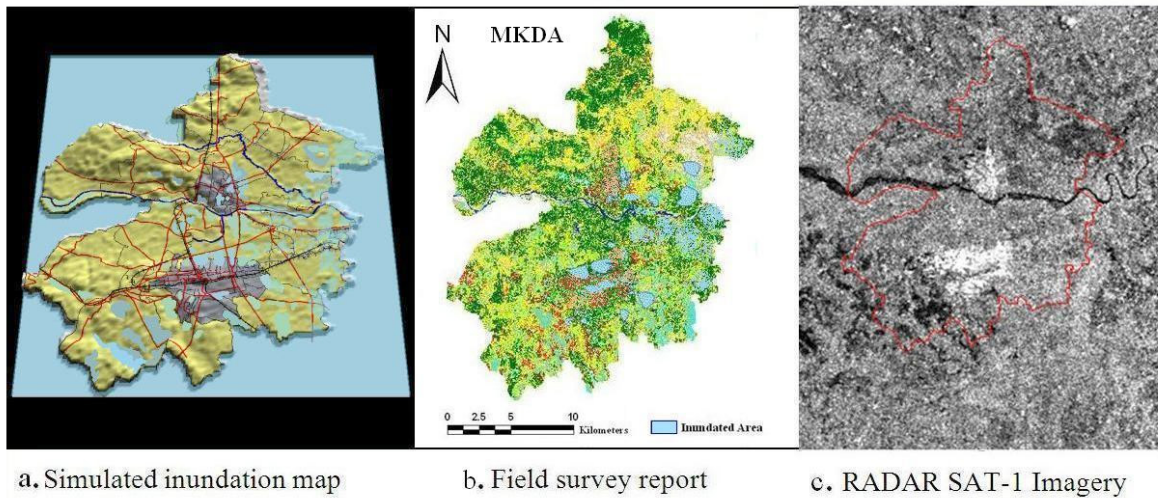


Fig.3. Model generated water logged areas and their corresponding ground truth (28th June, 2008).

Conclusion

Above result depicts that this model is capable of predicting the probability of inundation instantaneously but the accuracy level is not that high. Therefore it may be accepted as a partly successful model but introduction of few more factors like geological condition, ground water potentiality, may enhance the accuracy level up to 80% and in that case it would be very useful for assessment of the probability of inundation in other urban, sub urban and semi urban units of India.

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Assessing Drought for Arid Regions using Satellite Derived Vegetation Index (MSAVI2) and TRMM data

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Keywords: Drought, Remote Sensing, GIS, MSAVI2, TRMM, Assessment, Precipitation Anomaly Percentage (PAP), Correlation, 3B43 algorithm.

Abstract: The State of Rajasthan experiences drought and famine almost in successive years. In particular western part of the state is prone to severe drought conditions. The research enlightens use of satellite based precipitation analysis using Tropical Rainfall Measuring Mission (TRMM) in the study area. TRMM (3B43- Version6) data for the past 15 years (1998-2012) in the four months (June- September) was used in the three major drought prone districts of western Rajasthan. Further, the Precipitation Anomaly Percentage (PAP) analysis was carried out to substantiate the TRMM results. The study also involves spatial comparison of MSAVI2 and NDVI which proved the transcendence of MSAVI2 in less vegetated areas.

I. Introduction

Drought is a complex, slow-onset phenomenon of ecological challenge that affects people more than any other natural hazards (Gupta.A.K. *et al.*, 2011). Drought is a major environmental problem in arid and semi-arid environments (Wilhite 2000; Rathore, 2004). As precipitation is highly variable in both time and space and with the insufficiency of rain gauges, Satellite remote sensing is probably the only way to provide reliable rainfall data in a global scale (Chopra, 2006). TRMM (Tropical Rainfall Measuring Mission) is the first satellite to measure precipitation with the accuracy available from radar (George J. Huffman *et al.*, 2009).

The paper involves experimenting with the remote sensing data i.e. TRMM data to calculate the PAP. Precipitation Anomaly Percentage (PAP) is a Conventional drought monitoring index, which can intuitively reflect the anomaly of precipitation (Yang Shao-E *et al.*, 2007).

Further, to enhance the vegetation signal in remotely sensed data and provide an approximate measure of live green vegetation various vegetation indices have been introduced (Biol, 2010). The sensitivity of the normalized difference vegetation index (NDVI)

to the soil background and atmospheric effects has generated an increasing interest in the development of new indices (Ahmed, 2011). The soil-adjusted vegetation index (SAVI) was developed as a modification of the NDVI to correct for the influence of soil brightness when vegetative cover is low. The problem with the SAVI is that it required specifying the soil-brightness correction factor L through trial-and-error based on the amount of vegetation (Qi *et al.*, 2007). This study stresses on testing, MSAVI2 in the areas with high degree of exposed soil surface.

II. Study Area And Objectives

The study area comprises of three drought prone districts of western Rajasthan namely Jodhpur, Jaisalmer and Barmer as shown in figure 1. Total area under study as per census record is 89,638 sq km. Area is bounded by longitude 69°30' E to 74°00' E latitude 24°30' N to 28°00' N. It is surrounded by Pakistan in west, Bikaner district in North, Nagaur and Pali in East and Jalor district in the South. The objectives of this research paper include:

1. Creation of resource database and thematic layers for the study area in GIS environment.
2. Drought risk assessment by using TRMM data.

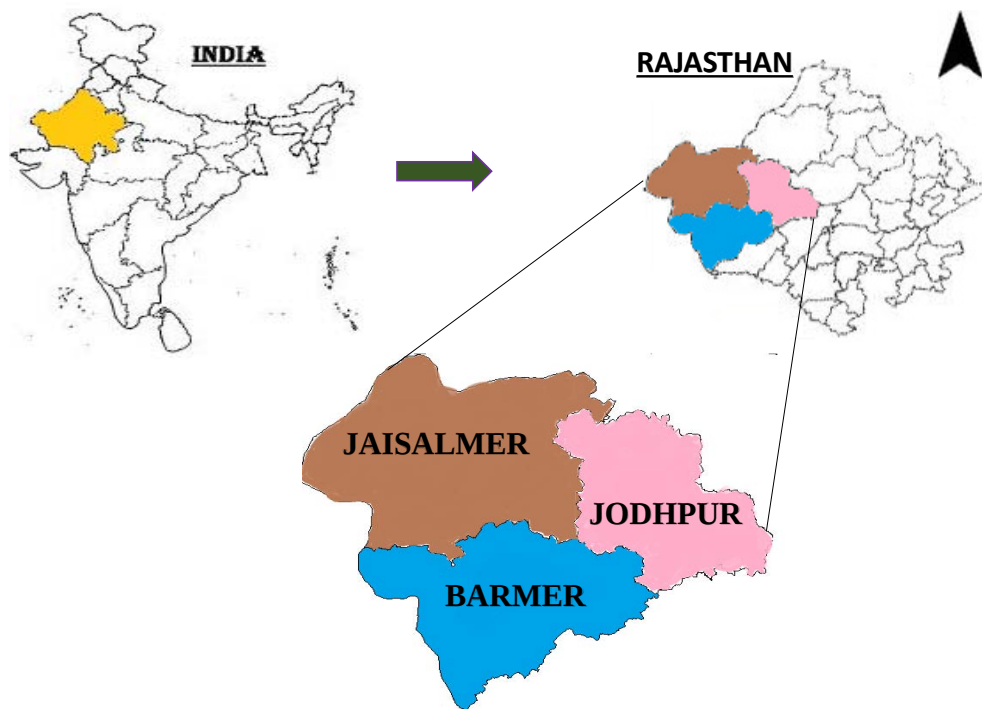


Fig. 1. Location of Study Area.

3. Analysis of NDVI and MSAVI2 images to analyze the transcendence of MSAVI2 in the study area.

III. Data And Methods

A. Creation of thematic layers in GIS environment

The Land Use Land Cover (LULC) data for Rajasthan State for the year 2008-09 was obtained from NRSC, Jodhpur which was further examined and categorized for the study area in ERDAS IMAGINE thereby forming thematic layers for the study area in GIS environment.

B. Monthly rainfall of TRMM (3B43-Version-6)

TRMM is the first space mission cosponsored by NASA and NASDA and dedicated to measuring tropical and subtropical rainfall through microwave and visible/infrared sensors, including the first space borne rain radar.

TRMM has attracted a large and active community of scientists interested in rainfall prediction and measurement. TRMM carries five instruments: the Precipitation Radar (PR), the TRMM Microwave Imager (TMI), the Visible

and Infrared Radiometer (VIRS), the Cloud and Earth Radiant Energy Sensor (CERES), and the Lightning Imaging Sensor (LIS). The TMI, the PR and the VIRS are the primary instruments on TRMM used to detect rainfall, but the VIRS cannot directly measure rainfall.

TRMM data have been reprocessed several times to incorporate improvements in processes and algorithms. Each reprocessing is denoted by a version number. The current version of the TRMM products is version 6 (V6). The V6 3B-43 is on a calendar month temporal resolution and a $0.25^\circ \times 0.25^\circ$ spatial resolution global band extending from 50 degrees south to 50 degrees north latitude [21]. Algorithm 3B-43 is executed once per calendar month to produce the single, best-estimate precipitation rate and root-mean-square (RMS) precipitation-error estimate field (3B-43) by combining the 3-hourly merged high-quality/IR estimates (3B-42) with the monthly accumulated Climate Assessment and Monitoring System (CAMS).

Since June to September is an important period for the crop growth and rainfall the period has been taken as the study period in this paper. All the TRMM V6 3B-43 products from June to September for the years 1998 to 2012 were downloaded by Goddard Space

Flight Center (GSFC) via anonymous FTP. After reprojection to Lambert Conformal Conic type of projection TRMM monthly rainfall data was examined for the study area. The raster TRMM data was converted to point data and the monthly rainfall was calculated by the precipitation rate (V6 3B-43 product) multiplying the total time in different months from June to September (hours).

C. Calculation of Precipitation Anomaly Percentage (PAP)

Precipitation Anomaly Percentage (PAP) is being used to substantiate the efficiency of TRMM.

$$P_a = \frac{P - \bar{P}}{\bar{P}} \times 100\%$$

$$\bar{P} = \frac{1}{n} \sum_{i=1}^n P_i$$

Where, P_a is PAP, P is the rainfall of a certain period, $\bar{P}$ is the long-term average rainfall of the period, n is 1 to 30 years,

$i = 1, 2, \dots, n$. P_a is calculated for a period of 15 years of TRMM 3B43 (Version 6) data i.e. 1998-2012 for the months June to September for the states Jodhpur, Jaisalmer and Barmer separately.

D. Generation of NDVI and MSAVI2 images

Tucker first suggested NDVI in 1979 as an index of vegetation health and density. NDVI is most commonly used vegetation index. But when applied to areas with less vegetation or high exposed soil surface it is sensitive to a number of perturbing factors, such as atmospheric effects, cloud, soil effects, and anisotropic effects *etc.* To reduce the impact to the NDVI from the soil variations in lower vegetation cover areas, Huete (1988) suggested a soil-adjusted vegetation index (SAVI) by introducing a correction factor 'L' (Yang *et al*, 2008). Liu and Huete (1995) proposed the enhanced vegetation index (EVI) to optimize the vegetation signal.

The MSAVI2 (Qi.J *et al*, 1994), is modified soil-adjusted vegetation indices that seek to address many limitations of NDVI when applied to areas with a high degree of exposed soil surface. The problem with the original soil-adjusted vegetation index (SAVI) is that it

requires specifying the soil-brightness correction factor L that ranges from 0, for very high vegetation cover, to 1 for very low vegetation cover. Mostly the value of L is taken as 0.5, which is for intermediate vegetation cover. L to 0 makes SAVI equivalent to NDVI (Huete, 1988). Further, MSAVI defined the value of L incorporating Weighted Difference Vegetation Index (WDVI). MSAVI was modified to MSAVI2 in order to reduce the complexity of calculations in the former (Marshall 2005).

NDVI	$\left(\frac{P_{NIR} - P_{RED}}{P_{NIR} + P_{RED}} \right)$
SAVI	$\left(\frac{P_{NIR} - P_{RED}}{P_{NIR} + P_{RED} + L} \right) (1+L)$ <i>L=Soil Adjustment Factor</i>
MSAVI	$\left(\frac{P_{NIR} - P_{RED}}{P_{NIR} + P_{RED} + L} \right) (1+L)$ <i>L = 1 - 2 * S * NDVI * WDVI</i> <i>S = Slope of the soil line</i> <i>WDVI-Weighted Difference Vegetation Index</i>
MSAVI2	$\frac{(2 * NIR + 1 - \sqrt{(2 * NIR + 1)^2 - 8 * (NIR - RED)})}{2}$ (NIR- Reflectance in near IR band & RED- Reflectance in RED band)

P_{NIR} - Reflectance in near IR band P_{RED} - Reflectance in RED band

Table 1. Comparison of vegetation indices

Table 1 shows the comparison between various vegetation indices.

In this paper temporal WiFS data obtained from NRSC, Jodhpur for September month in the years 1999 and 2009 i.e. drought and non-drought years respectively has been taken for the analysis and comparison between NDVI and MSAVI2. The preprocessing was done in ERDAS IMAGINE utilizing data preparation tool.

IV. Results And Discussions

Creation of Land Use Land Cover Map

Land use pattern is one of the most vital driving forces behind water demand and critical factors of drought. Therefore A generalized Land Use/Land Cover map of the study area as depicted in figure 2. was prepared using LULC map for whole Rajasthan for the year 2008-09 obtained from NRSC, Jodhpur.

The generalized land cover map presents five major types- built-up land, agriculture, forest, wasteland and water body. It is being used to extract the agricultural areas in the

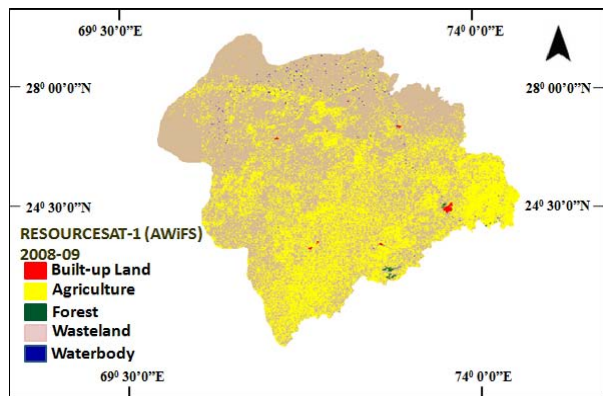


Fig. 2. GIS database map of the study area which are of major concern in the present research done.

B. Meteorological Drought Assessment using TRMM (3B43-Version 6)

Spatial analysis of processed TRMM data was performed for the study period among all the years (1998-2012) to analyze meteorological drought (Figure 3, 4, 5, 6). Depending upon the spatial analysis TRMM data was classified into five classes namely: no rainfall, moderate rainfall, scanty rainfall and high rainfall as shown in figures below. A normal drought condition was depicted in the three districts in 1998 and 2003. The spatial analysis rendered moderate to scanty rainfall in Jodhpur and Jaisalmer districts whereas Barmer received

a normal rainfall in 2004 and 2009. The three western districts under the study area were endowed with better rainfall in 2005 compared to the rain in former years comprehending moderate to high rainfall in Jaisalmer, Barmer and Jodhpur excluding some regions of Jaisalmer that underwent no rainfall. The north-western part of Jodhpur is a vast sandy area which also receives scanty to no rainfall that was considerably depicted through the TRMM spatial analysis over the years for the study area. Scanty to moderate rainfall was experienced in northwestern part of Jodhpur in the years 2010-2012. On the contrary, the district in its south witness decent rainfall as analyzed in 2008 and 2012.

The month of July is bestowed with adequate rainfall in Rajasthan. Except the drought years, all the three districts in the study area received optimum rainfall from 1998-2012. North-eastern part and some regions of Barmer witnessed no rainfall in 1998. Consecutive drought years of 1999, 2000, 2001 and 2002 were depicted through the TRMM analysis in the July month for the study area.

Alike July, the monsoon maintained its persistence in August over the study area with mere intensity and strength. The effect of drought was being delineated efficiently through the TRMM analysis for the years 1999,

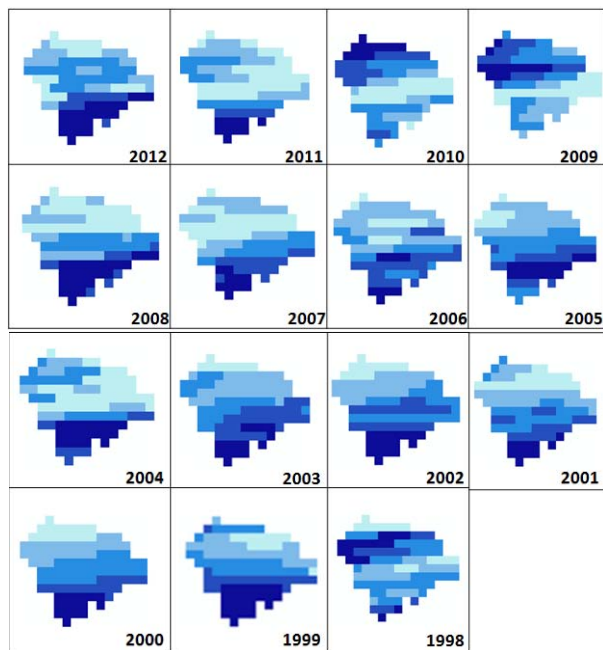


Fig. 3. Spatial Comparison of TRMM data in June month from 1998-2012.

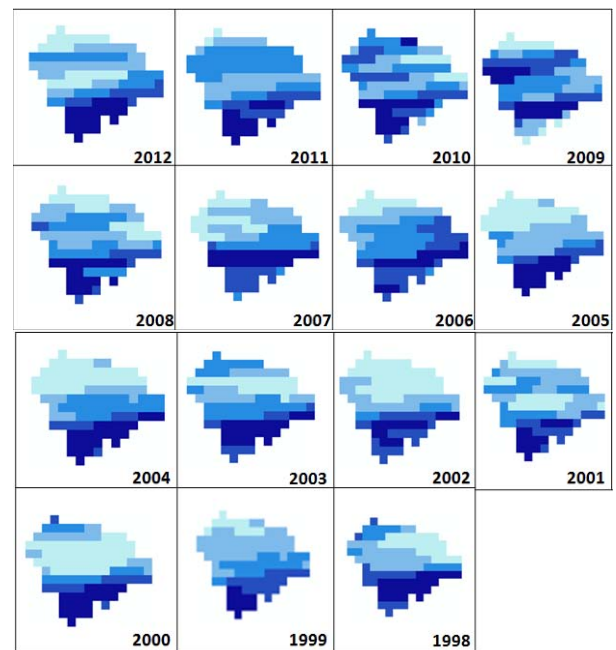


Fig. 4. Spatial Comparison of TRMM data in July month from 1998-2012.

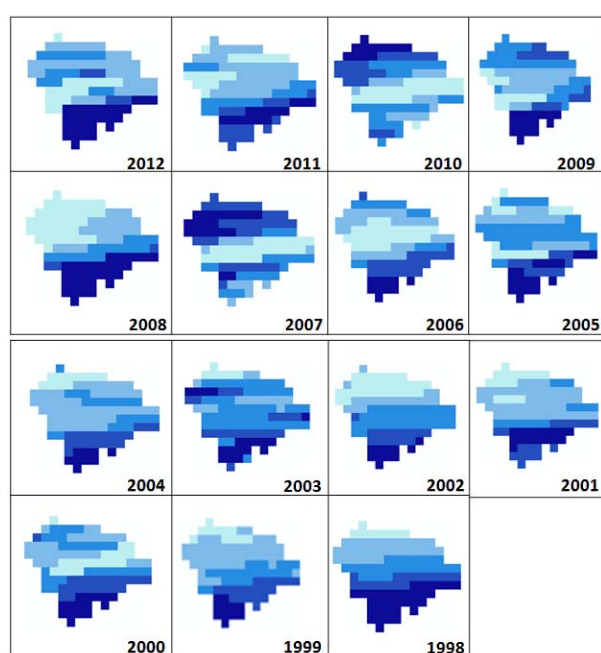


Fig. 5. Spatial Comparison of TRMM data in August month from 1998-2012.

2000, 2001 and 2002 in August. The study area got overall a moderate rainfall in 2003 except some dune regions of Barmer and Jaisalmer. The month of July is bestowed with moderate to high rainfall in the study area in all the years of the study period.

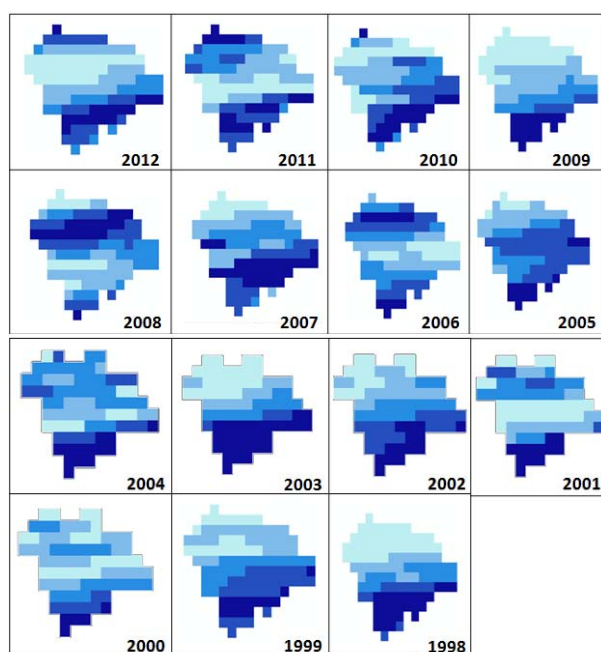


Fig. 6. Spatial Comparison of TRMM data in September month from 1998-2012.

■ No rainfall ■ Moderate rainfall ■ Scanty rainfall ■ High rainfall

Table 2. Meteorological Drought Assessment Using TRMM in Jodhpur District

Years	Precipitation Anomaly % (June-Sept)	Drought Severity
1998	14.23	Normal
1999	-53.24	Extreme Drought
2000	-44.59	Heavy Drought
2001	-37.62	Moderate drought
2002	-27.14	Moderate Drought
2003	13.06	Normal
2004	-2.97	Light Drought
2005	63.40	Wet
2006	10.36	Normal
2007	66.72	Wet
2008	24.17	Normal
2009	-16.40	Light Drought
2010	25.77	Wet
2011	10.44	Normal
2012	-27.17	Moderate Drought

TRMM analysis for the September month affirmed the departure of monsoon from the western Rajasthan. The consecutive drought years viz. 1999, 2000, 2001 and 2002 experienced almost no rainfall in September that was followed with the year 2003 which had no rainfall in many regions of Jaisalmer which advanced to Barmer acquiring scanty to moderate rainfall. The approaching years viz. 2004, 2005, 2006, 2007 and 2008 were depicted

Table 3. Meteorological Drought Assessment Using TRMM in Barmer District

Years	Precipitation Anomaly % (June-Sept)	Drought Severity
1998	25.11	Normal
1999	-59.38	Extreme Drought
2000	-32.98	Moderate Drought
2001	-32.74	Moderate Drought
2002	-55.92	Extreme Drought
2003	12.37	Normal
2004	2.48	Normal
2005	18.87	Normal
2006	-12.61	Normal
2007	42.32	Wet
2008	5.26	Normal
2009	-32.24	Moderate Drought
2010	3.19	Normal
2011	17.63	Normal
2012	-8.27	Moderate Drought

as non-drought years with good rainfall except some dune regions which received scanty rainfall. On to the contrary, 2009 witnessed no rainfall in September month virtually all over the study area omitting some low lying areas of Jodhpur that received moderate rainfall. Jaisalmer was the only district among the three districts in study area that received no to scanty rainfall in 2012 leaving some regions of Barmer and Jodhpur experiencing moderate rainfall.

Further, Precipitation Anomaly Percentage (PAP) substantiated meteorological drought analysis. The PAP was divided into five grades namely normal, extreme drought, moderate drought, light drought and wet. PAP was calculated cumulatively for June-September duration from 1998-2012 and meteorological drought intensity was obtained as depicted in tables 2, 3, 4.

Similarly, meteorological drought assessment was also carried out for Barmer and Jaisalmer districts of the State.

Table 4. Meteorological Drought Assessment Using TRMM in Jaisalmer District

Years	Precipitation Anomaly % (June-Sept)	Drought Severity
1998	2.52	Normal
1999	-47.51	Extreme Drought
2000	-48.69	Extreme Drought
2001	-37.71	Moderate Drought
2002	-33.95	Moderate Drought
2003	6.50	Normal
2004	-3.27	Light Drought
2005	37.52	Wet
2006	-19.54	Normal
2007	69.32	Wet
2008	26.75	Normal
2009	-5.33	Light Drought
2010	55.28	Wet
2011	10.74	Normal
2012	69.32	Wet

C. Comparison of NDVI and MSAVI2

Spatial comparison of NDVI and MSAVI2 was performed in order to substantiate the efficiency of MSAVI2 in drought prone districts in the study area. The study revealed the suitability of MSAVI2 in the study area better as compared to that of NDVI. MSAVI2 as being

a modified form of NDVI takes in account of the near infrared and red bands in the light which is being reflected back from the surface of the vegetation. Moreover, MSAVI2 has been generated performing iterations in MSAVI as a modification so as to simplify the value of "L" i.e. soil adjustment factor. Figure 7 depicted the variation in vegetation in drought and non-drought year using MSAVI2 and NDVI. As compared in 1999 the drought year MSAVI2 showed a little more region under very less vegetation as compared to that in NDVI which incorporated it under moderate vegetation. Similarly, in 2008 which was a non-drought year NDVI rendered vegetation from light to moderate vegetation wherein MSAVI2 depicted the area under moderate vegetation. The study emphasized the potentiality of MSAVI2 in the study area which is a drought prone region.

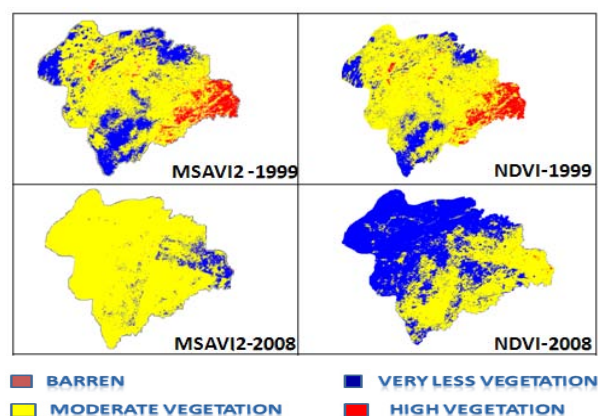


Fig. 7. Comparison of MSAVI2 and NDVI for drought and non-drought year for September Month of year 1998 & 2008.

A spatial comparison was done between NDVI and MSAVI2 as shown in figure 7. Vegetation indices were made to composite on the TRMM data and were correlated.

Consequently, MSAVI2 indicated a better correlation to the meteorological data obtained from TRMM, compared to NDVI for the study area as depicted in figure 8 (a, b).

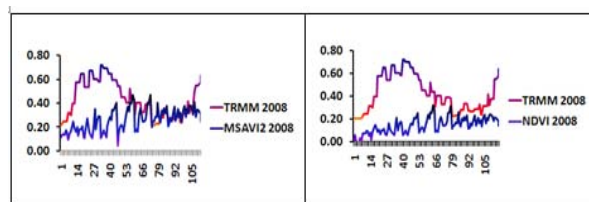


Fig. 8(a). Correlation between Vegetation indices and TRMM

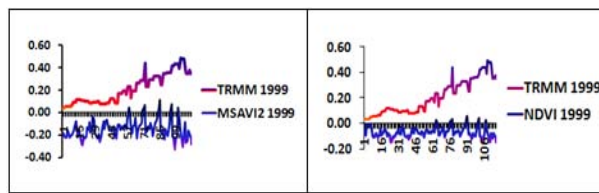


Fig. 8(b). Correlation between Vegetation indices and TRMM

V. Conclusions

The main objective of the study was to find the efficiency of TRMM and MSAVI2 as precipitation and vegetation index respectively in drought assessment.

Accordingly, analysis of TRMM data of the past 15 years was carried out which rendered the meteorological drought assessment. Further Precipitation Anomaly Percentage (PAP) affirmed the efficiency of TRMM as an easier and affordable mean of drought assessment.

Moreover the suitability of MSAVI2 in the study area was analyzed and it was concluded from the study that temporal NDVI and MSAVI2 data analysis and their respective correlation with the temporal TRMM data substantiated the transcendence of MSAVI2 to NDVI in drought assessment in the study area with less vegetation and high degree of exposed soil surface.

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GIS Based Analysis of Trends of Fire Occurrence in Relation to Deforestation Rate: A Case Study of Arunachal Pradesh

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Keywords: *Deforestation trend, Fire, Time-series analysis, Linear regression, MODIS*

Abstract: Arunachal Pradesh with 80.5% of its geographical area under forest cover (FSI, 2011) is undergoing rapid change in its land-use land-cover pattern. With about three fourth of its total population being rural and mostly practicing traditional slash and burn (local "Jhum") cultivation for their livelihood, there is increasing pressure on the forest lands. Present study focuses on analyzing satellite-derived deforestation and fire data to understand if there is any direct relationship between deforestation trend and fire occurrences. MODIS derived fire and deforestation data were used for the years 2003 to 2012 to do a time-series analysis. A combined trend analysis (fire occurrence and deforestation rate) reveals a strong spatial correlation. Interestingly in a few patches, a slowing trend in deforestation rate was found which were well corroborated with the negative trend in fire occurrence in those patches. This may be attributed to the abandonment of traditional Jhum cultivation and adapting to alternative way by the local community of those places. The present study is an attempt for using Geoinformatics as a tool to investigate if forest fire is directly linked with shifting cultivation practice.

Introduction

Arunachal Pradesh, covering a geographical area of 83,743 km², is one of the frontier states of India (Fig. 1). Having 80.5% of its geographical area under forest cover, it has a rich biodiversity in terms of forests. Due to its low population, the forest has remained intact for hundreds of years but this is going to change soon with human interference. As per Champion & Seth Classification 1968, the state has 16 forest types which are grouped in to form 10 forest type groups. In the degraded forests, bamboos and other grasses are of common occurrence. Since the last decade, deforestation has become a common phenomenon in the State of Arunachal Pradesh. The rate of deforestation keeps on increasing with each coming years. Forest Survey of India reported a net decrease of 74 sq. km in forest cover from 2009 to 2011. The main cause of deforestation has been attributed to mostly biotic pressure and shifting cultivation. According to a survey by Forest Research Institute, Dehradun a total of 93% of the total forest areas are being affected by the forest fire in the state (Lodhi et al, 2009). The leading causes of the forest fire can be categorized as slash and burn agricultural

practices, land clearing practices, grazing etc. The implications are frightening as it increases loss of forest cover causing habitat shrinkage, human-animal conflict and other serious health hazards. (Luiz et al. 2010) showed by analyzing satellite-derived deforestation and fire data that if sustainable fire-free land-management of deforested areas is not adopted, the consequence of increased fire hazard may partially negate the effect of reduction in carbon emissions achieved by avoiding deforestation. (Suyanto et al. 2005) has shown that in Indonesia, the conversion of natural forest to agricultural uses has often utilized fire in land clearing. Smallholders and large-scale plantation managers prefer to use slash and-burn methods in land clearing because it is cheap and easy. Uncontrolled and accidental fires burn thousands of square kilometers of forest each year and these previously burned tropical forests are highly susceptible to recurrent fires which are significantly more severe in intensity and impact (Cochrane, 2000). Locals generally clear an area for cultivation or grazing during the dry period (march to may) which leads to more extensive damage than intended as the forest are already susceptible to fire because of prolonged dry period. Apart from forest fire

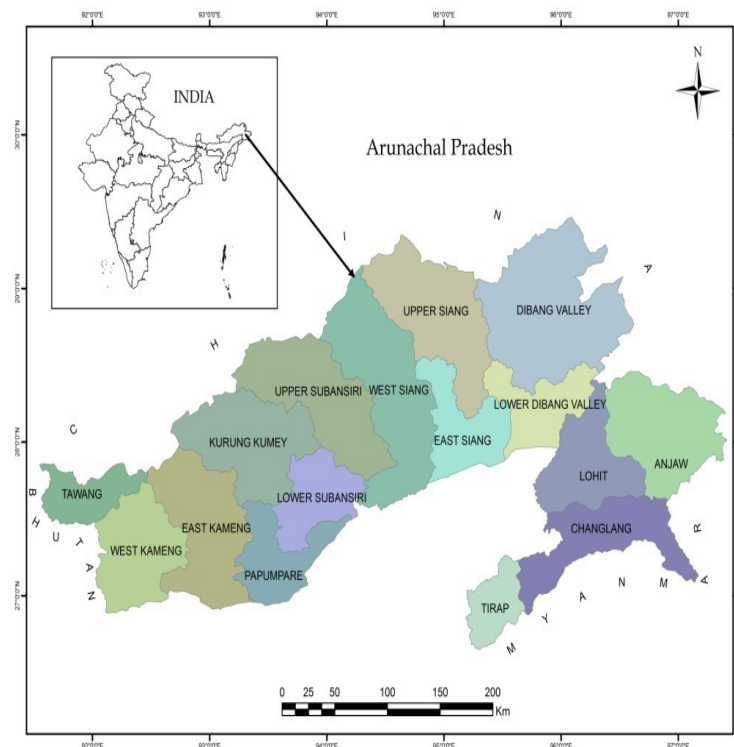


Fig. 1 Study Area

hazards in the state, localized village fire is another major hazard which causes damage to human life and their belongings. The major cause behind this village fire may be attributed to bamboo made houses, which are susceptible to the fire during sunny days.

There is a pressing need to consider the threat to forests posed by fire. State govt. should facilitate for providing alternative and sustainable technology of agriculture (like terrace cultivation) to the farmers or arrange other means of earning for livelihood. Instead of banning shifting cultivation at one go which may be impossible to implement due to the socio-economic scenario of the region, it is a wiser option to go for modifying and managing the shifting cultivation through proper policy decision and use of scientific knowledge. Locals should be made aware of the long term negative impacts of this traditional practice on both the climate as well as their future livelihood. Apart from these, the state forest and fire service departments should play proactive role in controlling the wild fire and jhum fire. The technology and the forest fire management equipments need to be made available to the Jhumias to control Jhum burning.

The present research study is focused on studying deforestation trend in relation with forest fire occurrences in Arunachal Pradesh. In order to get a proper understanding of the possible impacts and effects of fire upon the forests of Arunachal Pradesh in a comprehensive way, RS & GIS technique has been employed in order to detect the effects and losses which have been experienced in the past years. Thermal satellite data is an effective tool for identification and continuous monitoring of forest fire incidence. Optical satellite images provide a comprehensive way to assess and monitor forest cover information. Information derived from multiple remote sensing platforms can then be analyzed in GIS environment to extract useful conclusion. As a state rich in biodiversity, it is of utmost importance to protect the forest resources of the state. And in order to implement effective conservation planning it is necessary to evaluate the present status of deforestation with regard to past scenario and identify probable causes behind it. This research work intends to quantify and analyze the trends in fire incidence & deforestation rate and to investigate if there is any spatial relationship between fire incidence

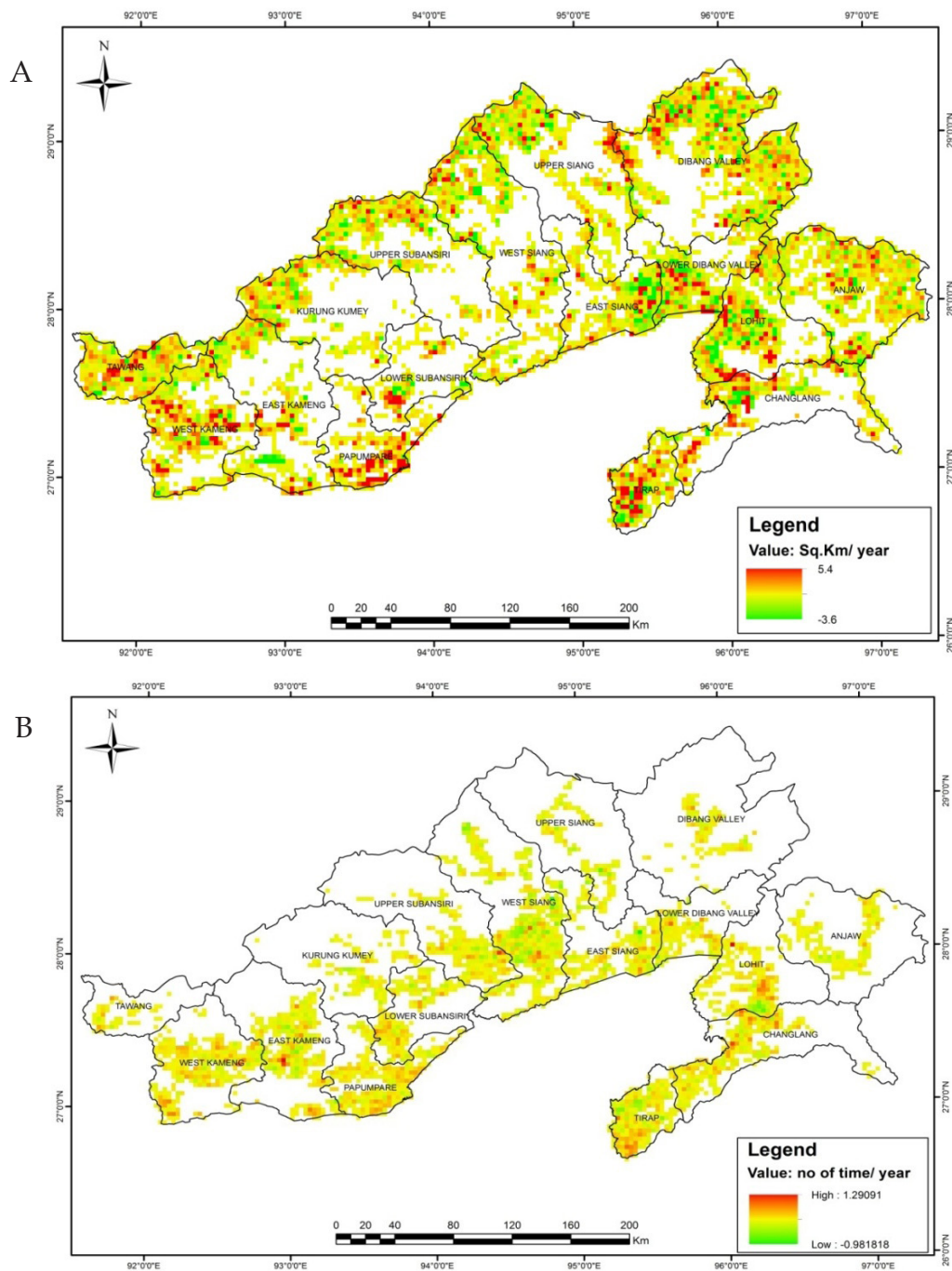


Fig. 2 Slopes of temporal linear trend regression; (A) fire incidence and (B) deforestation rate.

& deforestation rate. So that government can take informed decision while making policy and implement proper measures to mitigate forest degradation problem.

Methodology

MODIS (Moderate-resolution Imaging Spectro-Radiometer onboard Terra and Aqua)

derived fire and deforestation data were used for the years 2003 to 2012 to do a time-series analysis. All available thermal anomaly and land-cover data were downloaded from LPDAAC (Land Processes Distributed Active Archive Center) website to perform a pixel-based analysis of temporal trends in deforestation rates and fire incidence. MODIS

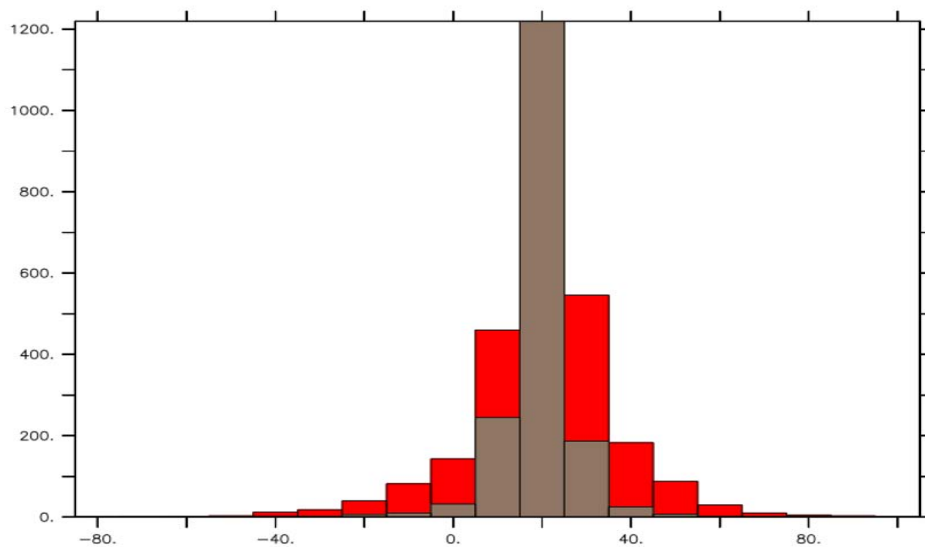


Fig 3 Combined histogram of percentage rate of fire frequency and deforestation rate

(onboard both Aqua & Terra) derived Thermal Anomaly & Fire (MYD14A2 & MOD14A2 8-day L3 Global) data were used for fire pixel extraction and combined MODIS Aqua & Terra derived Land Cover Type (MCD12Q1 Yearly L3 Global) data were used for annual deforestation rate calculation. Fire mask layer were filtered with QA (quality assurance) layer and subsequently a threshold was used to extract only the most confident fire pixels from each dataset. Each available 8-day data in a year were combined to get annual fire frequency image. Since the occurrence of fire pixels were sparse and scattered in nature, each 1000 meter resolution annual fire frequency images were again aggregated to 3000 meter grid for further analysis. This 10 year annual time-series data were analyzed using linear OLS (ordinary least square) approach to find the inherent trend in the series. For deforestation trend analysis, Land cover type-1 (following IGBP classification scheme) layer was extracted and subsequently processed to segregate the image into two classes, viz. forest and non-forest (i.e. all other classes except for forest). Deforestation pixels for a particular year were taken out by subtracting that year image from the previous year data. These deforestation area pixels were then aggregated to 3000 meter grid for analysis and comparison with the fire grids. A similar linear regression (OLS) approach was taken for time series analysis of the 10 year annual deforestation data as well.

Result & Discussion

The trend analysis revealed an overall increasing trend in fire incidence as well as in deforestation rate. The slopes of the pixel based linear trend regression for deforestation rate and fire occurrence is shown in Fig. 2.

Fig 2A shows the increase in fire frequency in a few pixels is as high as 1.3 times per year while the decline rate is a minimum of 1 time per year over a time period of ten years. The patches over the districts Tirap, Changlang, Lohit, Papumpare, West Kameng shows an increasing trend in fire occurrence while the districts East Kameng, West Siang, East Siang, Upper Siang, Dibang Valley, Anjaw are experiencing a decreasing tendency. Deforestation trend (Fig 2.B) is showing an alarmingly high rate of increase (as high as 5.4 sq. km/year) in parts of Tirap, Changlang, Lower Subansiri, Papumpare, West Kameng and Tawang district. The trend surfaces show an overall increasing trend with increasing as well as decreasing tendency in several patches all over the state for both fire incidence and deforestation rate. Temporal trend analysis of fire incidence reveals 16.3% of grid cells with positive slope against 13.4% with negative slope. In case of deforestation 30% grid cells shows a positive slope while 27.4% area shows a negative trend. Comparative analysis of above two maps gives an inclination of a positive correlation between fire incidence and deforestation trend. Fire occurrence and deforestation trend surfaces

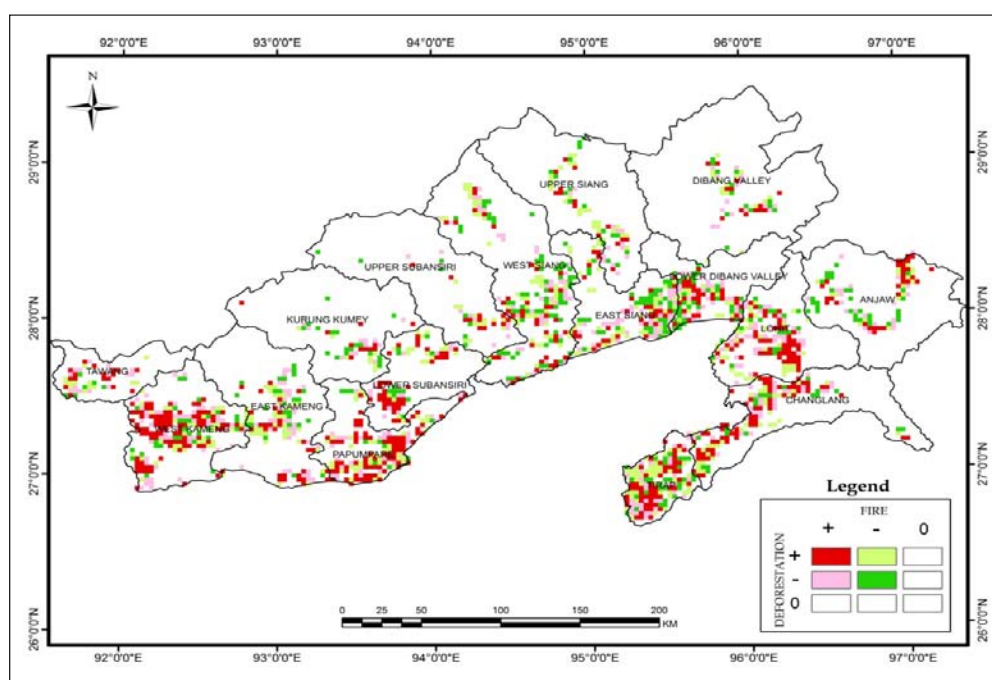


Fig. 4. Pixel based integration of the deforestation and fire trend surfaces.

were scaled to percentage rate (0% to 100% and 0% to -100% for increasing and decreasing trend respectively) and histogram of both these scaled trend surfaces were plotted together (Fig. 3). It was revealed that both the histogram were positively skewed giving a strong indication of a positive feedback between increase in fire frequency and deforestation rate in some areas.

In order to establish a spatial relationship between fire incidence and deforestation trend in a more comprehensive manner, further analysis was done. A pixel based integration of the deforestation and fire trend surfaces obtained by using a decision rule classifier clearly exposed the spatial correlation between them (Fig. 4).

It was seen that in majority of the cases increasing fire incidence is directly related with an increase in forest depletion rate. Tirap, Changlang, Lohit, Lower Dibrang Valley, Lower Subansiri, Papumpare and West Kameng districts are showing a positive trend in both fire occurrence and deforestation rate whereas that of decreasing nature is seen in parts of East Kameng, West Siang, East Siang, Upper Siang, Anjaw districts.

Conclusion

Overall there is an increasing trend in fire occurrence as well as in deforestation rate in

Arunachal Pradesh. The present study reveals that there is a positive correlation between the deforestation rate and incidence of fire occurrence. After analyzing the data for the years 2003 to 2012, we find out that the rate of deforestation and occurrence of fire goes side by side to each other. In Tirap, Changlang, Lohit, Lower Dibrang Valley, Lower Subansiri, Papumpare and West Kameng districts, trends in deforestation rate is on the higher side which is well corroborated with the fact that fire incidence is also increasing in those places. Interestingly the practice of shifting cultivation is also very high in these areas and the region surrounding them. However the regions around East Kameng, West Siang, East Siang, Anjaw, and Upper Dibrang Valley have progressively less patches of deforestation and forest fire incidence. This may be attributed to the least or minimal practice of shifting cultivation by the local people of the area. Apart from other activities which have brought down the percentage of forest cover in the state, traditional cultivation related forest fire is one of the major causes which have greatly reduced forest cover in the past years and it is still effective even at the present time. Government should take immediate and necessary steps to discourage local people from practicing Jhum cultivation by providing technology and support for alternative method of agriculture like step cultivation.

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Study of the Concept, Application and Feasibility of NTRIP (Networked Transport of RTCM via Internet Protocol)

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Keywords: NTRIP, Survey, DGNSS, GPS, GNSS, Internet, Radio, GSM, GPRS

Abstract: Keeping in mind the Land survey in our country where extensive areas are surveyed with an aim to acquire maximum accuracy and the present regulations to get Radio license active, NTRIP can act as an good alternative by reducing loss in connectivity and missing of data while data transfer over longer baselines along with reduction in cost of setting up of base station for each rover over different areas for differential surveying as the server provides it's uninterrupted correction, and the costing incurred for getting a radio license. But the challenge prevails in when the technique is used in remote areas, where the GSM, CDMA, CDPD, or WIFI data availability is restricted or not present. A DGNSS can be employed successfully where meter-level, or even centimeter-level accuracy is desired but accuracy degrades as the distance between user and reference receivers increases and the UHF connectivity reaches it's threshold, the Internet for streaming and sharing Differential GPS corrections (DGPS) to allow precise positioning and navigation comes in as "Networked Transport of RTCM via Internet Protocol (NTRIP)". Further here the application, the concept and the possibility of this technique is discussed.

1. Introduction

A vast range of techniques enables users to obtain point positions using a Global Navigation Satellite System (GNSS) at various levels of accuracy. At one end of the spectrum lies code-based autonomous GNSS yielding accuracies in the range of metres, while at the other end lies dual-frequency phase post-processed static solutions yielding accuracies of a few millimeters. Somewhere in the middle lie techniques of pseudorange correction (PRC) often called "differential correction".

Comparatively less accurate than RTK, PRC's still occupy a solid position in the modern GNSS market because of their relative low cost and ease of use when compared to RTK. Applications that are appropriate for these corrections are in establishing ground control for satellite imagery, providing positioning information for hydrographic surveys, and providing en route positioning for land, ocean and aerial navigation. Pseudo-range corrections can be broken down into two broad: wide area and regional.

Most application transfer data via Internet Protocol (IP) by dividing the data into

appropriately sized packages. The size of one package is limited to a maximum of 65536 bytes and every package gets its own IP address to be identified by the destination source. Compared to the data space (bandwidth) required to effectively stream a movie or music over the internet the bandwidth requirements for providing real time Differential GPS corrections (DGPS) is comparatively minute.

Due to deliberate degradation of GPS signals, i.e., selective availability, was turned off, Stand-alone GPS receivers typically experience position errors of 10-15 meters, and these errors follow a random walk pattern. While this accuracy is adequate for a wide variety of applications, there are other applications where meter-level, or even centimeter-level, accuracy is desired. For such high-accuracy applications, a Differential Global Navigation Satellite System (DGNSS) can be employed successfully. A DGNSS improves the accuracy of position, velocity, and time by providing measurements or correction data from one or more reference stations to mobile receivers. The position of each reference station is accurately known, so its measurements act as a calibration

for other nearby receivers, because the major error sources are common: satellite ephemeris and clock, tropospheric and ionospheric delay. The DGNSS accuracy degrades as the distance between user and reference receivers increases, so for some applications, information from multiple reference stations is desirable.

A new technique using the Internet for streaming and sharing Differential GPS corrections (DGPS) to allow precise positioning and navigation was announced September 2004 under the name "Networked Transport of RTCM via Internet Protocol (NTRIP)". The development of this new technique was carried out by the Federal Agency for Cartography and Geodesy (BKG) together with partners including the University of Dortmund. The main intention is using the "Internet" more or less as an alternative from the current existing real-time correction services provided via radio transmission (LF, MF, HF, UHF) or mobile communication networks like GSM, GPRS, EDGE or UMTS. NTRIP is a generic, stateless protocol based on the Hypertext Transfer Protocol HTTP/1.1 and is enhanced to GNSS data streams.

2. System Architecture

The NTRIP system (Dellmering, 2004) consists of the following elements: NTRIP architecture system is shown in fig. 1.

- NTRIP Sources, which generate data streams at a specific location,

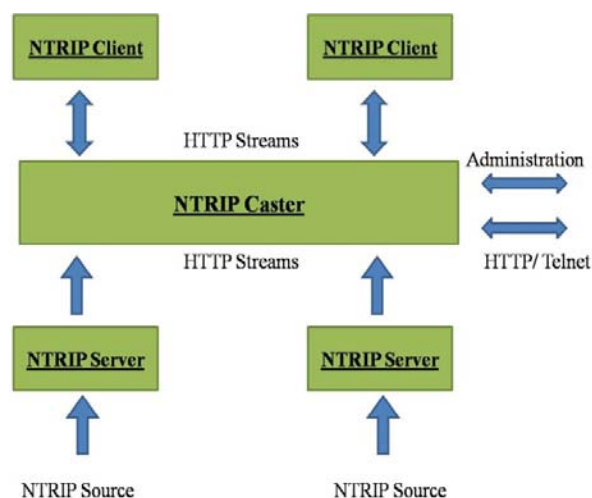


Fig. 1 NTRIP Architecture

- NTRIP Servers, which transfer the data streams from a source to the NTRIP Caster,
- NTRIP Caster, the major system component, and
- NTRIP Clients, which finally access data streams of desired NTRIP Sources on the NTRIP Caster.

2.1 NTRIP Source

A DGNSS reference station in its simplest configuration consists of a GNSS receiver, located at a well-surveyed position. Because this stationary-operated GNSS receiver knows where the satellites are located in space at any point in time, as well as its own exact position, the receiver can compute theoretical distance and signal travel times between itself and each satellite. The NTRIP Sources provide continuous GNSS data (e.g. RTCM-104 corrections) as streaming data. A single source represents GNSS data referring to a specific location. Source description parameters as compiled in the source-table specify the format in use (e.g. RTCM 2.0, RTCM 2.1, Raw), the recognized navigation system (e.g. GPS, GPS+GLONASS), location coordinates and other information.

2.2 NTRIP Server

The NTRIP Server (Weber, 2010) is used to transfer GNSS data of an NTRIP Source to the NTRIP Caster. Before transmitting GNSS data to the NTRIP Caster using the TCP/IP connection, the NTRIP Server sends an assignment of the mountpoint.

Server passwords and mountpoints must be defined by the administrator of the NTRIP Caster and handed over to the administrators of the participating NTRIP Servers. An NTRIP Server in its simplest setup is a computer program running on a PC that sends correction data of an NTRIP Source (e.g. as received via the serial communication port from a GNSS receiver) to the NTRIP Caster.

2.2.1 Data Transfer Methods

There are currently two possibilities of sending correction data. It can be handled directly from a single reference station or all observations from several reference stations used in a network can be forwarded to a central unit (server) for further processing before

broadcast. In both cases NTRIP provides an ideal medium for transporting the data.

2.3 NTRIP Caster

The NTRIP caster is the central block in the NTRIP architecture. All data streams are transmitted through this software program. NTRIP servers connect to the caster using HTTP and register their respective data streams by means of a unique identifier known as a "mountpoint". NTRIP clients may acquire access to data streams only through the caster. The caster is capable of serving many clients from the same data stream simultaneously, or serving many different streams simultaneously. The simple design of the caster has many important features. It acts as a central warehouse for all information regarding data sources. Upon request, a caster can provide a client with a "source table". This table contains an entry for every mountpoint available. For each, information regarding the type of data and the owner is provided. The caster also serves a security role. It implements a simple username/password scheme that can provide a certain level of control to the system (though secure HTTP. More importantly, the caster acts as an intermediary between sources and clients. This means that clients never have direct access to the actual source devices, which makes the entire system more safe, and less vulnerable threatening activities.

2.4 NTRIP Client

The NTRIP client is a software program that essentially carries out the reverse roll of the NTRIP server. It is an abstraction layer that interfaces with the NTRIP caster to provide data streams to a user. Because of the client, a typical user does not need any knowledge of NTRIP.

The NTRIP client allows for username and password exchange, as well as the receipt of a source-table from the caster. Once a stream is initialized, data is transferred from the caster to a user. An NTRIP Client will be accepted by and receive data from an NTRIP Caster, if the NTRIP Client sends the correct request message (TCP connection to the specified NTRIP Caster IP and listening Port). With respect to the message format and status code, the NTRIP Client - NTRIP Caster communication is fully compatible to HTTP 1.1, but NTRIP uses only non-persistent connections.

2.4.1 Server Communication

The NTRIP Server must connect to the NTRIP Caster using the IP and specified listening port of the NTRIP Caster. This means that the NTRIP Caster must be "up and running" before any source can connect. Before transmitting GNSS data to the NTRIP Caster using the TCP/IP connection, the NTRIP Server must send an NTRIP server message in order to get access and to specify a mountpoint.

2.4.2 Client Communication

A client's request is designed as an HTTP message similar to the server message. Each client only needs to know the mountpoint of the desired data stream. An NTRIP Client can either store a source-table in memory (e.g. hard disk), or request a new source-table before requesting an NTRIP Source. The desired NTRIP Source can be chosen manually (e.g. based on identifier, nav-system, and format information) or by software (e.g. based on position, format, and nav-system information). Requesting unavailable mountpoints (out-of-date source-table) will automatically result in the caster replying with an up-to-date source-table (Deming, 2009).

2.5 Source-Table

The NTRIP Caster maintains source-table containing information on available NTRIP Sources, networks of NTRIP Sources, and NTRIP Casters, to be sent to an NTRIP Client on request. Note that to request a source-table from the NTRIP Caster, the NTRIP Client uses the client message while leaving out the mountpoint parameter (Wolfgang et al, 2009).

2.6 Bandwidth Demand

For Wireless Internet-Based DGPS operation there is a minimum wireless Internet bandwidth that must be satisfied. The required bandwidth depends on which messages are being generated at the reference station, and the message period. The slowest rate at which one should send RTCM messages for a RTK DGPS system is once every 5 seconds. The remote receivers can fix integers with base station data arriving once every 5 seconds or faster [Magellan, 1998]. The position error will grow with an increase of data transmission latency, so a fast rate to send RTCM messages will help improve the RTK positioning accuracy (Mircea, 2009).

A rate of ten times per second was chosen in the prototype system since it was found that the server and the client can exchange data with the GPS receivers most reliably at this rate. The RTCM message types 18 and 19 are the most important messages for RTK positioning. They are usually set to output every second. The RTCM message types 3 and 22 are also used for RTK positioning. They are usually set to output every minute. Therefore the RTCM messages for RTK positioning are mainly composed of types 18 and 19 so that the bandwidth requirements are mainly determined by the above two types of messages. For RTCM, the data is packed in 6/8 format. The required number of bits is 8/6 times the number of bits in the message. The size of the TCP (Transmission Control Protocol) header is different from that of the UDP (User Datagram Protocol) header. For TCP, If the IP packet size is set as 512 bytes, the required number of bytes is 512/472 times the number of bytes in the RTCM messages. For UDP, If the IP packet size is set as 512 bytes, the required number of bytes is 512/484 times the number of bytes in the RTCM messages.

2. Field Study

2.1 Study Area:

Mumbai, Andheri West.

Andheri is a suburb, 30 km north of Mumbai, situated in the west of the city (Fig. 2). It is also a railway station on the Mumbai Suburban

Railway, Western line. Like many other Mumbai suburbs, Andheri is divided into an east and a west section, which are separated by the railway line. Andheri today has a population exceeding 1 million and, as per record, is by far the most populous suburb of Mumbai. Contemporary West Andheri is largely a residential area, whereas East Andheri has a mixture of commercial and residential areas, including MIDC-SEEPZ (Santacruz Electronic and Export Promotion Zone), Saki Naka (an industrial area), etc.

2.2 Extent of Study Area (Table 1)

- 19° 08' 34.54"N, 72° 49' 51.84" E to 19° 08' 34.25" N, 72° 50' 02.40" E
- 19° 07' 49.18"N, 72° 49' 51.64" E to 19° 07' 48.45"N, 72° 50' 17.03" E

2.3 Observations

- With increase in distance from the base, the fluctuation in data accuracy is more in radio than in NTRIP.
- The RTK Base rover setup initialization is faster in NTRIP than in Radio, though the NTRIP connectivity becomes a major determining factor.
- The accuracy remains more consistent in NTRIP over varying distance.
- The problem of RTK Float to RTK Fix is prevalent in Radio data link than in NTRIP.

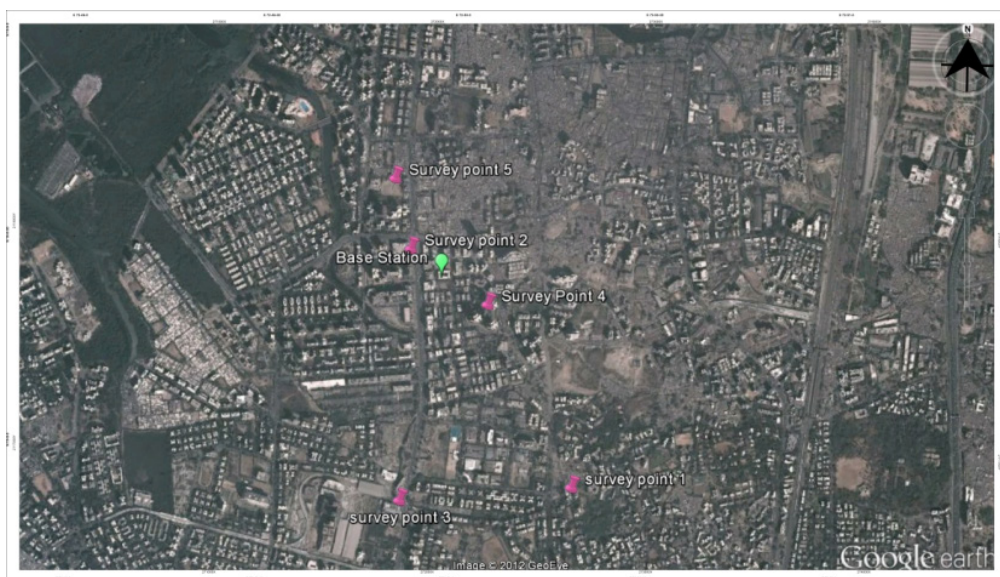


Fig. 2

Table 1.

Survey point	Latitude	Longitude	Base-Line	Radio		NTRIP	
				RTK	DGPS	RTK	DGPS
1	19° 7'53.52"N	72°50'18.45"E	1146.95 m	0.82m	0.663m	0.62m	0.532m
2	19° 8'27.48"N	72°49'52.29"E	187.28 m	0.71m	0.492m	0.64m	0.489m
3	19° 7'50.88"N	72°49'51.62"E	1068.54	0.75m	0.610m	0.61m	0.531m
4	19° 8'19.71"N	72°50'4.58"E	265.79 m	0.65m	0.608m	0.63m	0.485m
5	19° 8'37.67"N	72°49'49.54"E	458.19m	0.59m	0.485m	0.55m	0.488m

3. Discussion and Conclusion

NTRIP is a new technology to transfer GNSS data (for example RTCM correction data) via the Internet and mobile IP networks. Practical tests do not show a significant degradation of performance compared to using other transportation media. NTRIP's main software components are developed within EUREF under the GNU General Public Licence. RTCM's Special Committee 104 has setup a Working Group "Internet Protocol" to further develop NTRIP towards an international standard. Due to its almost worldwide availability and the widespread hardware for wireless Internet access, NTRIP is a source to become an alternative to the existing radio licensing hassles.

A radio data link has been used for communication between the base and rover stations in most DGPS systems. Radios that work in UHF Commercial Band ranging from 450MHz to 470 MHz, become the mainstream to provide data link for DGPS systems. Radio based transmissions (Micea, 2009), however, have several significant disadvantages when used for DGPS positioning and navigation. First, radio has a very short data transmission range limited to line of sight (LOS) between the base and rover radios. Second, the radio waves in UHF commercial band are crowded and noisy: the band is designed for public and improper frequency resource sharing strategy results in larger cross-channel interferences. The interferences deteriorate the communication quality seriously, and lead to even smaller radio effective range than LOS. In urban area, where the radio wave environment is harsh, the radio effective ranges are usually limited to a few kilometers. Moreover, the data transmission suffers problems such as UHF commercial band: LOS limitation, small channel separation, lack of effective frequency

resource sharing strategy, and inferior priority to voice (Kim et al, 2005).

With any kind of transmission technique the travel time of DGPS or RTK correction data is of decisive importance (Dammalage and Samarakoon, 2005). The positioning software on the rover side requires the relevant data almost instantaneously (depending, to a certain degree, on the type of positioning). Considerably delayed missing or irregularly arriving correction data will degrade accuracy, not such a problem when exclusive transmission paths (e.g. AM or FM broadcasters) are used. However, when using the Internet, a DGPS application shares resources of an Internet Service Provider (ISP) with other applications and hence the bandwidth cannot be controlled. Thus the challenge persists in rural areas or restricted areas where the availability of good internet connectivity is a hindrance. At present the NTRIP network can be assumed to be a good alternative to radio based surveys in urban areas.

4. Acknowledgement

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Preserving Heritage: Mapping Archaeological Sites through Web GIS Chalcolithic Settlements in West Bengal: A Case Study

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Keywords: *Chalcolithic, Black and Red Ware, Early-historic, GTS*

Abstract: It is the duty of the Present to preserve the Past glory properly so that the Future can draw inspiration from its heritage. Indeed, the available information of the cultural heritage of a country itself provides scope for developing plans for its appropriate preservation and apt utilisation. Centre for Archaeological Studies & Training, Eastern India (CASTEI, under Information and Cultural Affairs Dept., Govt. of West Bengal) has actually been doing this over a decade, i.e., trying to make people aware of the heritage as well as making attempts to preserve the past glory. Through a Web-GIS platform, CASTEI has been developing maps of archaeological settlements of different time frames in river basins of West Bengal. The main purpose has been to create a tool, easily accessible and suitable for students, experts, archaeological researchers as well as for common people who are interested in the cultural wealth of different areas for both research and tourism purposes. The regional and ecological importance has been coordinated in order to provide a complete and vivid description of the location of the archaeological entities. Data sources include both spatial and non-spatial data. All the data are processed and pre-loaded in the system as vector and raster files and PostgreSQL and DBMS tables. The whole system is loaded in a common website, in HTML language and using MapServer for GIS functions and PostGIS for its connection with PostgreSQL database. The improved functions of the web environment are map browsing, single and multiple queries and the thematic view of archaeological features.

The present paper as a case-study only focuses on the Chalcolithic settlement in the south western part of West Bengal. In the second millennium BC a vast area comprising the present administrative districts of Medinipur, Bankura, Bardhaman, Birbhum and part of Murshidhabad simultaneously came up as chalcolithic cultural settlements along the river basins, the fact which itself is fascinating and calls for detailed study.

1. Introduction

It is evident from history that, even in a cultural zone (a zone distinct for its special features in relation to particular culture or tradition) there are areas of significant concentration as well as areas of low intensity of manifestation. This is such as human activities relate differently to different segments of the zone. Again, with the passage of time and advent of new cultures, the patterns of concentration change. The reasons for changes in culture and spatial patterns of culture could be many – environmental, technological, mobility, expansion or a combination of many such factors. Understanding such changes in spatial patterns is essential for understanding history.

It is with the aim of illustrating the directions of archaeological and historical change within the state boundary of West Bengal, Centre for Archaeological Studies & Training, Eastern India (CASTEI, under Information & Cultural Affairs Dept., Govt. West Bengal) is engaged in preparing archaeological atlases (*Chottopadhyay, 2005*). The present author is closely associated with the work.

2. Study region

The study area, the Western parts of West Bengal, lies between 87°00'E and 88°05'E Longitude and between 22°30'N and 25°00'N Latitude. It is one of the areas intensely inhabited by the past population (*Sen, 1973*). A number of Chalcolithic and Early-

historic sites have been found in this region by the banks of various rivers (*Dasgupta, 1963*). Many archaeological sites like Kherur and Rajbadidanga (Murshidabad), Pandu Rajar Dhibi, Mangalkot and Banewardanga (Bardhaman), Bahiri (Birbhum), Dihar (Bankura), Tamluk (East Medinipur) etc were excavated yielding sequential cultural horizons with rich deposits (*Roychowdhury, 2002*).

2.1. Physiography of the western plain

The Western Plain is situated between the Delta and the plateau region of West Bengal and comprises the districts of Murshidabad, Birbhum, Bankura, Bardhaman and parts of Medinipur. This region is formed by the alluvium deposition from the eroded rocks of Chhotanagpur Plateau. It consists mostly of large grained lateritic soil, which is not thick and is alkaline in nature with little organic matter. Of the rivers flowing in this region—Mayurakshi, Ajay, Damodar, Dwarkeshwar, Silai and Kasai are the most important. All these rivers, originating in the Chhotanagpur Plateau, flow through these regions in the eastern, south-eastern directions and fall into the Bhagirathi-Hooghly River.

3. Previous research: GIS and web-mapping in archaeology

In Europe, GIS has been used in the field of archaeology since early 1980s and the Aerial Photography has had a long history of use. English Heritage's Finland Survey Project is supposed to be the beginning of the application of the GIS and RS in the domain of archaeology. Since 1988 there has been rapid growth in the application of GIS, a tool both for Archaeological Research and Cultural Resource Management.

3.1. Indian context

In the late 1990s when an attempt was made to establish that the Aryans had their roots by the side of the old course of the river Saraswati, RS and GIS were employed. Signatures of the old course of the river (i.e. the palaeo-channel) were detected by using satellite data. Many attempts have been made after that,

In the present decade, the Centre for Archaeological Studies & Training, Eastern India for the first time in West Bengal has been making use of RS and GIS in its attempt

to locate the archaeological sites on present landscape.

4. Role of RS, GIS, web-mapping in archaeology

Remote sensing (RS) and GIS are treated as important modules for acquiring digital information regarding the cultural topography and landscape. These techniques constitute a valuable tool in the mapping and management of archaeological sites during the course of large development works. Aerial and satellite images can contribute to the detection of new archaeological sites and in turn help outlining the protection plan for those sites. A further advantage of GIS lies in its ability of updating the geographical information index in a continuous and interactive mode, processing and storing large volume of diverse data and creating thematic maps based on specific inquiries. The above can be used in archaeological research for modeling the settlement patterns of a region, locating and outlining high density sites, studying the communication or defence networks, specifying cost surface regions used for the exploitation of natural resources, etc. The creation of electronic thematic maps that present various cultural and environmental information can be of great use in solving problems frequently confronted in environmental and development plans, as well as suggesting specific solutions for the protection, preservation and management of ancient monuments.

An earlier stage for any project dealing with the shelter, preservation and supervision of archaeological sites, as well as with archaeological landscape and settlement modeling, is the accurate mapping of sites and their correlation with the corresponding environmental information. Such venture is being made by the Centre. The course of actions is shown in the Flow Chart (Fig. 1).

The designing and construction of a website is being done which hosts the GIS-based digital archaeological map along with the rest of the results of the project. The website is serving both the digital map within a GIS environment and the database. Thus the user, accessing an HTML viewer, is able to define the map layers he or she wants to view. At the same time he or she has full access to the archaeological database for searching and printing the

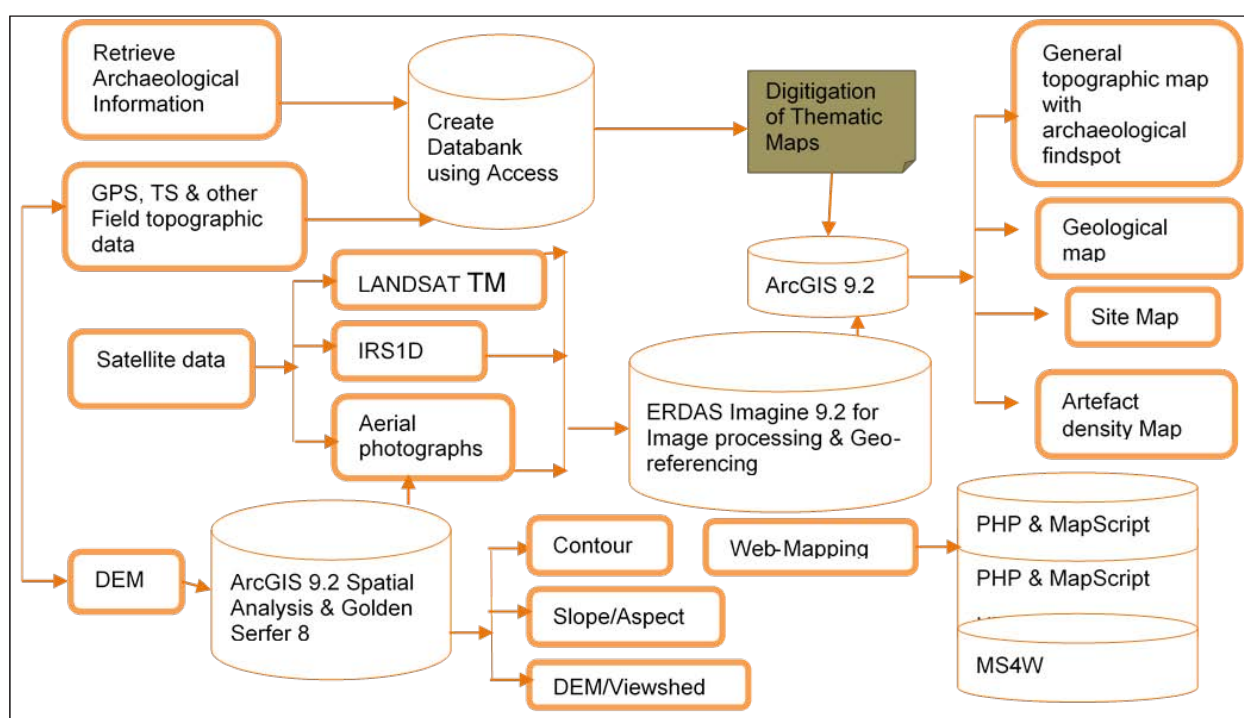


Fig 1: Flow-chart of the steps of web archaeological mapping

registered information. Once the sources of all data are known and how they have been processed and stored, it is now possible to see the web-GIS structure and how this information is used in it.

5. Archaeological database

A relational database has been created for the registration of the archaeological information collected from the published data (Hunter, 1973 and Peterson, 1997). The format and general design of the database have been based on the principle of compatibility with the rest modules of the Web-based GIS platform and the possibility of expanding the project within the wider region of West Bengal.

The GIS database covering the area in this paper is about 41.68 sq.km. It covers the maximum part of the western plain and its immediate environs. The current basic raster and vector layers of the GIS include elevation, aspects of slope, palaeo-channels, drainage, roads, archaeological sites and other field data. The archaeological sites have not only been demonstrated, an attempt to show the work of the past history in the present landscape of the basin has also been made which in turn has provided a database capable of responding to considerable demands of GIS technique.

The database has been initially created in Access and then it has been transformed to MDB and SQL formats. The MDB format of the database includes the coordinates of the sites and it has been connected to the rest geo-referenced maps. The SQL format of the database has been used for querying the archaeological information and producing reports of the sites of interest (Rivett, 1997).

The database consists of two basic tables which include various types of information, such as name of the sites, police station, nearest village, type of site, chronological periods, information regarding the excavation or surface survey, techniques, ancient-environmental data, present environment, bibliography, photographs, plans, GPS coordinates, general remarks. The tables have been related to each other through a common coding system, so that they ensure the successful retrieval of information through possible queries. The main tables of the database refer to the sites and the corresponding bibliography. Other tables contain the full path name of the files referring to the images or topographic plans of the sites with socio-economic models.

The database has been implemented in the GIS, which has been used for the digital map. The Web user is able to search the database by

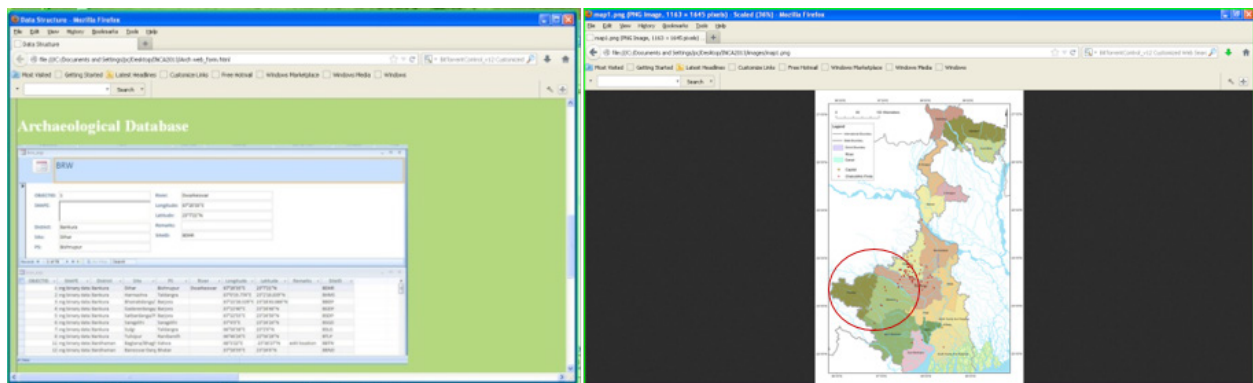


Fig. 2: Static Map in Web with Database

specifying either the full name or part of the letters that form the name of the site. Based on the query results, thematic maps can be produced based on simple or combined queries (eg. type, chronology, etc.). The user has also the opportunity to print specially designed reports for each site, through the WEB. The reports of the sites have been used for the better presentation of the information that is included in the database (Fig. 2).

6. Methodology of survey for archaeological sites

The base stations have been established in the beginning of each survey period, by taking measurements from GTS datum points and comparing them with their known coordinates using Garmin GPS. Each measurement has been represented with a distinct 4-digit code name, while a small draft plan of the site marks the locations that have been measured.

One of the first steps taken in surveying has been to obtain existing control points in

the toposheet of the area of interest. Once this is accomplished, field reconnaissance has been performed in an attempt to locate those control points. At first, the road crossing point of a village nearer to a site derived from the toposheets has been taken as the base-point for the survey. Two-fold survey method has been adopted. The traverse network has been laid out using chain and compass through a line of the badland area. Then the Total Station survey enables to find the height of the site. This helps in generating contour map.

7. Making thematic maps

A number of archaeological and topographic features have been digitized to be included in the thematic map list that can be activated in the final product. By making use of the *Spatially Extended Entity Relationship (SEER)* diagram (Firms, 1994), line data (river, contour, road. etc), point data (site, bench-mark etc.) and polygon data (geological formation, vegetation) have been correlated and cross-referenced leading to formation of thematic layers (Fig. 3).

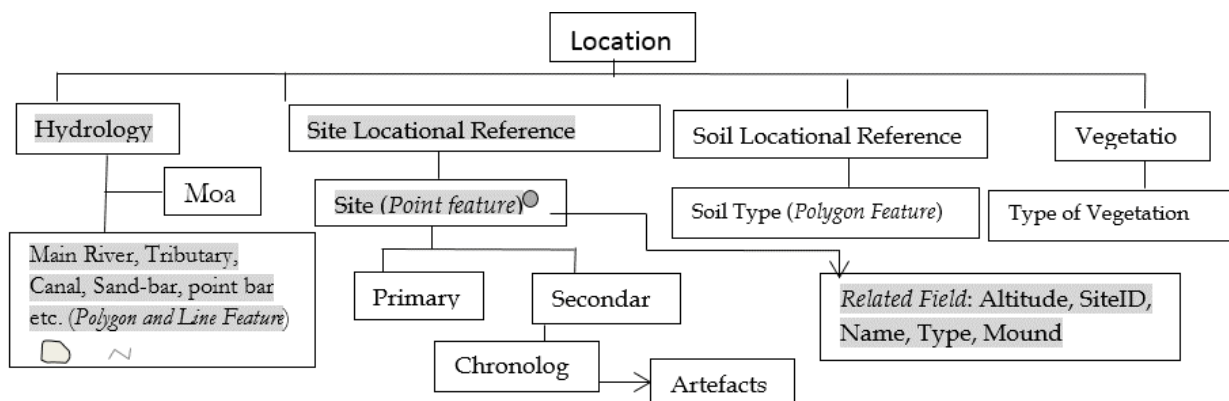


Fig. 3: SEER Diagram for making thematic layers

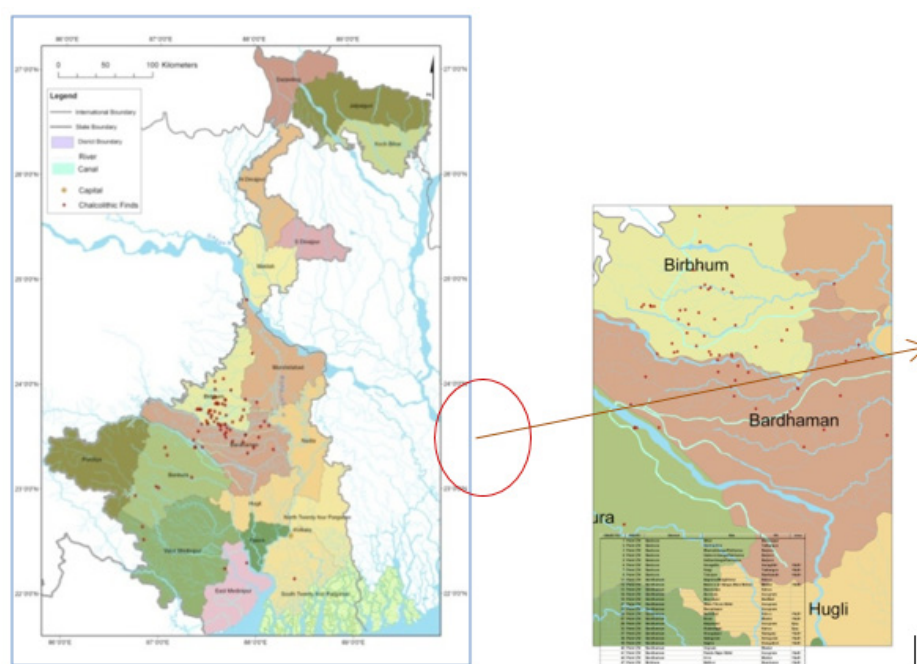


Fig.4: Distribution pattern of Chalcolithic culture in West Bengal

Different layers have been created in order to provide the capability of separation of the cartographic products. Different colours have been assigned to each layer. The topographic features digitized from the 1:1,000,000 scale maps are presented in Fig 4. 5m contour lines have been digitized from 1:25,000 scale maps for the wider view of the Ajay river Basin (south of the Ganga in West Bengal). The Basin is being presented here as the case study. Geomorphological maps too have been developed on the basis of GSI Reports (Roy, R.K. and B.K. Ghosh, 1988).

8. Remote sensing - Digital Elevation Model (DEM)

IRS 1D, LISS IV, Landsat TM images have been georeferenced to the Polyconic reference system (1956 India-Nepal datum). All images have been compressed with MrSid encoder down to a factor of 75-90%, resulting in images of total size less than 800KB, which can be easily served in the Web. All images have been processed through the application of contrast enhancement techniques.

For example, the DEM of the Ajay basin has been developed from the SOI Topographic sheets 73 M/10 (NE, NW, SE, and SW) and 73 M/14 (NE, NW, SE, and SW) at the scale of 1:25,000. Contours have been manually

digitized at an interval of 5m and some other characteristic features have been added, e.g. BM points, triangulation points etc., and also added height point of TS Survey taking from ground. Altogether, more than 15,155 points have been taken. Given the chosen resolution and the fact that data have been collected with a precision of plus or minus 5m, this number of points should be held sufficient for the development of a DEM.

The light brown or grey areas of the model (i.e. 65m) are the highest elevation points and sites like Pandu Rajar Dhibi (Panduk), Chellakamarpara, Gopalnagar, Nachansaha, Bergram (Roychowdhury, 2002a) are situated between 60m and 45m altitude. The dark green area (40m-19m) of the DEM harbours other sites like Mangalkot, Deuli, Bahiri, Aral, Ausgram, Majhigram etc. There has been a significant landscape change in this basin since the Late-Holocene period. Still some sites are yet not disturbed and survive in the upper region of the Ajay flood-plain rather than those situated in the alluvial zone (Fig. 5).

From the field study as well as from the data available it has been understood that the Illumbazar and the Natunhat surfaces provided the most stable landscape for the Chalcolithic people (Roychowdhury, 2002).

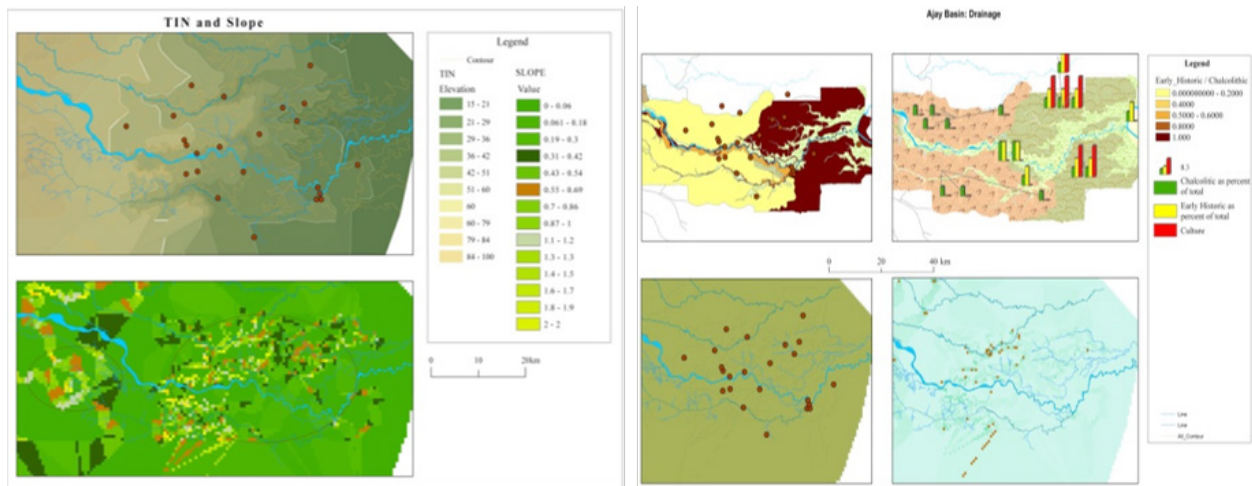


Fig. 5: DEM, Slope and high-density zone of chalcolithic people

The other part of the Map (Fig. 6) is about the *aspect* or the direction of the slope of the plain generated from the contour data. This also enables one to understand the rate of preservation of sites as most of the undisturbed sites (from the fluvial action) are situated at the point of merging of the two *aspects* of the riverine plain. The Illumbazar surface (Laterite Upland) has regional slope of 1.28 m/Km. The regional slope of Nutanhat surface and Katwa surface (alluvial terraces) are 0.61 m/Km. & 0.34 m/Km respectively.

9. Results: Creation of the web-based digital archaeological map

For the better dissemination of the results of the project, it is now decided to serve all the information layers through the Web. In this way, the user is provided access not only to colourful static maps, but is also allowed to interact with the system, activating any number of information layers at any time at his or her own will.

The initial web page of the digital map is presented in a very simplistic form, consisting

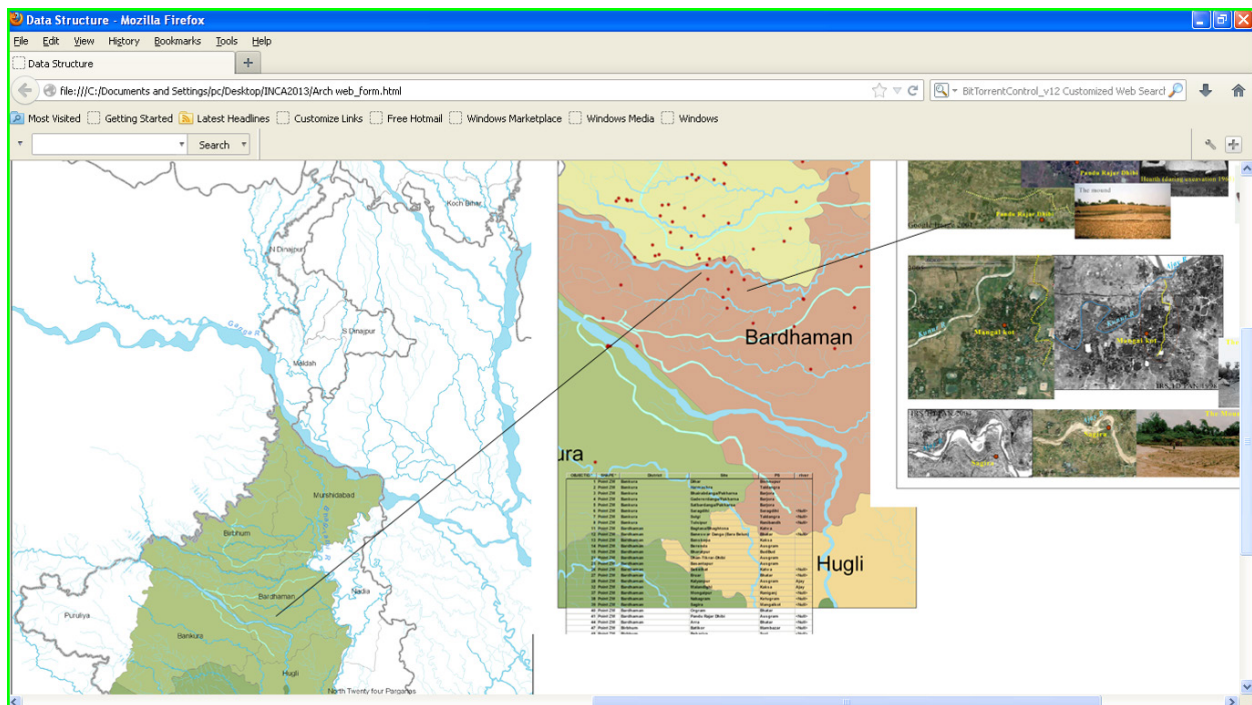


Fig. 6: Static web-Map of the study region

just the main and secondary road network. The user can activate any layer and query information included in the menu. The query results that satisfy the criteria of the user are presented at the lower portion of the screen, consisting of all the descriptive and spatial information that the administrator allows accessibility by the user (Fig.6).

10. The road ahead

The digital archaeological map of West Bengal constitutes the first step towards a more systematic plan for the management and preservation of the cultural resources of the land. This can be made model for other regions also. The final product of this approach could be accessible to the interested parties through the WEB, assisting the state planners as well as supporting the local and regional growth, enhancing the tourism and cultural industry and offering a multidimensional and integrated solution to a number of problems encountered in the management of cultural heritage.

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GIS Data and Algorithms Based Data Structures: A Review of Problems and Solutions

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Keywords: *Data Structure Algorithms for GIS; Programming Languages for GIS; Geospatial Software Engineering Techniques*

Abstract: A Geographical Information System (GIS) is a software package for storing geographic data and performing complex operations on that data (spatial and non-spatial). For example finding out and reporting the area of land that will be flood affected when water level rises of a river nearby, or analyzing the costs, benefits, and/or risks involved with the development of industrial activities or implementation of new agricultural practices at some place. A significant part of these functions/uses of GIS involves computing with the geometry of the data; such as location, shape, proximity, and spatial distribution etc. And the massive amounts of data stored in a GIS calls for efficient methods of storing, manipulating, analyzing, and displaying it all. This makes the field of GIS to be dependent on various Computational Geometers and Data Structures. In Computer Science, a data structure is a particular way of storing and organizing data in a computer so that it can be used efficiently for further processing and analyses. These analyses or processes are performed according to the design of the data structure. This combination and inter-dependency of the field of GIS and Computational Data Structures opens up a world of problems and their solutions.

Introduction

Database Management Systems play an important role in GIS, since DBMSs are traditionally used to handle large volumes of data and to ensure the logical consistency and integrity of data, which also have become major requirements in GIS. Today spatial data is mostly part of a complete work and information process. In many organizations there is a need to implement GIS functionality as part of a central Database Management System (DBMS), at least at the conceptual level, in which spatial data and alphanumerical data are maintained in one integrated environment. Consequently DBMS occupies a central place in the new generation GIS architecture.

We know that:

1. Database is the backbone of GIS.
2. It needs to be stored in a computer.
3. For efficient retrieval of data, it needs to be arranged according to certain Data Structures.

A significant part of GIS functions involves computing with the geometry of the data such as location, shape, proximity and spatial distribution etc. stored in these DBMS's. And the massive amounts of data stored in a GIS calls for efficient methods of storing, manipulating, analyzing, and displaying it all. In Computer Science, a data structure is a particular way of storing and organizing data in a computer so that it can be used efficiently for further processing and analyses. These analyses or processes are performed according to the design of the data structure.

Background and literature

A. GIS Data and Map Layers

In a GIS data is stored in separate layers. Maps in GIS are composed of a series of map layers (Fig. 1) drawn in a particular order. A map layer defines how a GIS dataset is symbolized and labeled (that is, portrayed) in map views. A layer represents geographic data according to particular themes designated. Examples of map layers include streams and

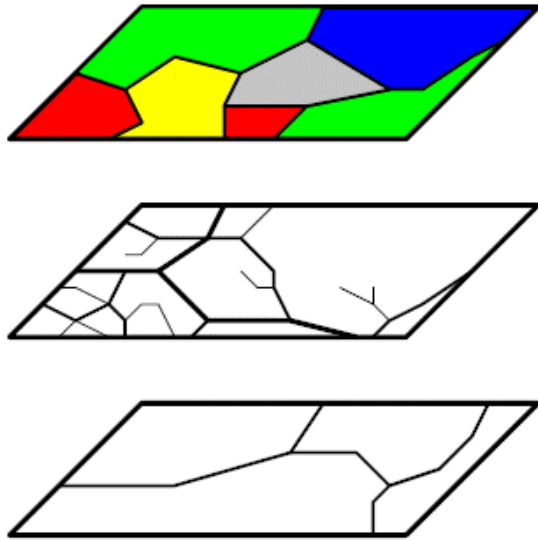


Fig. 1: Layers in a Map

lakes, terrain, roads, political boundaries, parcels, building footprints, utility lines, and orthophoto imagery. Each map layer is used to display and work with a specific GIS dataset. A layer references the data stored in geodatabases, coverages, shapefiles, imagery, rasters, CAD files, and so on, rather than actually storing the geographic data. Thus, a layer always reflects the most up-to-date information in your database. A layer won't draw on your map unless you also have access to the data source on which the layer is based. When you create a new layer by adding a dataset, the layer will draw using a default set of drawing properties.

B. Data Types in GIS

In GIS the real world geographic features are prominently represented using one of the two data formats: raster and vector. Raster form stores the data in grids of cells with each cell storing a single value. Raster data requires

more storage space than vector data as the representation cannot automatically assume the inclusion of intermediate points given the start and end points. In vector data, geographic features are represented as geometrical shapes such as points, lines, and polygons. Polygons are composed of multiple line segments, and one line segment connects another line segment at its endpoint. Vector data is represented in GIS using different file formats such as GML, shapefile, etc.

Problem introduction

Map Overlay

Map overlay is the combination of two (or more) map layers (Fig. 2). It is one of the key spatial operations in GIS. It is the process of inter-relating several spatial features (points, lines, or polygons) from multiple data sets, which creates a new output vector dataset, visually similar to stacking several maps of the same region together. It is often needed to combine two or more maps according to logical rules called overlay operations in GIS. For instance an Intersection overlay operation, defines the overlapping area and retains a set of attribute fields for each. In case of raster data format, the operation is called grid overlay and in the case of vector data format the operation is called polygon overlay.

It should be noted here that the process of map overlay in case of raster data is entirely different from that of vector data and our solution deals with vector data. Since resulting topological features are created from two or more existing features of the input map layers, the overlay processing task can be time consuming. For a given a set of n line segments in the plane, it finds all intersection points efficiently.

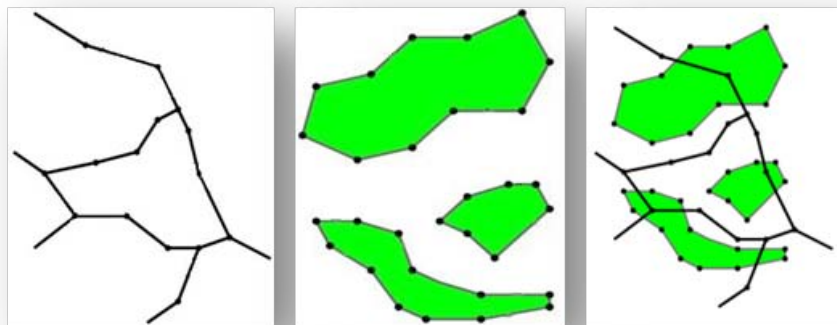


Fig. 2: a) Road Network b) Forest Cover c) Map Overlay

An Easy and Optimal Algorithm?

Algorithm 1 presents the high level sequential algorithm for polygon overlay.

Algorithm 1: Sequential Polygon Overlay algorithm [1]

INPUT: Set of Base layer polygon A and set of overlay layer polygons B

OUTPUT: Set of Output polygons O

for all polygon P_A in S_A **do**

Step 1: find all intersecting polygons I from set B

Step 2: for each P_B in I

Step 3: compute $P_O = \text{overlay}(P_A, P_B)$

Step 4: add polygon P_O to O

end for

When we perform overlay between two map layers, a polygon from base layer A can spatially overlap with zero or more polygon(s) from overlay layer B . This overlapping relationship between polygons from two different layers can be represented in the form of intersection graph.

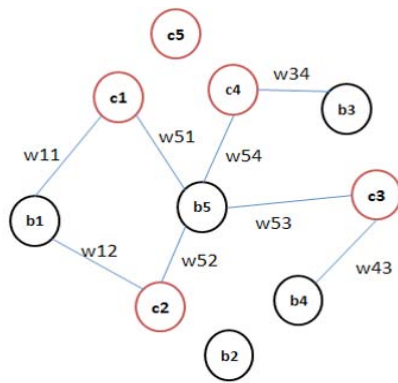


Fig. 3: Weighted Intersection Graph

As we can see in this figure 3, polygon $b5$ has the highest degree and it overlaps with 4 other polygons and $b2$ and $c5$ polygons that do not overlap with other polygons, have 0 degree. The polygonal data has high degree of irregularity. The size of polygons in terms of number of vertices varies from less than a hundred to more than a thousand. The complexity of overlay operation is captured by a weight function w . Every edge in the graph G has weight w_{ij} which denotes the weight

corresponding to the connecting edge where i and j are indices of base and overlay polygon respectively.

A Sweep Line Algorithm: An Optimal Approach

Plane-sweep is an algorithmic paradigm that emerges in the study of two-dimensional geometric problems. The idea is to sweep the plane with a line and perform the computations in the sequence the data is encountered. Imagine sweeping a vertical line across the segments from left to right. At each position of the sweep line, look at the sequence of (labels of) segments that the line hits, sorted from top to bottom. The only times this sorted sequence can change is when the sweep line passes an endpoint or when the sweep line passes an intersection point. In the second case, the order changes because two adjacent labels swap places (Actually, if more than two segments intersect at the same point, there could be a larger reversal, but this won't have any effect on our algorithm.). Our algorithm will simulate this sweep, looking for potential swaps between adjacent segments. The sweep line algorithm begins by sorting the $2n$ segment endpoints from left to right by comparing their x -coordinates, in $O(n \log n)$ time. The algorithm then moves the sweep line from left to right, stopping at each endpoint). We store the vertical label sequence in some sort of balanced binary tree that supports the following operations in $O(\log n)$ time. Note that the tree does not store any explicit search keys, only segment labels.

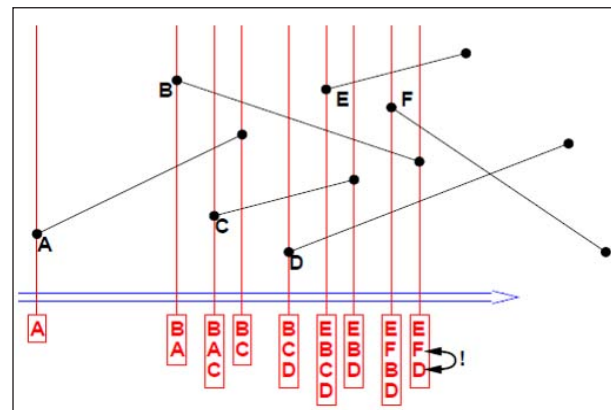


Fig. 4: The sweep line algorithm in action. The boxes show the label sequence stored in the binary tree. The intersection between F and D is detected in the last step.

- A. Insert a segment label.
- B. Delete a segment label.
- C. Find the neighbors of a segment label in the sorted sequence.

Whenever the sweep line hits a left endpoint, we insert the corresponding label into the tree in $O(\log n)$ time. In order to do this, we have to answer questions of the form ‘Does the new label X go above or below the old label Y ?’ To answer this question, we test whether the new left endpoint of X is above segment Y , or equivalently, if the triple of endpoints $\text{left}(Y)$, $\text{right}(Y)$, $\text{left}(X)$ is in counterclockwise order.

Once the new label is inserted, we test whether the new segment intersects either of its twoneighbour in the label sequence. For example, in the figure above, when the sweep line hits the left endpoint of F , we test whether F intersects either B or E . These tests require $O(1)$ time.

Whenever the sweep line hits a right endpoint, we delete the corresponding label from the tree in $O(\log n)$ time, and then check whether its two neighbors intersect in $O(1)$ time. For example, in the figure 4, when the sweep line hits the right endpoint of C , we test whether B and D intersect.

If at any time we discover a pair of segments that intersects, we stop the algorithm (Fig. 5)

and report the intersection. For example, in the figure 4, when the sweep line reaches the right endpoint of B , we discover that F and D intersect, and we halt. Note that we may not discover the intersection until long after the two segments are inserted, and the intersection we discover may not be the one that the sweep line would hit first. Specifically, if the algorithm reaches the n th right endpoint without detecting an intersection, none of the segments intersect.

For each segment endpoint, we spend $O(\log n)$ time updating the binary tree, plus $O(1)$ time performing pairwise intersection tests at-most two at each left endpoint and at most one at each right endpoint. Thus, the entire sweep requires $O(n \log n)$ time in the worst case. Since we also spent $O(n \log n)$ time sorting the endpoints, the overall running time is $O(n \log n)$.

Conclusion

We obtain a faster algorithm by sweeping the plane with a vertical line from left to right. We do an insertion into the dictionary for each left endpoint and a deletion from the dictionary for each right endpoint, both in time $O(\log I)$. In addition, we do at most two crossing tests per endpoint, which takes constant time. In total, the algorithm takes time $O(n \log n)$ to test whether a set of n line segments contains two that cross. The top and bottom segments

```

ANYINTERSECTIONS( $S[1..n]$ ):
  sort the endpoints of  $S$  from left to right
  create an empty label sequence
  for  $i \leftarrow 1$  to  $2n$ 
     $\ell \leftarrow \text{label}[i]$ 
    if isleft[ $i$ ]
      INSERT( $\ell$ )
      if INTERSECT( $S[\ell]$ ,  $S[\text{SUCCESSOR}(\ell)]$ )
        return TRUE
      if INTERSECT( $S[\ell]$ ,  $S[\text{PREDECESSOR}(\ell)]$ )
        return TRUE
    else
      if INTERSECT( $S[\text{SUCCESSOR}(\ell)]$ ,  $S[\text{PREDECESSOR}(\ell)]$ )
        return TRUE
      DELETE( $\text{label}[i]$ )
  return FALSE

```

Fig. 5: A Sweep Line Algorithm

would be checked $n - 1$ times, once at the top left endpoint, and once at the right endpoint of every short segment. But since we've already spent $O(n \log n)$ time just sorting the inputs, $O(n)$ redundant segment intersection tests make no difference in the overall running time.

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Open Source Tools in Development of Web GIS for Decentralized Planning: A Review

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Keywords: *WebGIS; Open sources tools; Decentralized Planning, GIS.*

Abstract: Open Source Softwares and Tools are those which are available under a license that allows the modification and re-distribution of the software at a nominal cost or free of cost in comparison to commercially available Software and Tools. It means that the source code is easily accessible; and we can modify, extend and distribute the code, which can be used by researchers, academics and other end users for a robust participatory, spatial and integrated decentralized Planning using Web GIS. WebGIS allows view, edit and manipulate spatial data over the Web. In this study the comparison of relevant open source GIS Softwares based on two main criterions General purpose desktop GIS application and Web based GIS applications which allows users to view the data in temporal as well as in live mode, further facilities like downloading and append the data at users end. The other factors which affect the suitability of an Open Source Tools are cross-platform, help for developers, less cost of implementation, up gradation, scalability, security and ease to operate etc.

Planning and developmental activities carried out through a decentralized manner, is referred as decentralized planning. The GIS based decentralized planning will be able to meet the requirements of user by using Remote Sensing and GIS technology and tools through a co-ordinated approach at root level. It aims is to create and maintain the Information System over the Web comprising the spatial representation of all resources available and combining associated non-spatial data for a proper and accurate decentralized planning. Using Open source Technology and Tools we can cater the need of large volume of users which include Panchayati Raj Institutions ,Researchers , NGO's and small group or community involved in decentralized planning at local level.

Now a days number of Open Source tools and technologies are available which can be useful for development of WebGIS which consists of QGIS & Grass GIS(Client Softwares), Open Layer, Web GL and Open GL (Map Library for Web Map Services) and GeoServer, Mapserver, Apache HTTP Server, PostgreSQL/PostGIS Geo-Database Servers for Web data hosting.

Introduction

Planning and developmental activities carried through a decentralized manner, is referred as decentralized planning. The GIS based decentralized planning will be able to meet the requirements of user by using Remote Sensing and GIS technology and tools through a co-ordinated approach at root level. It aims is to create and maintain the Information System over the Web comprising the spatial representation of all resources available and combining associated non-spatial data for a proper and accurate decentralized planning. Using Open source Technology and Tools we

can cater the need of large volume of users which include Panchayati Raj Institutions ,Researchers ,NGO's and small group or community involved in decentralized planning at local level. Decentralized Planning (Fig. 1) can be defined as a type of planning where local organizations and institutions formulate, adopt, execute actions and supervise the plan without interference by the central body (*Jaisan. N.D. Centre for Ecological Sciences, IISc, Bangalore*).

Roadblocks in Growth of Open Source Tools Development

The growth of GIS based decentralized planning is hindered by highly priced

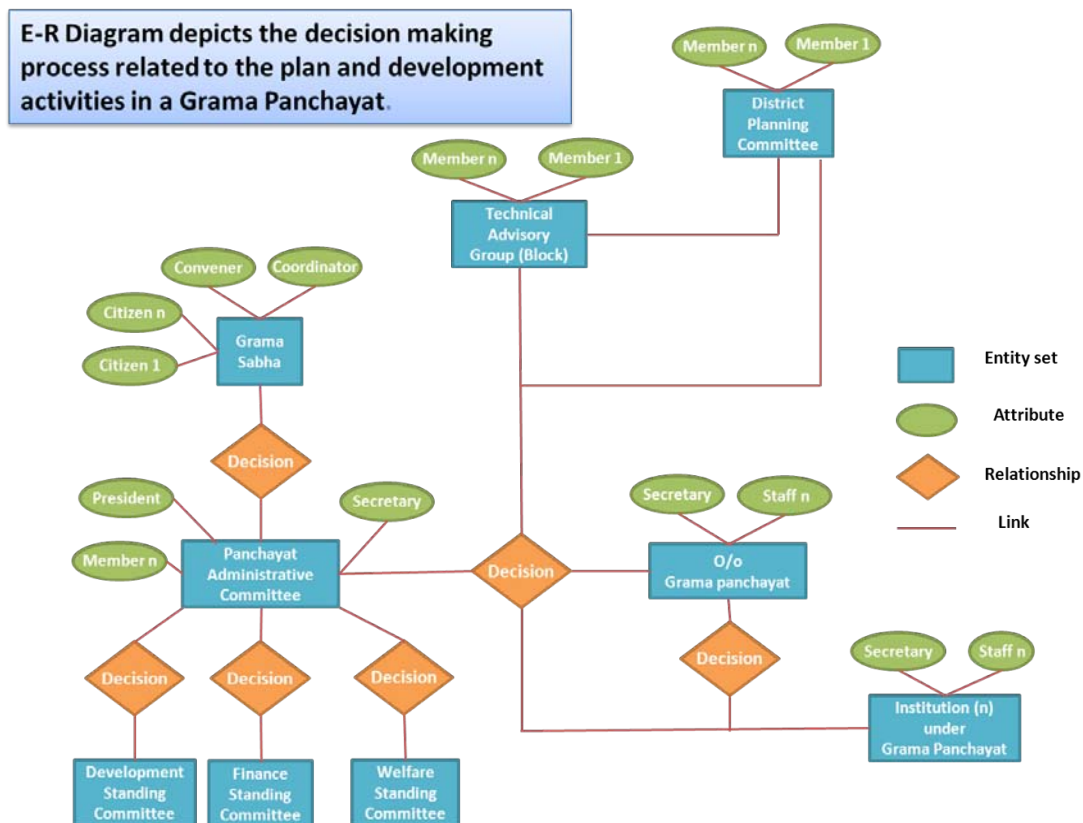


Fig. 1: E-R Diagram for Decentralized Planning

proprietary software's and unavailability of public Geodata. Many of such licensed software's remain unutilized in various government offices because they require either extensive training or easy availability on multiple locations. All this can be changed by the use of Free/Open Source Software Tools. This is significant since all government data and most educational institutions work in local language media. FOSS GIS or Free/Open source Geospatial Software's are more powerful and usable for developing systems where more and more public participation is sought. In this regard the proposed study helps to understand the potential and limitations of Open Source GIS apart from exploring the possible development for Decentralized Planning.

1. Assessment Criteria and Information Collection for Review of Open Source tools for Decentralized Planning.

1.1 Major Considerations in Assessment

In present scenario Open source Softwares are becoming popular and increasingly more reliable than in the past. Taking in the consideration the resource limitations faced

at root level like at tehsil, block or village level, the utilization of open source software is to be considered in the development of the decentralized planning. In addition to the cost issue, the inter-operability is the major challenge faced by possible collaborations between different organizations.

Geographic Information Systems (GIS) are effective in supporting the management and modeling of spatially distributed information. As an international standard for the development of a new generation of GIS, the Open GIS standard has been developed in the past decade driven by the Open GIS consortium under the W3C, primarily for the purpose of addressing the inter-operability issue. There are number of GIS tools have been published on the internet. The advantages and disadvantages of those GIS tools need to be analyzed in real condition at various user levels and according to their needs.

1.2 Assessment Criteria and Procedure

The main objective of this study is to select open source GIS software packages which are suitable for Decentralized Planning.

Some selection criterions are established by considering a list of factors including:

- Capacity, Efficiency and Reliability.
- Built-in applications Support.
- Interoperability across the different platforms.
- Ease and effectiveness of use.
- Speed and demand for computing resources.
- Cost of Implementation and utilization.
- Technical support for Maintains, Troubleshooting and Updation.

2. Assessment of Open Source GIS Software

Screening of Open Sources GIS Software Packages: Through extensive search, several hundreds of GIS relevant software packages were found over the internet. Many Web-GIS packages were excluded from the list to make a precise decision related to Decentralized Planning. The various Open Sources GIS Softwares are shown in fig. 2 for their suitability in the Decentralized Planning.

It has been noticed that there are broadly two types of open source GIS Softwares. One is developed for catering the needs of specific users which are based on Desktop Applications primarily for their modeling work; analysis of data etc. and others are

WebGIS based users who want to consume the information in a readymade mode as available for making a decision support system. As the GIS development became much simpler than before, it had promoted the development of open source GIS and a number of projects are still undergoing for more vast use of available resources to cater the needs of a large base of users.

3. Detailed Studies of Suitable GIS Softwares and Tools

3.1. Web Map Server

3.1.1. Map Server

Mapserver is an Open Source platform for publishing spatial data and interactive mapping applications to the web. Originally developed in the mid-1990 at the University of Minnesota, and runs on all major platforms (Windows, Linux, Mac OS X). Mapserver is an open source development environment for building spatially-enabled web mapping applications and services.

It is fast, flexible, reliable and can be integrated into just about any GIS environment. Map Server features Map Script, a powerful scripting environment that supports many popular languages including PHP, Python, Perl, C# and Java. Using Map Script makes it fast and easy to build complex geospatial web applications.

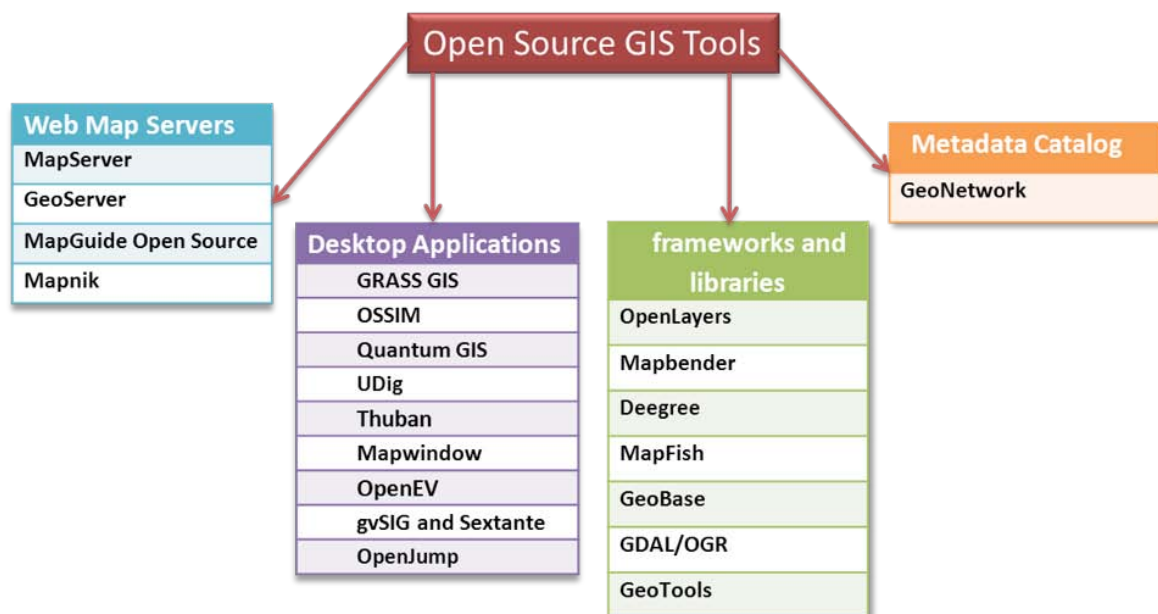


Fig. 2. Open Source GIS Tools

Key Features:-

1. Rendering spatial data.
2. Supports industry standard data formats and spatial databases.
3. On-the-fly projection for both raster and vector data.
4. Provides a wide variety of spatial and attribute-based queries.
5. Supports popular Open Geospatial Consortium (OGC) standards including WMS, WFS and WCS.
6. Integrates with popular front-end environments such as ka-Map, Chameleon, Mapbender, MapBuilder and Cartoweb.

3.1.2. GeoServer

GeoServer is written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards.

It is the reference implementation of the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as a high performance certified compliant Web Map Service (WMS). GeoServer forms a core component of the Geospatial Web (B. Loesch *et al.*, 2012).

Key Features:-

1. Rendering images, serving and editing geospatial data.
2. Outputs are available in: WMS, WFS, KML, GeoJSON, GeorSS format.
3. Open standards allow publishing from any major spatial data source including: shape files, SQL Server, PostGIS, DB2, Oracle, WFS, TIFF Images, MySQL;
4. Integrates with existing API's like Google, yahoo, etc.
5. Connects to Any GeoServer- WMS services can be easily integrated with any available server for publication of web service over the web.

3.1.3. Map Guide

Map Guide Open Source enables users to develop and deploy web mapping applications

and geospatial web services. It features an interactive viewer that includes support for feature selection, property inspection, map tips, and operations such as buffer, select within, and measure.

Key Features

1. Windows and Linux, Apache and IIS, and multiple browser support
2. Interactive map viewing
3. Quality cartographic output
4. Built-in storage of XML resource documents
5. Uniform access of vector and raster data using [Feature Data Objects \(FDO\)](#) API
6. Flexible application development: PHP, .NET, Java
7. Extensive server-side APIs
8. Fast, scalable, secure server platform

3.2. Software development frameworks and libraries (for web applications)**3.2.1. Open Layers**

Open Layers is a completely free, Open Source JavaScript, released under the BSD License. Open Layers makes it easy to put a dynamic map in any web page. It can display map tiles and markers loaded from any source. Open Layers is a pure JavaScript library for displaying map data in most modern web browsers, with no server-side dependencies. Open Layers implements a JavaScript API for building rich web-based geographic applications, similar to the Google Maps and MSN Virtual Earth APIs, with one important difference - Open Layers is Free Software, developed for and by the Open Source software community.

Furthermore, OpenLayers implements industry-standard methods for geographic data access, such as the OpenGIS Consortium's Web Mapping Service (WMS) and Web Feature Service (WFS) protocols. As a framework, OpenLayers is intended to separate map tools from map data so that all the tools can operate on all the data sources.

Key Features

1. Support for a variety of data sources.

2. Support for displaying geographic features, with markers and popups.
3. OpenLayers offers easy build configuration, designed to help into other applications.
4. Javascript API to allow full control over OpenLayers-powered map from within Javascript on a web page.

3.2.2. MapFish

MapFish is a flexible and complete framework for building rich web-mapping applications. It emphasizes high productivity, and high-quality development. MapFish is based on the [Pylons](#) Python web framework. MapFish extends Pylons with geospatial-specific functionality. For example MapFish provides specific tools for creating web services that allows querying and editing geographic objects.

MapFish also provides a complete RIA-oriented JavaScript toolbox, a JavaScript testing environment, and tools for compressing JavaScript code. The JavaScript toolbox is composed of the [ExtJS](#), [OpenLayers](#), [GeoExt](#) JavaScript toolkits. It is compliant with the [Open Geospatial Consortium](#) standards. This is achieved through OpenLayers or GeoExt supporting several OGC norms, like WMS, WFS, WMC, KML, GML etc.

3.2.3. Mapbender

A client suite for managing spatial data services. It provides interfaces for displaying, navigating and querying Open Web Services (e.g. OGC WMS, WFS).

Key Features

1. Displaying, navigating, editing and querying spatial data and maps.
2. Map services authorization services (OWS proxy functionality).
3. Management interfaces for user, group and service administration.
4. Management of WMS and WFS.
5. User interface configuration and tool stored in data base.

3.2.4. GeoTools

GeoTools is an open source Java GIS toolkit providing implementations of many Open

Geospatial Consortium (OGC) specifications as they are developed. GeoTools is also associated with the GeoAPI project that creates geospatial, Java interfaces.

GeoTools code is built using the latest Java tools and environments and its modular architecture allows extra functionality to be easily incorporated. GeoTools code is released under the GNU Lesser General Public License (LGPL). (Source- <http://web.sourceforge.com/>)

Key Features

1. Supports OGC Grid Coverage implementation, graphs and networks.
2. Coordinate reference system and transformation support.
3. Symbology using OGC Styled Layer Descriptor (SLD) specification.
4. Attribute and spatial filters using OGC Filter Encoding specification.
5. Java Topology Suite (JTS) - with support for the OGC Simple Features Specification - used as the geometry model for vector features.
6. Two Renderers:
 - Lite Renderer - a stateless, low memory renderer, particularly useful in server-side environments.
 - J2D - a state full renderer with optimizations for update rate and good for interactive client-side displays.

3.2.5. Geospatial Data Abstraction Library (GDAL/OGR)

Geospatial Data Abstraction Library (GDAL/OGR) is a cross platform C++ translator library for raster and vector geospatial data formats that is released under an X/MIT style Open Source license by the Open Source Geospatial Foundation. As a library, it presents a single abstract data model to the calling application for all supported formats. It also comes with a variety of useful command line utilities for data translation and processing. GDAL supports over 50 raster formats, and OGR over 20 vector formats.

It provides the primary data access engine for many applications including MapServer,

GRASS, QGIS, and OpenEV. It is also utilized by packages such as OSSIM, Cadcorp SIS, FME, Google Earth, VTP, Thuban, ILWIS, MapGuide and ArcGIS. GDAL/OGR is the most widely used geospatial data access library (James Gray, 2008).

Key Features

1. Library access from Python, Java, C#, Ruby, VB6 and Perl
2. Vector data model closely aligned with OGC Simple Features
3. Coordinate system engine built on PROJ.4 and OGC Well Known Text coordinate system descriptions
4. Utilities for data translation, image warping, subsetting, and various other common tasks
5. Highly efficiency raster data access, taking advantage of tiling and overviews
6. Support for large files - larger than 4GB

3.3. Desktop Applications

3.3.1. QGIS

QGIS Desktop can Create, edit, visualize, analyses and publish geospatial information for Windows, Mac, Linux, BSD and Android operating systems. With the use of QGIS Browser, user can browse and preview data, metadata, drag and drop his data from one data store into the other one.

QGIS Server provides the facility to Publish QGIS projects and layers as OGC compatible WMS and WFS services. QGIS Web Client allows publishing QGIS projects on the web with ease. Powerful symbology, labeling and blending features helps in serving impressive maps. (Source- <http://www.osgeo.org>)

3.3.2. GRASS GIS

Geographic Resources Analysis Support System, commonly referred to as GRASS GIS, is a Geographic Information System (GIS) used for data management, image processing, graphics production, spatial modeling, and visualization of many types of data.

3.3.3. Open JUMP

It is written in the Java programming language. It is developed and maintained by

a group of volunteers from around the globe. Open JUMP started as JUMP GIS designed by Vivid Solutions and Kosmo-SAIG.

3.3.4. gvSIG

gvSIG is a desktop tool designed to manage geographic information. It is characterized by a user-friendly interface that can easily access the most common raster and vector formats. In a single view, it includes local files as well as remote data through SDI standards, geographic databases, etc.

3.4. Metadata Catalog

3.4.1. GeoNetwork

GeoNetwork is a catalog application to manage spatially referenced resources. It provides powerful metadata editing and search functions as well as an embedded interactive web map viewer. It is currently used in numerous Spatial Data Infrastructure initiatives across the world. GeoNetwork has been developed to connect spatial information communities and their data using a modern architecture, which is at the same time powerful and low cost.

Key features

1. Immediate search access to local and distributed geospatial catalogues
2. Up- and downloading of data, graphics, documents, pdf files and any other content type
3. An interactive Web Map Viewer to combine Web Map Services from distributed servers around the world
4. Online editing of metadata with a powerful template system
5. Scheduled harvesting and synchronization of metadata between distributed catalogs
6. Support for OGC-CSW 2.0.2 ISO Profile, OAI-PMH, Z39.50 protocols
7. Fine-grained access control with group and user management
8. Multi-lingual user interface

4. Decentralized planning with Open source Tools and Softwares

The traditional planning process is centralized and it can reach only up to district

level developmental problems and the experts make regional plans having no idea about local social setting and grass root problems. The village/block specific problems remain untouched in existing decision making process

When Planning and developmental activities carried out through a decentralized manner, is referred as decentralized planning. In decentralized planning there is no center authority every decision is done in decentralized manner at local level. Decentralized planning can be implanted at large scale by use of open source tools and softwares in a developing country like India where financial hurdles are main road block in implementing the any scheme at root level like at village level. When the local resource map, infrastructure map get ready though WebGIS based on open source GIS tools, it would be very easy for local bodies and stake holders to pursue administrators and higher planning bodies.

1. Open source tools are free of cost and implementing costs are also very small in comparison to the licensed softwares which add to big amount of money in the total expenditure. A full fledged information system at village level can be easily made by using open source GIS tools, which can provide the users all schemes available to the them like ,number of drinking water facilities, watershed deletion, health facilities and access to database, by using which they can do planning. A geo-visualization connected with a geodatabase; accessible through a web browser - A WebGIS - will enable the decision makers to formulate better solutions for problems related with planning at grassroot level at zero cost or very small cost. (Source-<http://www.osgeo.org/>)

4. Conclusions

The menu driven GUI developed in Open Source tools and softwares are user friendly and incorporates various spatial utility maps including education and health facilities, road network, water supply, electricity, etc. which will increase its acceptability and utilization among planners and decision-makers and is expected to increase the efficacy of administration.

QGIS performed extremely well under very poor computing conditions and its

functionalities are adequate for most general applications in water resources management like drinking water schemes, number of wells, watershed delineation etc. Its functionalities may be enhanced by linking to GRASS.

Map Window has performed satisfactorily under relatively weak computing conditions but not acceptable at the very poor computing conditions. However, it has very rich water related functionalities and the list of plug-ins is still increasing.

Both gvSIG and open JUMP offered balanced performance in efficiencies and functionalities at an acceptable level. The GvSIG seems to perform slightly better than the open JUMP and thus it is recommended for decentralized planning too. The Open JUMP could possibly be a good reserve.

A number of GIS software packages are still in their developmental processes; hence, it is expected that some interesting packages would be released in the near future which will lead to next level in the decentralized planning for effective use.

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Spatial Decision Support System for Infrastructure Management

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Abstract: A region's infrastructure is a collection of public assets that can be managed to maximize public profit. It is diverse and distributed throughout the region, interacting in complex ways with the region's people and landscape. Both private and public institutions have responsibilities for the system's management. The management task is beset by difficulties of data collection, measurement, and evaluation. Geographic information systems (GIS), a key set of tools increasingly adopted by local and regional organizations, represent an important step toward truly integrated infrastructure management systems. Spatial decision support systems (SDSS) are designed and implemented to address these difficulties (for development of infrastructure) with advanced analytical tools that help people explore a problem, and use the information gained for optimal decision making. These systems are designed to help decision makers solve complex spatially related problems and provide a framework for integrating analytical and spatial modeling capabilities, spatial and nonspatial data management, domain knowledge, spatial display and reporting capabilities. The paper addresses the electrical utility infrastructure management in Jodhpur city using remote sensing datasets for large scale mapping of the infrastructure along with all related datasets and GIS analysis for effective management of the electrical distribution infrastructure.

Introduction:

Public and private agencies have always tried to maintain their infrastructure assets in good and serviceable condition at a minimum cost; therefore, they practiced infrastructure management. However, as most of the nation's infrastructure systems reached maturity and the demands placed on them started to rapidly increasing, infrastructure agencies started to focus on a systems approach for infrastructure management. This process has lead to today's Infrastructure Management concept. In continuation to this, intricate collections of materials, infrastructure, machinery and people, with countless spatial and temporal relationships and dependencies, require progressively more sophisticated tools to design and manage them. One milestone in the development of engineering management systems is the concept of integrated infrastructure management systems. This type of system is complex and mandates a need for integration and consideration of data sharing and security. The existing databases and data

management system design traditionally have not been effective at allowing division within the departments of infrastructures to use or share data as extensively or as easily as should be the case. One major reason for this lack of sharing has been that the spatial component of the data has not been effectively or correctly associated with the attribute data. This has led to problems in the quality, integrity, duplication, access, and availability of the databases.

Spatial decision support systems (SDSS) are designed and implemented to address such problems, with advanced analytical tools that help people explore a problem, and use the information gained for optimal decision making for Infrastructure management. There are several tools, technologies, or systems such as Geographic Information Systems (GIS), decision support systems (DSS), expert systems (ES), and remote sensing (RS) available which can play a crucial role in the development of spatial decision support systems (SDSS). GIS can be defined as "a computer system for capturing, storing, querying, analyzing, and displaying

geospatial data". Geographic information systems are a very useful technology because they provide utility for creating, managing, and analyzing a variety of spatial and nonspatial datasets. Decision support systems (DSS) have been developed over the course of the last several decades across many disciplines to support decision making. They incorporate modeling or analysis along with database management systems and user interfaces for aiding the user. Remote sensing can be defined as "the science, technology, and art of obtaining information about objects from a distance" (Aronoff 2005). There are many software systems that are designed for processing, analyzing, and discerning information from imagery that is collected from remote sensing platforms. The primary benefits from remotely sensed imagery include the possibility of mapping features of the Earth's surface using manual interpretation and automated processing. All of these technologies can play a crucial role in the development of SDSS for development and management of infrastructure.

Spatial Decision Support System for Infrastructure Management:

Spatial decision support systems (SDSS) are designed to help decision makers solve complex spatially related problems. The use of SDSS in various domains of Infrastructure like transport, utility, academic, construction, business analyses, public health, and hazard analysis is increasing tremendously. For example, businesses are using sophisticated SDSS to analyze customer information for marketing, customer relationship management, and generating business intelligence to gain competitive advantage. Strategic Infrastructure Development is a necessary Component of economic development and vitality. For the

same, requirements should be as effective and as efficient as possible in the Planning, Construction and Operation of Strategic Infrastructure investments. Thus, spatial decision support systems developed using integration of focused technologies like GIS, RS and decision making can help us achieve these goals. Modern Infrastructure Projects are Complex Multi-Year Projects which require careful monitoring, coordination, and management. Require access to large amounts of data and information in real-time. According to a study of US capital facility industry's engineering information system, 40% to 60% of engineering time is spent locating and validating information. Effective data and information communication can reduce project delivery time by 20% to 50%. Poor communication between systems wastes up to 30% of project costs. Effective data management from the early project stages could save up to 14% of O&M costs.

SDSS helps in smooth flow of information at every stage of development, which is the key of healthy infrastructure life cycle. In Fig. 1 & Fig. 2, transportation, one of domain of infrastructure management is considered and shown that how SDSS can helps in addressing the interoperability issues.

For construction and project management, with the use of GIS, multiagency coordination can be done from single point web GIS interface i.e. with the GIS interface, user can access project status, project financials, and project documents all over web.

Single point GIS interface with the use of these focused technologies in SDSS, efficient and effective development and management can be done as shown in fig. 3 and 4.

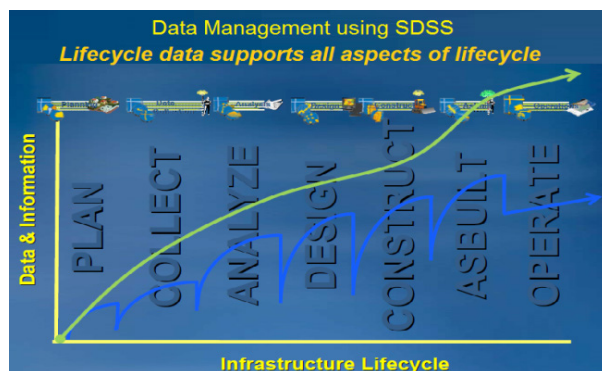


Fig. 1. transportation Infrastructure lifecycle .

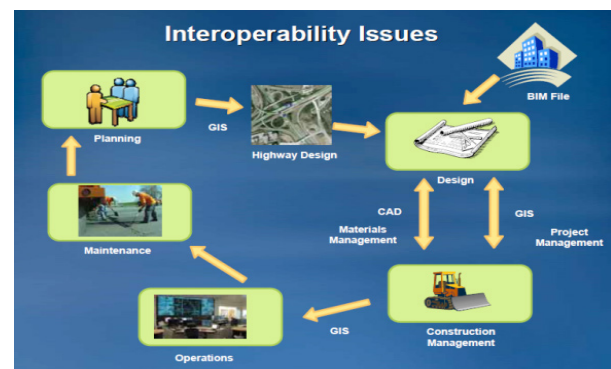


Fig. 2. Interoperability Issues.

Fig. 4. Project & construction management.

voltage (e.g. 10 or 20 kV) distribution networks (distribution primary system), which supply power to still lower voltage (0.4 kV) distribution networks (distribution secondary system). Both distribution network lines supply power to customers directly. Thus, the total network is a complex grid of interconnected lines. This network has the function of transmitting power from the points of generation to the points of consumption. The distribution system is particularly important to an electrical utility for two reasons: its proximity to the ultimate customer and its high investment cost.

To efficiently manage utility operations separate systems exist and the role of each system is different and unique. GIS (Geographical information system) is used to superimpose the complete electrical network assets from Generation to distribution on top of the land base data. Fig. 5 shows feeder map and fig. 6 electrical network superimposed on

Fig. 6. Electrical network.

geographical land base data. GIS plays vital role in Electrical power system which leverages modern computing capabilities to deliver highly actionable information to a wide range of users, all while meeting the organization's increasing need for real-time information. Advanced capabilities such simulation tools, network monitoring, Query shell, Technical Loss Calculations, analysis and energy forecasting can go far in giving utilities the power to be successful. In the present days, many of the Electrical utility companies in India are facing problems due to high energy losses, reduced quality & reliability of supply, billing issues, theft of energy, no proper strategic revenue collection methods & representation, etc. This results in inefficient operation, consumer dissatisfaction & loss of market value of the utility in public.

Thus, Reliable and sufficiently detailed data of existing network is required to facilitate decision making in all activities of the Utility System Management. Improving efficiency and reducing down time and controlling costs has become essential for a utility in order to be successful in the today's highly competitive environment. With the huge & complex electrical distribution network consisting of many sources, feeders, alternate feeding points; updating and management of network data is a Herculean task. As stated above a multi disciplinary, multi-attribute decision support system can assist in solution of complex problems and provide Efficiency gains in operational & non-operational areas of business such as fast operations, Reduction in response time, Customer Care, proper Energy Auditing & forecasting, loss calculations & most importantly it helps utility sector for simple & effective visualization of complex distribution network. There are several tools, technologies, or systems such as SCADA (Supervisory Control and Data Acquisition) & DMS (Distribution Management System), GIS (Geographic Information System), AMR (Automatic Meter Reading), EABS (Energy Auditing & Billing System) available which can play a crucial role in optimal working of power sector. Thus, by integrating all the technologies with GIS, Spatial decision support system can be design and develop which can improves visualization of all the required information on Network Map with respect to location for better management.

Distribution is the weakest link in the chain of power supply. Distribution has been identified as the key focus area in power sector reforms. Ideally, T&D losses should be in range of 5- 7%, but in India, T&D losses are in the range of 30-40%. This is the major factor of energy shortage. Some of the following areas shall be looked at to implement distribution reforms to reduce losses and improve energy efficiency. They are 100% consumer metering and AMR, Installation of capacitor banks & network reconfiguration, Feeder & DT metering, Total energy accounting, High Voltage Distribution System (HVDS) , Effective MIS etc. The support of IT and GIS in SDSS for Utility infrastructure is briefed in current paragraph. Enabling these focused technologies helps in achieving the above reforms (a) accurate up-to-date information of the entire network, (b) Electrical Network & Consumer mapping by physical pole to pole survey, (c) unique code for electrical assets like Sub-stations, 11 KV feeders, DTs, Poles and LT feeders, (d) Technical attributes of the electrical network assets physically surveyed & linked with GIS map, (e) detailed door-to-door consumer survey for the creation of consumer database, (f) unique Consumer Index Number (CIN) provided to all types of consumers based on electrical address, (g) consumer database shall be linked with the network database for the purpose of defining the consumer's electrical connectivity, (h) This data shall be shared or exchanged with other systems (i.e. Network Analysis, Inventory, Trouble Call Management, Billing, Energy Auditing etc,) to know the actual scenario.

The ongoing reforms programme in the Indian power sector requires Information Technology (IT) to play a dominant role in institutionalizing the changes and improvements. Here these focused technologies serves a dual purpose, i.e. Provides the platform for execution of business processes and Creates the information base for timely, effective decision making at the operational and strategic levels. Various functionalities provided by GIS Application Software are -

The changes in the network can be timely monitored, analyzed and correctly updated on a periodic basis.

(b) Network Analysis: Evaluate 33 KV, 11 KV and LT feeder-wise technical losses. Identify

the network section overloaded or having high technical losses. Identify the area of unbalanced loading of DT and LT Network and take corrective action to minimize technical loss. Work out voltage regulation of the network and identify the areas having high voltage drops and suffering with low voltage problem. Using the GIS & Network Analysis software, virtually network shall be re-configured to minimize technical losses, voltage drop, over loading.

(c) Load Forecasting: GIS becomes an effective tool in optimal design and choice of substation location, demand-side management, future load assessment and load planning and load distribution.

(d) EABS (Energy Auditing & Billing System): The Computerized Billing System shall be implemented to effective and prompt customer billing system, which will provide tools to monitor control and process the revenue collection functions of the DISCOM.

(e) SCADA (Supervisory Control and Data Acquisition): SCADA system like an alert watch dog monitors utility network in real time and provides remote control of switching devices, transformers and equipments. Integration with GIS facilitates Utility to coordinate the maintenance and fault rectification activities of the distribution system with in less turnaround time.

(f) DMS (Distribution Management System): Supports operational improvements by using online network, data received from SCADA. Used efficiently to manage 11kV and below network, by providing planned switching orders and load flow analysis.

Objectives:

To study Infrastructure Management and its various applications identified, also to investigate the major technological drivers so developed.

To study Spatial Decision Support System (SDSS) together with its evolution and trends over the last several decades.

To identify main components of a SDSS, including the database, model base, user interface and knowledge components for managing infrastructure together with utility structure for the study area.

Review the existing electrical utility structure of the study area.

To efficiently design, develop and implement SDSS (query shell) and validate the same with study area's geographical and electrical datasets.

Study Area:

Geographical area of Investigation i.e. study area for research is Jodhpur city, second largest district of Rajasthan state which is centrally situated in Western region of the State.

Jodhpur Vidyut Vitran Nigam Ltd, (JODHPUR DISCOM) has been created with the principal object of engaging in the business of distribution and supply of electricity in 10 districts of Rajasthan, including Jodhpur. The area of operation of Jodhpur Discom is 182509 sq. km, approximately electrifying 83% of villages/towns with 1520871 total customers with 39% of T&D losses.

Methodology:

As the research comprises of various individual elements / systems and their integration, so methodology for the research comprises study of Spatial Decision Support System together with its evolution and trends over the last several decades with variety of SDSS application examples from a range of disciplines using a variety of techniques developed nationally and internationally. Also include study of Infrastructure Management and its various applications. Geographical area of Investigation i.e. study area for research is Jodhpur city. Detailed study of the existing electrical utility structure of the study area with understanding of complete electrical network and schematics will be conducted, which later in turn, will help in identifying the main components of a spatial decision support system for design and development of utility infrastructure management, including the database, model base, user interface and knowledge components for managing utility structure for the area. Data creation will include extraction of landbase dataset from satellite image by hybrid classification. Electrical dataset will be collected Jodhpur DISCOM. SDSS development will include web application layout with its customization for various modules like report generation, customer

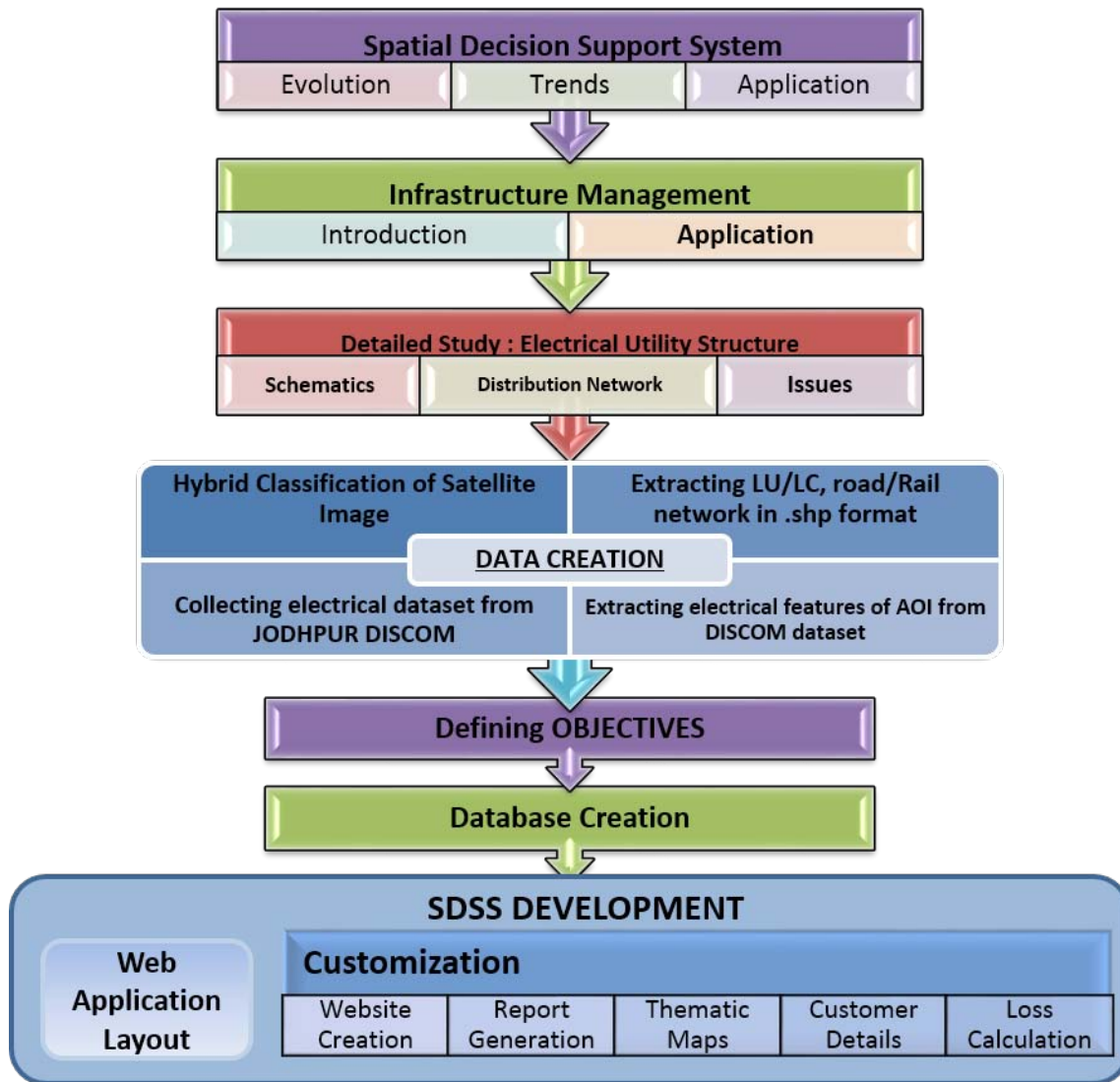


Fig 7. Methodology

details, thematic maps, loss calculation etc. Fig. 7 shows methodology adopted in the project.

Advantages of SDSS for Utility Infrastructure Development:

- Consumer indexing and asset codification for Efficient network management and Accurate data management
- Geo reference network display enables easy identification and setting up new connections
- Provides necessary information on land use pattern for planning optimum expansion of network and enables more systematic network operation and maintenance
- Sorting of consumers based on feeder which helps in fault identification and energy auditing
- Aids in planning and analyzing future expansion of the utility network
- Decreases turnaround time for servicing complaints
- Improves efficiency by means of periodic scheduled assets maintenance
- Decreases the outage levels of assets and increases operational efficiency of the system
- Provides facility to conduct energy auditing, load forecasting and voltage regulation based on feeder

- Provides facility to reconfigure network as per requirement
- Power pilferage analysis by determining the amount of power consumed by a particular Transformer against the load sanctioned
- Analysis of Power flows and load balancing
- Virtually reconfiguring / replacing conductor types / placing capacitors, voltage regulators to analyze the voltage regulation for system improvement
- Integration with billing system and Energy audit study, gives the information about total energy losses (technical and commercial) in the system

Summary:

This research and development effort can build on the powerful analysis capabilities that GIS is bringing to public works infrastructure management. However, if the SDSS is to serve decision makers at all levels—policy development, infrastructure-system administration, and operations management

—then we must look ultimately toward a broader view for integration to develop multi-disciplinary, multi-attribute system which can assist in solution of complex problems and provide Efficiency gains in operational & non-operational areas of business. Together with fast operations, Reduction in response time, Customer Care, proper Energy Auditing & forecasting, loss calculations & most importantly it helps utility sector for simple & effective visualization of complex distribution network. The key features most likely to be involved in electrical utility SDSS are Layer Management for each asset, Attribute driven symbology for assets, Spatial & Non-Spatial Query Builder tool, Developed using Open Source GIS Engine, Annotation of layers based on attribute data, Import / export to various GIS formats, Printing and plotting of data, Simple GIS tools for adding / modifying network, Network Management & Analysis, technical loss calculations, fault location, Facility to querying spatial as well as non spatial attributes and Customized Reporting utility for user defined reports etc.

Laser Scanning as an advanced mapping tool in the assessment and documentation of Traditional Architecture

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Keywords: *Laser Scanning, Digital photography, Digital elevation model, Point cloud data*

Abstract: With advancement in technology and available systems in mapping and survey tools, a major shift from conventional methods to new advanced methods is taking place. This provides scope for efficient collection of data and analysis for building construction, restoration, conservation and adaptive reuse of traditional architecture sites. The conventional 2-D and 3-D documentation techniques involve more time, higher expenses, and inferior quality of collected data, featured with more time involvement. The recent 3-D model capturing techniques is featured with more precise, multifunctional, Computer Aided Design (CAD) and Building Information Modeling (BIM) compatible data. The paper illustrates on 3-D laser scanning technology as a tool to efficiently acquire and analyze multi-point data even in unsuitable conditions for conventional methods. The significance of the data obtained from 3-D laser scanning further multiplies when other relevant techniques are referred and utilized during various stages of data processing.

Application of data for traditional architecture documentation can vary for a wide variety. It usually comprises of a very complex setup of built and surrounding environment. This makes the task of capturing data very comprehensive, so as to reach results closer to reality. To meet out the demanding conditions and pre-requisites of such collection-compilation of data, laser scanning along with the allied techniques and software can provide with the best output. The variation in point cloud data from scanned imagery at two different points of time gives the fair account of changes taken place in the built structure and rate of those changes with respect to deterioration, modification, refinement and revision.

Introduction

Digital photography tools serve as a base of advancing documentation and photographic world (Haddad, 2010; Haddad & Akasheh, 2005). Such tools outclass the primitive and conventional 2-D recording of data using CAD applications. These help in easing the challenging task of data collection and representation by converging at conveniently interpreted information. There are varied

applications of 3-D architectural modeling including restoration and conservation of traditional architecture. It also helps in the suitable adaptive reuse of a built form. While following any of the approaches to develop a 3-D model, the focus should be on integration of desired geometric accuracy, level of precision, time management and other related parameters to reach an outcome of photo- realism.

The nature of elements in traditional and heritage documentation is discrete with respect to scale, details and properties. Hence the selection of proper methodology and technology is a challenging task that suits the purpose of documentation. Basically there are two categories of tools for data collection viz. photographic techniques and non- photographic techniques. Photographic techniques take the help of automated still and motion Photogrammetry systems, non-contact 3-D digitizers, laser scanners and others. While the non- photographic tools include total station survey equipments, measuring tapes, etc. They are capable of collecting data at some good precision level.

In case of 3-D documentation of large architectural projects, it doesn't fit with the purpose being a time involving procedure to gather a large set of readings for attaining the desired level of precision and detailing. Hence when a complex and comprehensive detailing is to be measured and processed, then photographic documentation is preferred over non- photographic procedures. For assuring the extent of suitability of any relevant method or technique, it is important to analyze the desired level of accuracy, appropriate resolution and convenience in approaching the object or building (Boehler, 2005).

Application status

When traditional surveying systems are directly compared with laser scanning at cost front, laser scanning appears to be costly in terms of equipment costs, mobilization costs, and processing time. However, when seen in terms of data generated by laser scanning compared with a total station, 3D scanning does much more than brings efficiency to existing processes. It evolves new ways to analyze measure, assess, and monitor which can be evaluated in terms of the value provided to the client (Fig. 1).

The laser scanning system can rapidly rebuild a 3D solid model of an object. In the process the 3D laser point cloud data can also use the complete target data for post processing (such as mapping, computation, stress analysis, finite element analysis, simulation analysis, mission analysis, etc.) It is also seen as a symmetric application of all kinds of forward engineering tools like : CATIA, UG, CAD, PDMS, PDS, GIS, VR, 3DSMAX, MAYA, ERP, etc.

There are simple steps for generating a data image by surveying the target's 3D coordinate and then process the data to extract 3D information and generate the Digital elevation model (DEM) with high accuracy, contour map

and orthography ; after generating the elevation model the 3D solid image of buildings is generated. This is then followed by generating various other features of urban 3D diorama and vegetation.

Principle of laser scanning

A laser scanner requires two different directions (vertical and horizontal) for surveying a certain region. The modulated light beam travels from an electronic unit and hit the optical element, which is rotating with large velocity. On the surface of this optical unit the beam is reflected and exits the laser scanning device with the specific angle. Once the scanner has finished acquiring the specific angle profile the upper part of the scanner rotates with a very small angle around the vertical axis (Kraus, 2004).

The object is scanned from different positions to completely cover its surface. The overlapping areas on the edges of the object should be small which is useful for precise merging. The latest laser scanners capture information regarding the geometric positions and register value of radiometric intensities for each point. This technique creates the distance image as well as the intensity image of the scanned area.

Active contour based on 'level- set' methods for point cloud data

Many researchers have proposed and applied various kinds of methods using high-resolution satellite images or aerial photographs. Presently, automation in data acquisition and 3D reconstruction of 3D urban models has been an important research area. LIDAR data is now being widely used to reconstruct 3D building models. To delineate the building boundary and roof topology, we aimed to apply "active contour" based on level-set methods in dense point cloud data.

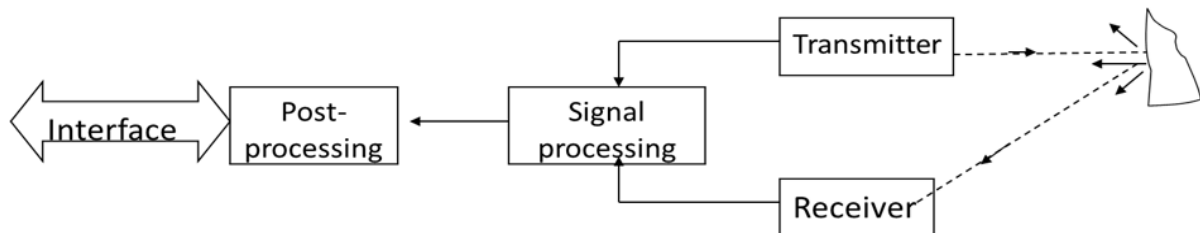


Fig. 1. The workflow in 3D Laser Scanning System.

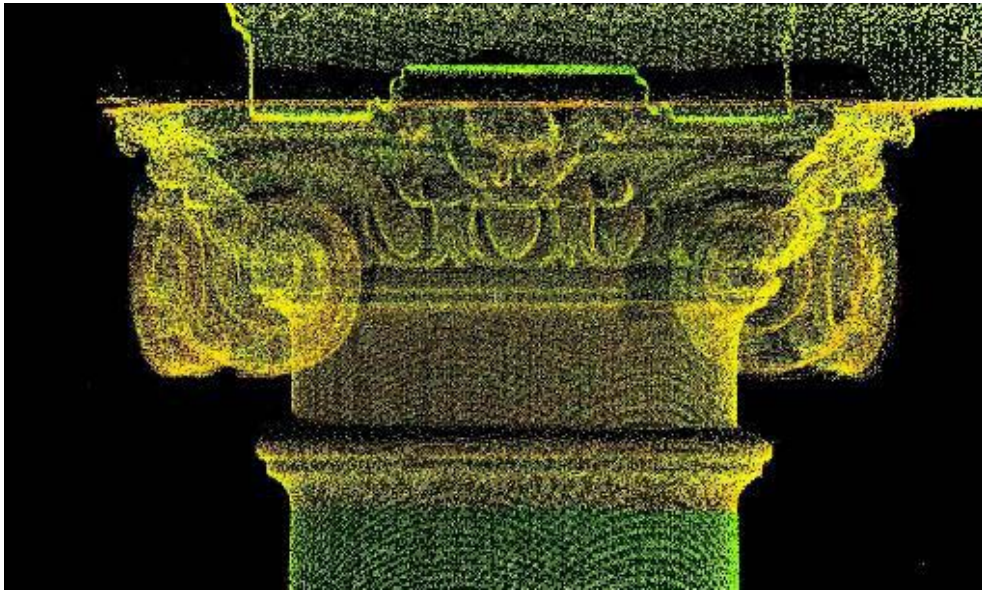


Fig. 2. Column detail modeling using point cloud overlaid onto the photograph.

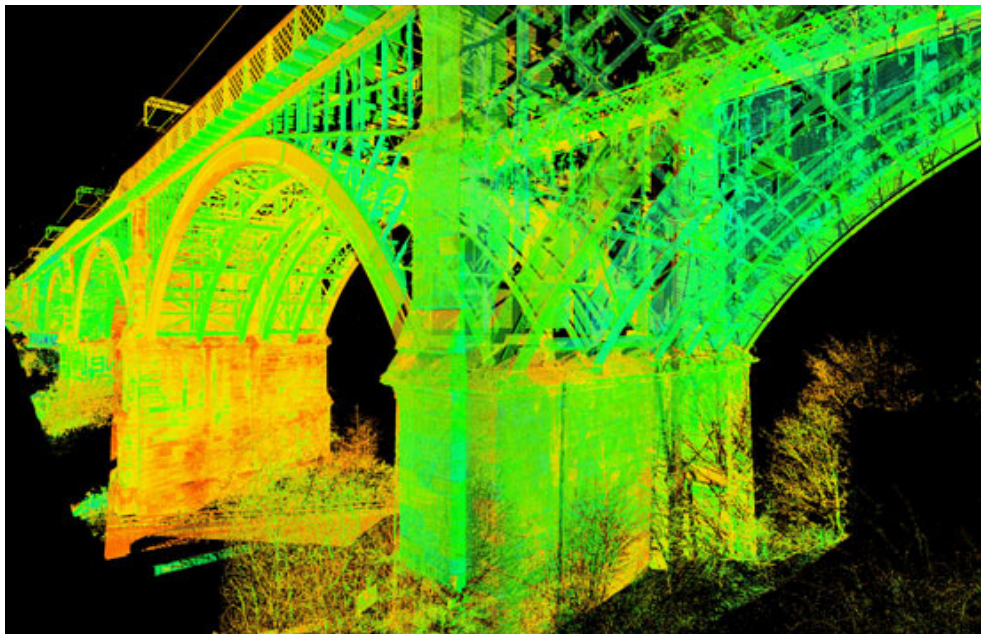


Fig. 3. Bridge modeling using point cloud data overlaid onto the photograph.

The above two figures (Fig. 2 and Fig. 3) show the output image after overlapping the point cloud data onto the photograph of an object. It is visible that with the help of overlaying layers, details of any object could be easily achieved.

The approach leads to the application of traditional active contour based on level-set method into dense point clouds data and check the possibilities for further research. To delineate the inner topology of building roof multi-phase level set method is used.

Overview of 3D construction techniques

There are 3 broad types of 3D construction techniques (Fig. 4), which are explained in detail in the following portions.

Image based Modeling

Image Based modeling is the technique of creating 3D models from photographs and then mapping the image onto the surface of the Model (Alshawabkeh, 2006). With this technique two or more source photos are taken to achieve common points which are

used to create the geometry. Further to form the edge and the surface of the object, the topological relation between these points have to be considered creating models directly from photographs has received increased interest in both computer vision and in computer graphics under the title of the image based modeling and rendering (Leveau et.al, 1994). Such image based system has an advantage in producing photorealistic rendering as they use the real image as inputs.

Debevec et al in 1996 developed the facade technique. In most of the cases it is seen that the image modeling approaches require closely spaced images for automatic robust matching. Thus the methods based on images alone are not able to capture highly architectural environment (Grun et al, 2002). This method can be used for general visualization but not for documentation requirements.

Range image modeling

Instead of the approach of using multiple images to reconstruct scene structure, an alternate technique is to use ranged imaging sensors to directly measure depth to various points in the scene (Alshawabkeh, 2006). Recently the trend of using 3D scanners in the reconstruction and reproduction has emphasized the requirement of more precise 3D data in shorter time span.

There are mainly two types of sensors, one based on the Triangulation principle and the other based on the time of flight principle. In the first one, the accuracy of measurement depends on the triangle base relative of its height which in most of the cases has a limited range of less than 10 meters (Boehler et al, 2001). Whereas

the second type of sensor measures the delay between emission and detection of the light reflected by the surface, this type has a long range imaging though it has a relatively low accuracy.

Combining laser data with image based techniques

During the 3D reconstruction of complex terrestrial scenes a combination of terrestrial LIDAR and the image data is applied. A successful integration of both data sources not only support the surface reconstruction but also facilitate subsequent processing activities such as 3D textured models.

Advantages and Disadvantages of Laser scanning technique

With advanced technology of mapping and survey tools, a major shift from conventional methods to new advanced methods took place. The new advanced system is not only efficient with high speed but it also completes measurement with more accuracy. It also provided multi-angle view of observation of the object.

This technique helps build all kinds of geometrical shapes such as elbow, taper tube etc. It also helps in converting the 3D model into a data format of CAD system or different software operating platforms for 3D modeling. Such conversions can be really useful for editing and analysis of the data.

But along with its positive feature the model still contains various drawbacks. The process in this technique takes longer processing time after data scan. The scan data patch lacks compatibility with some of the software. It

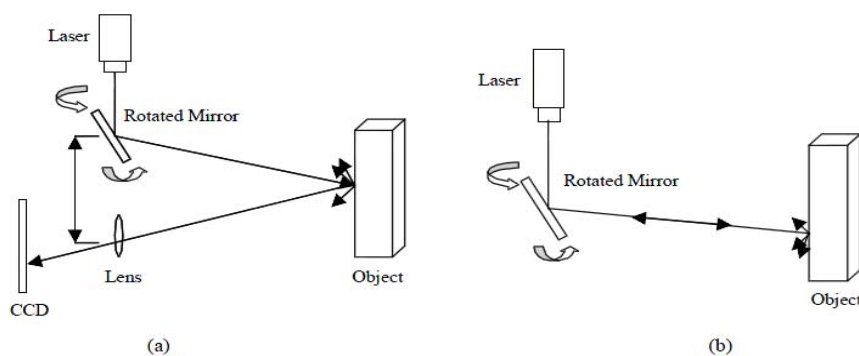


Fig. 4. The types of range sensors: a) Triangulation principle and b) Time of flight principle.

is also seen in many cases that 3D modeling has certain subjectivity attached to it and the layman usually are puzzled by virtual imagery.

Conclusion

In case of traditional architecture documentation the application of data can vary for a wide variety and usually comprises of a very complex setup of built and surrounding environment. Many a times it is also seen that the traditional measuring methods are inaccurate and time consuming. This makes the task of capturing data very comprehensive.

Thus it is seen that to meet out the demanding conditions and pre-requisites of such collection-compilation of data we need to look into new technologies that provide with better output. Laser scanning is one such surveying technology of choice when it comes to difficult environments. Laser scanning technology is efficient in survey of historic buildings, exterior elevations and capturing very precise measurement data of heavy MEP conditions.

It also generates millions of data points to create a 3D image referred to as a "point cloud." The point cloud can be measured and viewed in any direction, which virtually puts you back at the work site. This point cloud is then utilized to generate AutoCAD drawings, building information models (BIM), or used as a design tool itself. In addition to this, the Models and AutoCAD files can be generated on site and in real time which greatly reduces the amount of work required back in the office. In this competitive scenario where we need accuracy and time at the same time Laser Scanning as evolved as an advanced mapping tool for improving the assessment and documentation process of Traditional Architecture.

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RiverineGIS –A Geo-Visual Framework for Enhancing River Literacy

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Keywords: *RiverineGIS, River Literacy, Geographic Information System, Geo-Visuals*

Abstract: RiverineGiS is a web-based GIS Interface for understanding and to geo-visualize the water resources, including the entire rivers. Objective of the RiverineGiS Interface is the generation of a GIS based repository delivered in public domain. Presently, water resources of Kerala are being implemented with scope for the extension of global river basins. Through RiverineGiS, each of the 44 rivers of Kerala is illustrated from headwater sources up to the river mouth through geo-visual slices and multimedia. The Interface is designed to serve two purposes. Foremost, the Interface is envisaged to enhance elite public awareness on rivers through geo-visuals and river literacy snippets. In addition, a secondary mashup is generated by overlay of a Web Map Service (WMS) from OpenWeatherMap, which uses NOAA GFS model, with the natively developed RiverineGiS. Mashup enables forecasting of meteorological conditions prevailing in the catchment areas of a river basin. This allows the possibility of monitoring formation of severe weather phenomena to take appropriate safety measures to avert human and property loss. Thus, RiverineGiS can be used simultaneously for educational and planning purposes. Inclusion of appropriate themes allows supplementing on-going river rejuvenation efforts of various user groups. The RiverineGiS interface and salient features of the Interface are presented.

1. Introduction

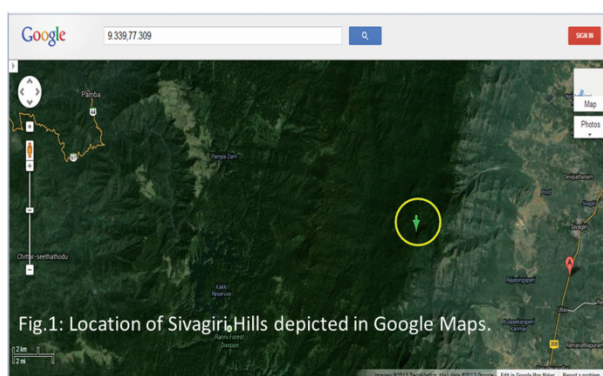
Space explorations during the fag-end of the twentieth century and beyond has revealed the presence of water bodies on numerous planetary bodies in the Solar System. Water bodies now exist not only in Planet Earth, but also in Europa (Smart and Anil Bhardwaj, 2003; Carr *et. al.*, 1998), the satellites of Jupiter right up to Charon (Marcialis, 1987), the satellite of dwarf planet Pluto. Even though, water bodies are now a ubiquitous feature, and ‘habitable zones’ (Hart, 1978, 1979) exist and extend the entire Solar System, significantly, human life is bestowed only on Planet Earth. Because, position inside the habitable zone and the presence of water resources in Planet Earth, down through the ages, has been conducive for the existence of humanity’s survival and economic prosperity. In recognition of the many facets rivers enrich human life and endeavour, United Nations General Assembly has declared 2005-2015 as the International Decade for action, “Water for Life” (United Nations, 2004); and 2013 as the International Year of Water Cooperation, (United Nations, 2011). World

Rivers Day is being celebrated on the last Sunday of September. The paper presents the conceptual, philosophical and salient features of RiverineGiS, a web-GIS Interface illustrating water resources of Kerala, and its pragmatic applications conceived for leveraging River Literacy campaigns at the grass roots.

2. Context for the Implementation of River Literacy

In the regional scenario, Kerala is endowed with 44 rivers, most of them originating from the Western Ghats and drains into the Arabian Sea. Among these, there are 3 rivers, viz., Kabbini, Bhavani and Pambar which also originate from the Western Ghats, but they flow eastwards into the neighbouring States of Karnataka and Tamil Nadu. The Societal requirements for livelihood are met from the water resources available in these rivers.

During the past few years, most of the riverine ecosystems in Kerala, as elsewhere, have been heading towards a continuous degradation stage. Kerala is already included in moderate category of desertification process



(Chouhan, 2005). Climatic factors, deforestation, clay mining, illicit human activities such as river sand mining, among a plethora of other factors, has contributed and played a cumulative role to aggravate degradation processes. According to the Planning Commission (2007), Government of India, in the national scenario, non-availability of potable water is posed to be a major crisis in terms of spread and severity. In the global context also, world's great rivers are drying up at an alarming rate. Worldwide, the emerging situations have serious consequences not only for humankind, but also for the flora and fauna and on the future of Planet Earth.

Under the spell of these environmental aspects, the need of the hour is the implementation of a clear 'River Literacy' programme. We take privilege to define 'River Literacy' as the 'ability to appreciate the manifold functions lotic ecosystems bestow on inhabitants of Planet Earth so as to initiate and embark on a prolonged process of river conservation, restoration and rejuvenation process in volition'. Implementation of 'River Literacy' is envisaged to enhance community perception and awareness of the diverse and crucial aspects water resources behold to nurture and sustain life on Planet Earth. It is envisaged that 'River Literacy' will eventually lead to optimum utilization of water resources to ensure prolonged access to potable water for humanity.

3. Context for RiverineGiS Geo-visual Interface

There exist a few probable hurdles to overcome to initiate participation in river management and conservation efforts at the grass roots. Foremost is the lack of access even to basic information pertaining to the riverine environment! This is because some of

the information is laid in documents having restricted access for content. Moreover, most of the literature remains inside bound volumes but not as geo-spatial digitized content, even if it exists, it is only in the closed camp of relevant professionals. Society has paid very little attention to bring comprehensive aspects concerning the rivers in an easily accessible form to be useful for different cross sections of society.

For example, scientific literature suggests River Periyar originates from Sivagiri Hills; however, it is very difficult to locate Sivagiri Hills from existing web mapping domains, be it Google (<http://google.co.in>) (Fig.1) Wikimapia, or even ISRO Bhuvan. To know the geospatial locations of tributaries Mullayar and Periyar of River Mullaperiyar need much exercise; situations are not much different for other rivers elsewhere.

Therefore, the first step to ensure community participation in river protection, conservation and management aspects is the need and presence of a medium to present and access basic riverine information. Equally, the medium could also be conceptualized as a Web-GIS Interface to collate and present the riverine database for the public. This interface can then be designed as a dynamic user interface through appropriate web technologies as a portal to deliver crucial scientific elements for societal empowerment through easily perceptual knowledge snippets. Recent technological advancements in web based GIS make it possible that the relevant riverine literature content can now be made available to larger cross sections of the society including student community, research scholars, planners and elite public alike. This will also be helpful for river activists.

Being available, all relevant riverine information in public domain will increase rapid availability as well as accessibility to evoke a much wider movement and participation. The technologies available today are apt and mature enough to develop such an Interface in public domain. Wikimapia, Google Earth and Bhuvan have leapfrogged technology in this regard. However, region-specific, especially of the water resources of Kerala, is so far absent in public domain. For us, the deficit of sufficient information in the public domain was an

opportunity to propose RiverineGiS. Thus, it seems essential and meaningful for an attempt to generate a GIS based geo-visual framework of the water resources of Kerala, including the entire rivers of Kerala.

RiverineGiS is a web-GIS Interface illustrating water resources of Kerala conceived, developed and implemented for supporting River Literacy campaigns at the grass roots. Conservation and optimum usage of natural resources can occur only when community perception through river literacy is enhanced to ensure community participation.

4. Objectives of RiverineGiS Geo-visual Interface

The main objective is the generation of a GIS repository of natural resources and environmental parameters and delivered into public domain for the geo-visualization of the water resources of Kerala. The repository is developed as an easily accessible Web Mapping Service (WMS) Interface. The Interface, RiverineGiS, presents the drainage network of Kerala draped over a Digital Elevation Model (DEM). Through the Interface, each of the 44 rivers of Kerala and their tributaries are illustrated from headwater sources up to the river mouth through different geo-visual thematic layers and multimedia.

The RiverineGiS geo-visual Interface is designed to serve two purposes. Foremost, the Interface is envisaged and developed to enhance public awareness on rivers through geo-visuals and river literacy snippets. In addition, a secondary RiverineGiS Open Weather mashup is generated by overlay of a Web Map Service (WMS) from Open Weather Map, which uses NOAA GFS model, with the natively developed RiverineGiS Interface. Currently, in the weather mashup, meteorological parameters such as clouds and precipitation forecasts, pressure, temperature and wind magnitude are supported. Mashup enables forecasting of meteorological conditions prevailing in the catchment areas of a river basin. This allows the possibility of monitoring formation of severe weather phenomena to take appropriate safety measures to avert human and property loss. Thus, RiverineGiS can be used simultaneously for educational and planning purposes. Inclusion of appropriate

themes allows supplementing on-going river rejuvenation efforts of various user groups.

5. RiverineGiS Geo-visual Framework

Geo-visual Concepts

Geo-informatics is defined as "Science and Technology dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information" (Raju, 2003). Geographic Information System (GIS) is one of the branches of Geo-informatics. GIS enables stacking of layers of information from varied sources into a unified software domain to analyse the relationships, if any, and correlate the physical and environmental entities within the geographical context to derive an optimum deduction. The database thus generated can be organized to distribute and enabled to access over a local or wide area network. The database can also be hosted in a server for easier access in public domain.

Data Sources

The RiverineGiS Interface is composed of raster and vector data. Raster data is the base layer; GEBCO (www.gebco.net) is used to depict bathymetry, and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) for topography. In the present dataset, depth varies up to 8698 m, whereas elevation up to 2536 m and the variations are depicted through a colour index. Topographical sheets of entire Kerala from Survey of India at 1: 50,000 scale (<http://www.surveyofindia.gov.in>) are used to generate vector layers except administrative boundaries, airports, KSRTC and railway stations, mud banks and sand mining kadavu in Palakkad District. Administrative boundaries are generated from GADM Database of Global Administrative Areas (www.gadm.org). Airports, KSRTC and railway stations are generated from Google Maps. Mud banks and sand-mining Kadavu in Palakkad District (CESS, 2004) are generated from various scientific publications. Kerala State Gazetteer (Ramachandran, 1986) and Water Resources of Kerala: A Compendium of Advance Report (Vaidyanathan, 1958) provided literature for rivers of Kerala.

Software

Free and Open Source Software is used in development. Geographic Resources Analysis Support System (GRASS GIS) and Quantum GIS Version 1.7.1 through 1.7.4 was used for basic GIS operations and for the generation of Vector layers and its attributes. OGC compliant Web Map Servers, viz., Mapserver and Geoserver are used to develop the mapping application. Mapserver is hosted in Apache Server whereas Geoserver requires either an Apache Tomcat or Jetty Server; we used Apache Tomcat. PostgreSQL together with PostGIS 1.5 is used to generate the vector database. The database is then fed into Geoserver (2.1.3), and front-end is developed using OpenLayers 2.13. Geoserver

map script was generated using java script. RiverineGiS Mapserver Interface was generated using MapScript.

Thematic Layers:

The following themes were generated: drainage of 44 rivers of Kerala along with ocean boundaries, maritime boundary, bathymetry and administration units consisting of district, panchayat, village and watershed boundary. Connectivity, viz., national highway, state highway, railway, airport, port and harbour, railway and KSRTC stations, place names, mountains and reserved forests, beaches, light houses, mud banks along Kerala coast, sand mining kadavu in Palakkad are also incorporated into the RiverineGiS Interface.

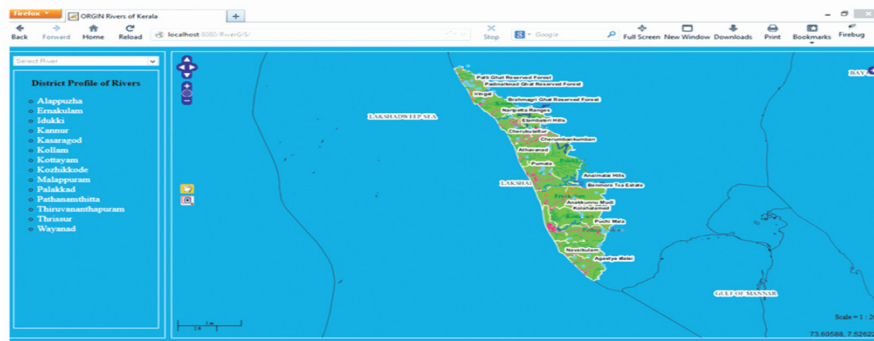


Fig.2A: RiverineGiS Interface using Geoserver

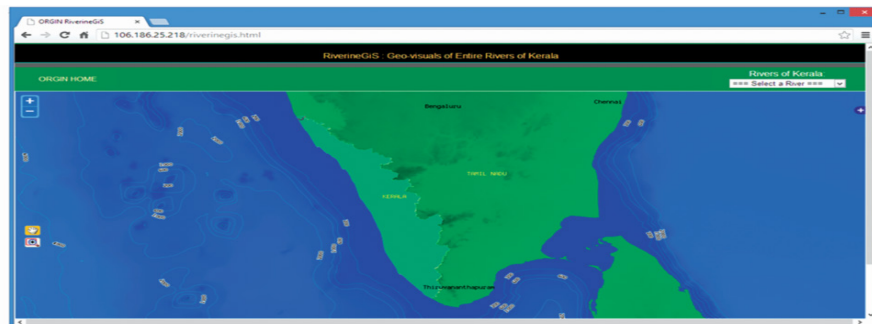


Fig.2B: RiverineGiS Interface using Mapserver

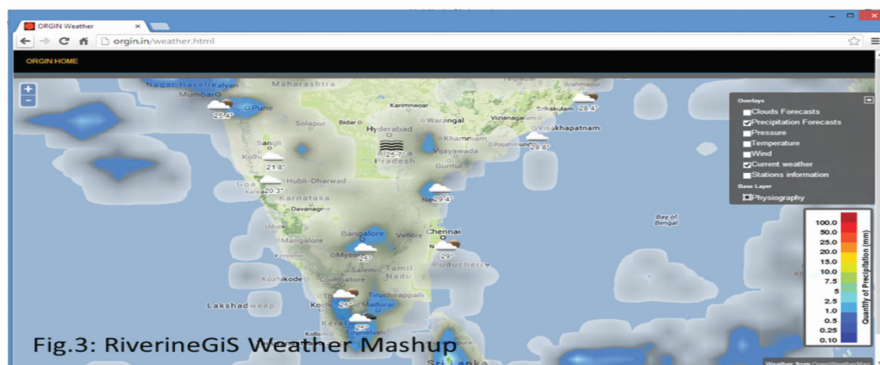


Fig.3: RiverineGiS Weather Mashup

Graphical User Interface of RiverineGiS

There are three ways to navigate the RiverineGiS Interface based on Geoserver. The Interface (Fig.2A) has a Pan and Zoom icon through which any spatial location can be accessed. From a drop down combo box, client can select any of the 44 rivers of Kerala, and map will automatically zoom to the headwater source of the selected river. The district profile of rivers is also included.

Mapping application, generated using Geoserver consume more system resources than Mapserver. Hence, a bare minimum interface is developed using OpenLayers and Mapserver (Fig. 2B).

RiverineGiS OpenWeather Mashup

The OpenWeatherMap (<http://openweathermap.org>) service provides free weather data and forecast API suitable for any cartographic services like web and smartphones applications. Weather data is received from global meteorological broadcast services. The service use data from two weather services - NOAA that use GFS model, and Environment Canada. Both models are global, and determine the total atmospheric dynamics on the planet as a whole; with a grid size of about 50 km and longer ranged forecast of 5-7 days. Using OpenWeatherMap WMS, Clients can use global forecasts for large scale, and get more and more detailed data just by zooming. RiverineGiS Interface is over layered (Fig.3) with OpenWeather WMS to yield weather conditions persisting in river basins.

6. RiverineGiS Highlights

Critical aspects of the riverine environment that require immediate attention, viz. river sand mining, in Bharathapuzha, are focused and highlighted. The Interface also demonstrates usefulness of the RiverineGiS geo-visuals as

an innovative tool for interactive academic and scientific research under the backdrop of natural landscapes. The highlights of the RiverineGiS Interface are as follows.

Geo-visual Portal of Entire Rivers of Kerala

Through the RiverineGiS Interface, the entire rivers of Kerala are delivered into public domain. Clients can browse, pan and zoom the Interface. The RiverineGiS Interface delivers an exclusive GIS repository of the entire rivers of Kerala into the public domain. Through the Interface, clients can pan, zoom and browse for information related to the water resources of Kerala in the backdrop of natural landscapes. The clients can pan right from the headwater sources, each of the tributaries through river mouth and beyond coastal oceans. Interface using Mapserver can be accessed through <http://origin.in/riverinegis.html>.

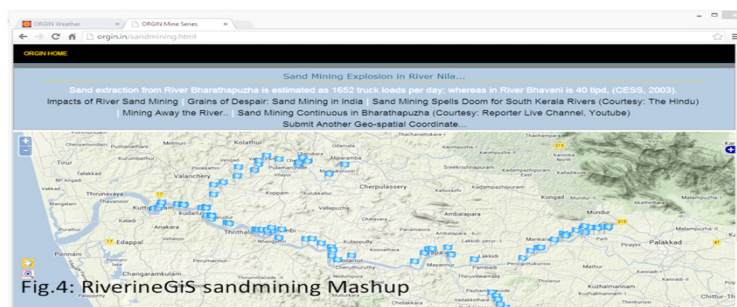
Sand Mining in Palakkad District

Illegal sand mining poses serious environmental issues. Sand mining persists in almost all the rivers of Kerala. It is more rampant in Bharathapuzha. The locations where illegal sand mining persists in the drainage basis of Bharathapuzha are identified and mapped (Fig. 4). We have also developed a database through which it is easier to identify the kadavu, panchayat and village details and are part of WMS service 'RiverineGiS'.

Science communication and awareness information explaining the adverse impacts imposed is also provided. The Interface is available at <http://origin.in/sandmining.html>

7. Performance Appraisal

Earlier performance benchmarking studies has revealed that Geoserver (Aime, Andrea and Gianecchini, Simone, 2011) performs well with PostGIS database whereas Mapserver with shapefiles. Accordingly, RiverineGiS Interface



was developed based on both Mapserver and GeoServer to assess mutual performance.

For the performance appraisal, both applications are uploaded and hosted in an external Virtual Private Server. The specification of the server is as follows; viz., 1 GB RAM with 8 CPU (1x priority) with 48 GB storage and 2 TB transfer. The usage shows that application based on Mapserver loads faster than the Map based on Geoserver. Maps based on Mapserver delivers good performance even with a memory allocation of 1 GB RAM. Java dependency of the Geoserver necessities of a Server with at least 2 GB RAM to deliver the same performance of Mapserver.

8. Future Prospects

Implementation of live editing of RiverineGiS Interface of critical and vulnerable regional areas through crowdsourcing is under progress. Modified etopo2 (Sindhu et al., 2007) is being used to generate bathymetry within 200 m contour. Work is in progress to encompass global rivers with special reference to those in crisis.

9. Conclusion

Rivers are the lifeline of a society; without drainage, what waits is a barren desert. A dewdrop or a raindrop, each droplet beholds and nurture life on Planet Earth. We have to save and preserve it for posterity to survive and continue habitat on Planet Earth. RiverineGiS is the first step towards achieving this end.

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knowledge and requirements that helped to add appropriate content to RiverineGiS.

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Automatic Powerline Point Detection and Reconstruction Using Airborne Lidar Data

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Keywords: *LiDAR, Power lines, Sag and Tension mapping, catenary.*

Abstract: Energy is an essential requirement for all facets of the life. Electricity is the primary source of supply of energy. Power line corridors are used to transfer the electricity from one place to another place. Generally these corridors are passing through forests and steep hilly areas. Currently monitoring and maintenance of power lines is carried out by ground surveys, where the personal visits are carried out to check for danger objects, sag, and tension of the power line. For monitoring this power line by ground methods are time, cost consuming and it is very difficult to visit regularly each and every place. India is having approximately 250000 Circuit kilometers of power transmission lines all over the country by March 2011. Monitoring and maintenance of these power lines requires lot of manpower, time and cost.

Airborne laser sensor ALS which works on LiDAR (Light Detection And Ranging) technology facilitate to acquire height of the power lines, towers and the terrain along the corridor with high point density at the rate of 50-500 kHz using multiple return technology. This sensor enables to monitor the power lines in regular intervals with minimum manpower and less time with less effort in processing. Currently many countries are employing this technology to replace the manual inspection. This paper was focused on understanding the detection & reconstruction of power lines using airborne LiDAR point data. A case study was also presented with results comparing field vs LiDAR.

1. Introduction

Power line network conveys electric energy between networks of electric facilities to provide electricity to millions of homes and business. Electrical energy is transmitted through line conductors. The safety of power line infrastructure significantly affects our everyday life and industrial activities. There are many factors and objects to threaten power line safety, which include encroaching vegetation, tree healthiness, ambient temperature of the power lines and so on. A timely and accurate monitoring of those key power line features enables to prevent causing possible dangerous situation such as blackout.

1.1 Literature Review

For the last two decades, many research works have been carrying out using Airborne LiDAR data for automatic detection and extraction of power lines. To reconstruct 3D power lines using airborne LiDAR point clouds, points which are falling on power lines

are to be detected. This is being done using Hough transformation function and for a 3D power line extraction a Voxel-based Piece-wise Line Detector (VPLD) technique is used (Y. Jwa and G. Sohn, 2009). A new method for classifying key features (power lines, pylons, and buildings) comprising utility corridor scene using airborne LiDAR data and modelling power lines in 3D object space was proposed by Gunho Sohn & Yoonseok Jwa, 2012.

Zhengrong Li and Rodney Walker (2010) developed an algorithm to classify terrain and object points by performing statistical analysis on LiDAR intensity data. After this classification, the object points were mapped to a horizontal plane to create a 2D grey level image and the Hough transform is employed to detect lines. By mapping the rough position of the detected lines in 2D image back to point cloud data, the power line points are obtained, but they have not reconstructed the catenary curve from 3D point clouds. Norbert Pfeifer (2008), developed two algorithms one for

simple 2D-segmentation of power line corridors using image processing techniques, and the other to refine 3D-segmentation of power lines by means of robust model fitting (resampling). The proposed approach starts from Power line corridor center identification, within which power lines are modelled with catenary curve models in 3D. Once a local catenary curve model is established, this initial model progressively extends to capture entire power line points by adopting model hypothesis and verification.

1.2 COTS packages

Commercial products for detecting and modeling of power lines from LiDAR point cloud data, such as PLS-CADD (Power Line Systems - Computer Aided Design and Drafting), for the structural and geometrical design of power lines (http://www.powline.com/products/pls_cadd.html), Power Line Maintenance Inspection system (PLMI), which integrates all inspections and provides exact distance measurements, built using Math Works tools (http://www.albatroz-eng.com/solutions/power_line_maintenance_inspection.html) and TerraSolid's TerraScan software, capable of detecting power lines and analyzing them (www.terrasolid.fi/en/users_guide/terrascan_users_guide).

1.3 Indian Scenario

The total length of the transmission system in India is approximately 250000 circuit kilometres (http://www.indiaworldenergy.org/pdf/T&D%20Report_PGCIL.pdf). The important segment in total power line system

is distribution system. The distribution segment continues to carry electricity from the point where transmission leaves off, that is, at the 66/33 kV level. The main distribution equipment comprises HT and LT lines, transformers, substations, switchgears, capacitors, conductors and meters.

Generally these HT power lines pass through the hilly, high vegetated and forest areas. By mapping these power lines, one can analyze the sag, tension of the power lines. Detecting areas prone to interference of power lines with vegetation (called as "danger zones") is also an important component in mapping because this may result some times as forest fires. At present, utility firms heavily rely on men-centric field power line monitoring methods for HT and LT lines. These methods consume more time, cost and inaccessible due to bad weather conditions also hazardous.

1.4 About LiDAR - DC Technology

Light Detection And Ranging (LiDAR) is a modern technology, which has received wide acceptance and popularity around the world, due to its uniqueness in power line mapping. LiDAR instrument is integrated with 3 unit's viz. laser sensor, Global Positioning System (GPS) and Inertial Measurement Unit (IMU). The LiDAR sensor records range by measuring the time difference emitted and received signal from a given point. Range computed is integrated with precise positioning information gathered by on board GPS and IMU (see figure1). Once the total information volume is stored and processed, the resulting product is an extremely accurate x, y, z for every position

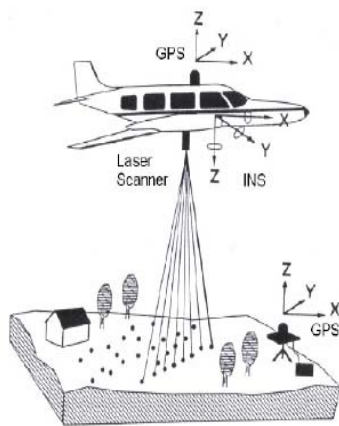


Fig. 1. Overview of LiDAR Technology.

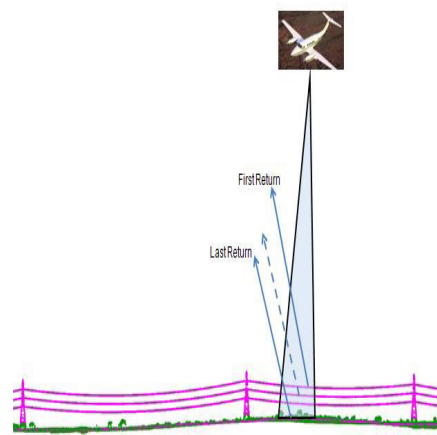


Fig. 2. Flying pattern for power line corridor surveys.

scanned on the ground. LiDAR sensor can also be integrated with medium format digital camera by which it is possible to generate ortho images of the area, which can be used for planimetric mapping of the corridor.

LiDAR systems unique capability is measuring “multiple returns” from the single pulse. LiDAR beam hits at the top of powerline, while part of the beam travels further and may hit ground or vegetation (see figure 2). This feature can be advantageous when the application calls for elevations for not only the ground, but for tree, power line or building heights.

Airborne LiDAR system is a cost effective data acquisition tool which enables to rapidly capture (with better than 15 cm accuracy with high pulse rate upto 500KHz) 3D power line scene with up to about 30 points/m².

LiDAR data accurately depicts wires, structures and vegetation, and provides a basis to determine the minimum specified safety clearance information. Now, accurate line-to-ground clearance information derived from lidar data can be made available to operators of heavy equipment, thus helping the operator to reach directly to the location of the danger zone and to avoid contact with high voltage wires.

1.5 Objective of the Study

The study presents the procedure for classifying power line points, extracting power lines from 3D laser point cloud, estimation of sag, tension of the HT power lines and to determine the “danger zones” in the power line corridors using LiDAR – DC technology.

1. Study Area

The study area is located near Bhuvanagiri town (Ramagundam to Hyderabad Double

Circuit 3 & 4 power line), 40 km distance from Hyderabad, Andhra Pradesh (Fig. 3). For this study purpose 15 line km stretch was selected along the HT power line.

Description of Study Area

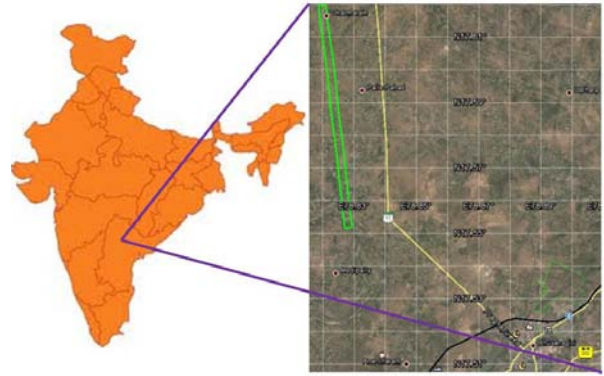


Fig. 3. Location of the study area (Green color polygon is study area boundary)

2. Methodology:

Extraction of power lines requires more number of laser points along the power line to detect automatically. Flight planning for these projects should be such that, we should not miss the power line at any case in across direction. To achieve this we should do the flight plan such that, the footprint of previous point and present point should have some overlap across the flight direction. With the flight planning parameters given below (table 2), one can able to achieve a point density of approximately 4 points/m² only, per single flight line. However it is required to have more than 10 points/ m² density. This was achieved by flying the same line thrice, with the same settings by shifting the acquisition in along direction for each flight line.

Table 2. Power line corridor survey parameters

Sensor Used	ALS 50
Date of Acquisition	13 th December 2004
Corridor size	15 Km long & 125 m wide
Number of flight lines	3
Point spacing	0.25m across X 1.0m along
Field of view	15 deg
Scan rate	60 Hz
Pulse rate	47 KHz
Flying height	1000 m AGL
Aircraft speed	140 Knots

Table 1. Study area description

Location of the study area	Near Ghatkesar Village, Andhra Pradesh	
Area of extents	17°42'N, 78°40'E	17°42'N, 78°55'E
	17°26'N, 78°40'E	17°26'N, 78°55'E
Land Cover	Covered by 80% Agricultural, 1% water bodies, 10% settlements and 9% others	
Topography	95% of land is flat with slope < 5 deg	

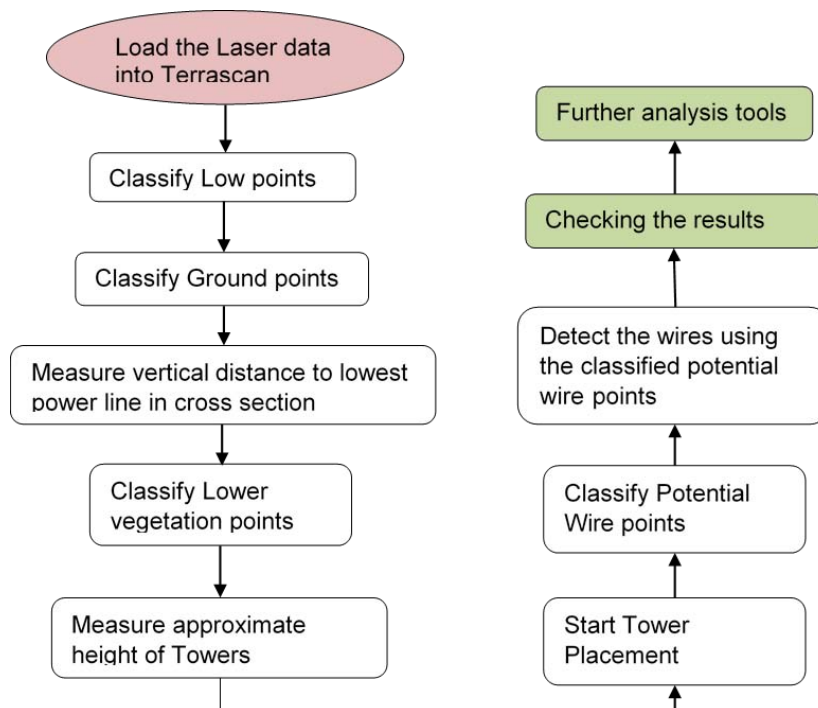


Fig. 4. Flow chart of process flow for power line extraction.

Before going for automatic power line extraction the raw laser data acquired has to be preprocessed. During preprocessing the misalignment angles are incorporated along with other calibration parameters like range correction, torsion rigidity constant, elevation offset, intensity bias correction, and encoder latency to achieve precise position of LiDAR point cloud. Along with the LiDAR data, a medium format Digital camera data is also acquired. This data can be used to map the features along the power line corridor. The basic power line classification process flow used in this study is shown in figure 4.

To extract power lines, initially the data has to be classified for low points (points which are below the actual ground, noise) and ground points (terrain points). Low points are classified by comparing the neighboring points elevation with each point with some tolerance and ground points are classified based on progressive\e densification algorithm. To extract powerline points it is required to separate out the other information like vegetation, buildings, i.e. non powerline points. To classify the lower vegetation points from the whole data set it is required to know the minimum distance between the ground and lowest elevation point

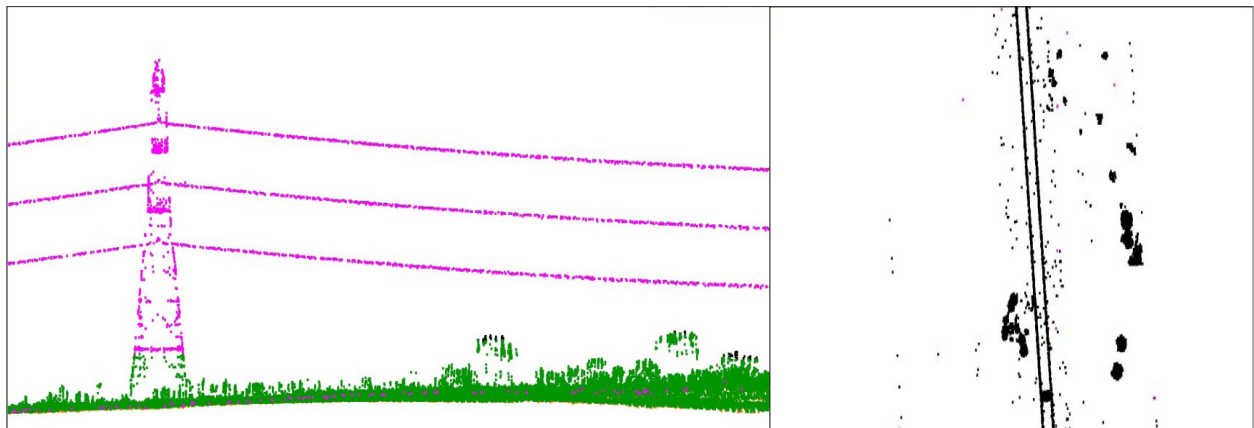


Fig. 5. Visualization of the power lines after switching off ground and low vegetation points.

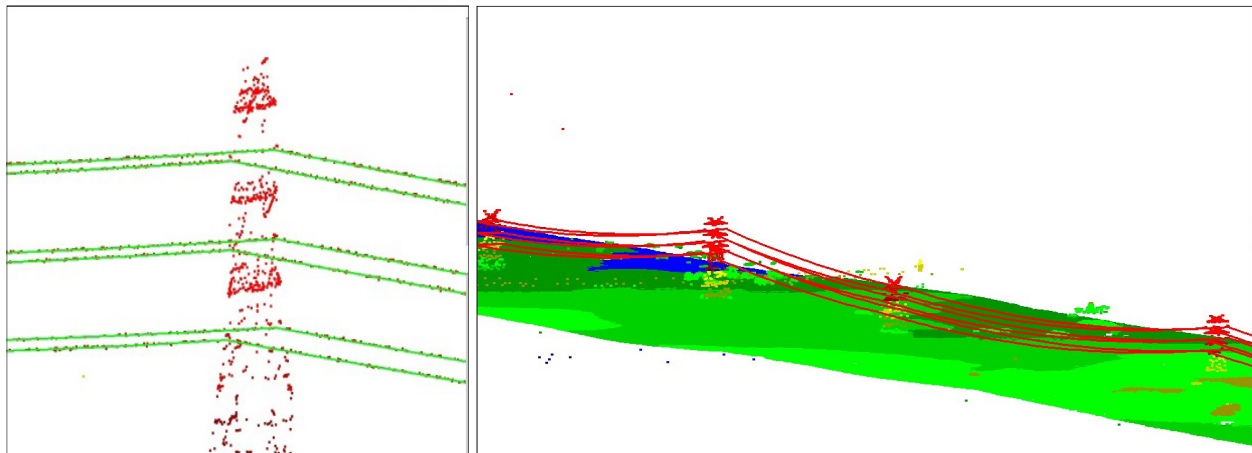


Fig. 6. Figure showing the power line wires detected in different views.

of a power line. This is achieved by manual inspection of the whole data to get an idea and fix the value. Once the points are classified to Low vegetation it can be visualized the power lines in the screen by switching off the all classified data (fig. 5).

To classify the points which are falling on the power line it is required to identify an approximate location of the towers. This is done by connecting the string with the towers seen in the LiDAR data manually. Using classify by centerline tool, potential power line points are classified by specifying distance on either side of the tower connected string to a class named potential wire points. Using these potential wire points, a least-squares model is used to fit a curve along the potential wire points as said below, to detect and vectorize the catenary power lines (fig. 6).

To detect the wires maximum vertical offset between power lines, horizontal offset between power lines, linear tolerance between points in plan view, elevation tolerances and minimum number of points per wire are to be defined along with catenary constants. Once these wires are vectorized placement of the pre modeled towers are placed at their locations

with proper connections between tower and wires. Now this data is used to analyze the data for measurement of tension, sag present in the wires, height of the towers and can find the danger objects (Checks surrounding terrain to see if there are any hazards near to lines). Danger objects are determined by specifying the distance from the catenary wire to vegetation points classified previously.

3. Results

Mapped/detected power lines are compared with field data supplied by Powergrid corporation team. Apart from that, tower heights, sag of the wires and identifying of danger objects also measured (Fig. 7). The results are tabulated in table 3. These results are agreeing with field measurements with 99% accuracy.

Using ortho photographs of the area generated, the angle of deflection of the towers were mapped. Apart from this these maps can be used for approach to power lines in case of any danger objects are determined (see fig. 7).

4. Conclusions

- After analyzing the data it is concluded that the results are agreeing with field data upto

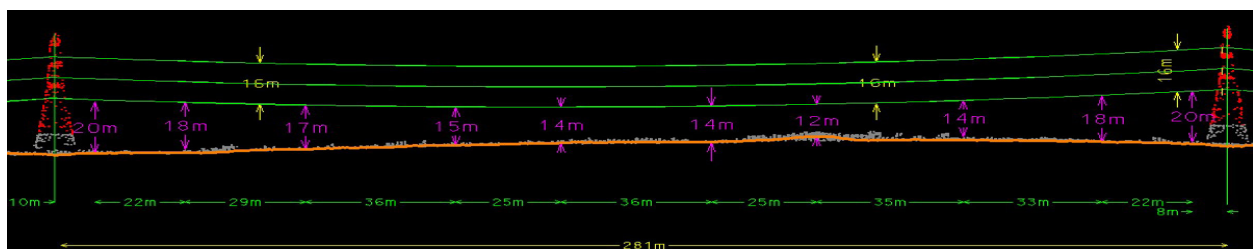


Fig. 7. Cross section view of detected wires with measurements.

Table 3: Comparison of results with Powergrid corporation drawings

Description	LIDAR Values from NRSC	Field Values from Powergrid
Height of Tower 1	64.27 m	64.30 m
Height of Tower 2	49 m	49 m
Distance between towers	280.98 m	281 m
Distance between main tower and a crossing tower	84 m	84 m
Angle of Deflection at tower 2	9 degree	9 degree
Ground Elevation difference between the successive towers	3.9 m	4 m
Permissible clearance between two wires in vertical direction	8 m	8 m

10 cms accuracy. So LiDAR surveys can be used to replace the existing field methods.

- This technology is more useful for regular maintenance of the power lines as it is accurate to 100% in detection of wires.
- Using this technology one can analyze the data in the lab to find out the danger zone and to check the sag, tension of the wires.
- Based on the identified results field persons can be deputed to exact location by using the help of ortho image.
- Once the wires are detected, these drawings can be used for modeling of the oscillations induced by winds.

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Performance analysis of GCPs derived from GAGAN-SBAS for satellite data geo-referencing and mapping applications

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Key words: GPS, GIS, GCPs, RTK, GAGAN, SBAS

Abstract: The demand for accurate and up-to-date spatial information is increasing day by day for different GIS applications. Cartosat-1 and Cartosat-2, with spatial resolution of 2.5 meter and 1 meter respectively are the two Indian Space Research Organization's (ISRO) high resolution satellites used for extraction of accurate spatial information. Cartosat-1 is better suitable for generation and updation of topographic maps of scale 1:10,000 by applying photogrammetric models and Ground Control Points (GCP's). GCPs play an important role in the photogrammetric process. In practice, GCPs are derived using GPS ground control survey with relative point positioning technique. In this technique, a network of ground based reference stations with precisely known co-ordinates is required. During this survey, one GPS receiver is operated at reference station and another receiver is operated at unknown station to derive its precise co-ordinates. The accuracy achieved depends on the baseline distance and also accuracy of reference station co-ordinates. Real Time Kinematic (RTK) is another survey technique used to derive GCPs in real time mode but requires a huge infrastructure. GPS Aided Geo Augmented Navigation (GAGAN) system is a Satellite Based Augmentation System (SBAS) jointly developed by ISRO and Airports Authority of India (AAI) for civil aviation applications. GAGAN system improves the accuracy of GPS solution by providing correction signals i.e. signal-in-space (SIS). Primarily it is meant for civil aviation applications, however the same correction signal is useful for non-aviation applications also. In this study, non-aviation application of GAGAN is discussed that includes GCP collection using GAGAN-SBAS receivers and use of these GCPs for geo-referencing and Orthoimage generation of Cartosat-1 data. In this method of deriving GCPs, operation of GPS reference station can be avoided which is a mandatory in relative positioning technique and also does not require huge infrastructure like RTK method. The accuracy of these GCPs is compared with GCPs derived with relative positioning technique. It is observed that the accuracy is around 50 cm and suitable for generation of Cartosat-1 data products. Orthoimage and contours from Cartosat-1 data are generated using GAGAN derived GCPs and validated with those derived by relative positioning technique in terms of distances and areas. The products are also compared with ground measurements and SOI topomap of 1:25,000 scale having contours of 5m. The results show that GAGAN derived GCPs collection can replace the existing practice of relative positioning GPS surveys for geo-referencing of Cartosat-1 data and subsequent mapping process.

Introduction

Demand for accurate and up-to-date spatial information is increasing day by day for different GIS applications for monitoring and management of natural resources. Cartosat-1 (spatial resolution : 2.5 meter) and Cartosat-2 (spatial resolution : 1 meter) are the two Indian Space Research Organization's (ISRO) high resolution satellites used for extraction of accurate spatial information. Cartosat-1 is

suitable for generation and to update geo-spatial database up to the map scale of 1:10,000 or smaller using photogrammetric techniques (Radhadevi et al., 2009). Ground Control Points (GCP) play an important role in the photogrammetric process. In practice, GCPs are derived using GPS ground control survey with relative point positioning technique. In this technique, a network of ground based reference stations with precisely known co-ordinates is used. GPS measurements at a reference point

models the errors at unknown locations to an accuracy better than a centimeter. However, the overall accuracy depends on the baseline distance and accuracy of reference station position (Matt King et al, 2002). Real Time Kinematic (RTK) is another survey technique used to derive GCPs in real time mode by applying GPS corrections online. This technique has the limitation of visibility between reference and rover stations and also requires additional technical infrastructure (Cetin Medic et al., 2009). Precise Point Positioning (PPP) technique is the latest one, where single GPS receiver data is used to derive the precise co-ordinates of GCPs. This technique requires GPS data for a period of minimum 3 to 4 hours to converge the solution and to get an accuracy of decimeter (Rani et al., 2010).

2. GAGAN

GPS Aided Geo Augmented Navigation (GAGAN) system is a Satellite Based Augmentation System (SBAS) developed jointly by ISRO and Airports Authority of India (AAI) to render GPS signal suitable for civil aviation applications such as seamless navigation and approach over the Indian airspace and its surroundings. GAGAN system improves accuracy, integrity, availability and continuity of GPS solution by providing necessary correction signals for ionospheric interference, clock and ephemeris errors. The GAGAN architecture includes the following three segments are shown in Figure 1 (Suryanarayana Rao et al., 2007, Ganeshan et al., 2013).

Ground segment: 15 Indian Reference Stations (INRESs) record GPS signals continuously. These stations are spread all over India to provide coverage over required service volume. The data is forwarded to two Indian Master Control Stations (INMCCs) to determine the differential corrections and residual error for each GPS satellite. The information from INMCC is sent to three Indian Land Uplink Stations (INLUSs) and is uplinked via two chains of networks (OFC and VSAT) to space segment.

Space segment: INLUSs uplink GEO navigation message to the three Geo stationary satellites (GSAT) having GAGAN payload. At present two GSATs (GSAT-8 and 10) are broadcasting the correction information via two L-bands (L1 and L5) to user segment. GSAT-8

and GSAT-10 provide GAGAN signal on PRN-127 and PRN-128 respectively.

User segment: The user segment is a GAGAN enabled GPS receivers that will receive the GPS and GAGAN correction signal simultaneously and determine the position of the receiver location. The correction signal is transmitted on GPS L1 frequency (1575.42 MHz) and therefore no additional receiver is required to make use of the correction and integrity data. GAGAN system will enable to give the real time position co-ordinates. GAGAN-SBAS receiver used for this study consists of u-blox NEO-6P module which combines the SBAS with PPP carrier phase measurements technique. (<http://www.u-blox.com/en/gps-modules/neo-6p-/neo-6p.html>)

At present, test signals are being broadcasted from GSAT-8 and GSAT-10. The final signal will be broadcasted once the final operation phase (FOP) is completed. Primarily GAGAN is meant for civil aviation applications, however the same correction signal is useful for non-aviation applications also. In this study, non-aviation application of GAGAN is discussed that includes GCP collection using GAGAN-SBAS receiver and its usage for geo-referencing and photogrammetric data product generation of Cartosat-1 data.

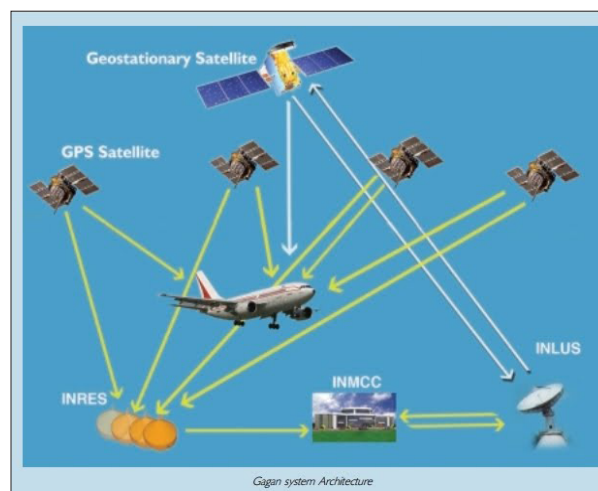


Fig. 1. Architecture of GAGAN.

Objective

Generation process of accurate Photogrammetric products such as Digital Elevation Model (DEM), Orthoimage etc, requires accurate GCPs. Therefore, a study has been made with GAGAN enabled GPS

receiver to collect GCPs with time and cost effective way. The study includes following observations.

- Accuracy analysis of GCPs derived using GAGAN receiver with relative GPS positioning technique.
- Accuracy analysis of Photogrammetric products-DEM and Orthoimages generated using GCPs derived from GAGAN receiver with check points, field measurements and SOI map.

Study Area

The study area covers Kothapalli village and its surroundings in Rangareddy district, Andhra Pradesh, India. Cartosat-1 stereo pair (Path 0543 and Row 0316) acquired on 21st December 2007 is used to generate Orthoimages. An area of 729 sq.km is surveyed for GCPs collection. The study area falls in SOI toposheets 56G/15, 16 & 56K/3, 4, 7 and 8. The topography of the area is flat and located at an elevation of about 600m above mean sea level (AMSL).

Methodology

The methodology follows ground control survey using Relative GPS technique and GAGAN-SBAS receivers and standard photogrammetric process to derive DEM and

Orthoimages. Finally, the derived products are validated with check points, ground measurements and SOI map. The methodology is given in Flow chart Figure 2. The ground control survey has been planned for collecting 11 GCPs in relative point positioning mode using GPS receivers and 4 GCPs with GAGAN-SBAS receiver in standalone mode. The GCPs are equally distributed over the study area. Table 1 shows the control survey details of relative GPS and GAGAN-SBAS receiver. 30DS point (zero order station) located on NRSC/AS&DM building is used as reference station for applying differential corrections to the atmospheric, clock, cycle slip errors etc. The GPS data is logged at 30-second data sampling rate for one hour duration. There is a minimum of 15 minutes overlap between the GCPs while GPS data collection to form a proper network. Co-ordinates of GCPs are computed in WGS-84 co-ordinate system using UTM Zone no.44 projection.

The control survey is also carried out using GAGAN-SBAS receiver. The data is collected for 15 minutes at each GCP at every one second sample interval. Total 900 epoch data was recorded in 15 minutes and positions of each epoch are plotted. They are within circle of radius 50-60cms. The average co-ordinate is taken as the final co-ordinate. Figure 3 shows the GAGAN-GCP accuracy and tracking of GPS satellites, PRN127 and PRN128.

The GCPs co-ordinates derived in relative GPS mode at Epoch ITRF 97 are converted to ITRF 2008 to match GAGAN-SBAS receiver

Table 1. Control survey details

Details	Relative GPS	GAGAN
Study area	Kothapalli village surroundings, RR dist, A.P.	
Reference station	30 DS (Zero Order stn)	No Reference station
No. of GCPs	11 (7-check points)	4
Systems used	Leica 500 & 1200	u-blox NEO-6P GAGAN receiver
Constellation	GPS	GPS+GAGAN signal
Post processing	yes	no
GDOP	3.8	5
Frequency	dual	single
Duration of Observation	1 hr	15 minutes

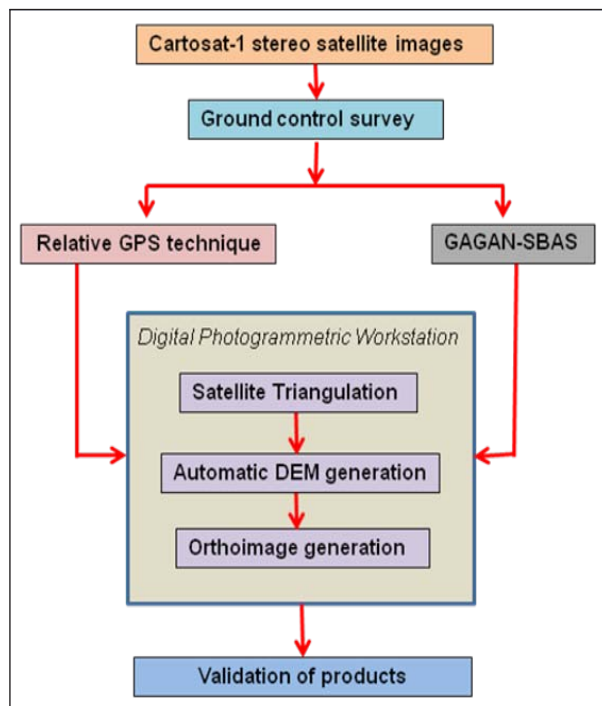


Fig. 2. Methodology.

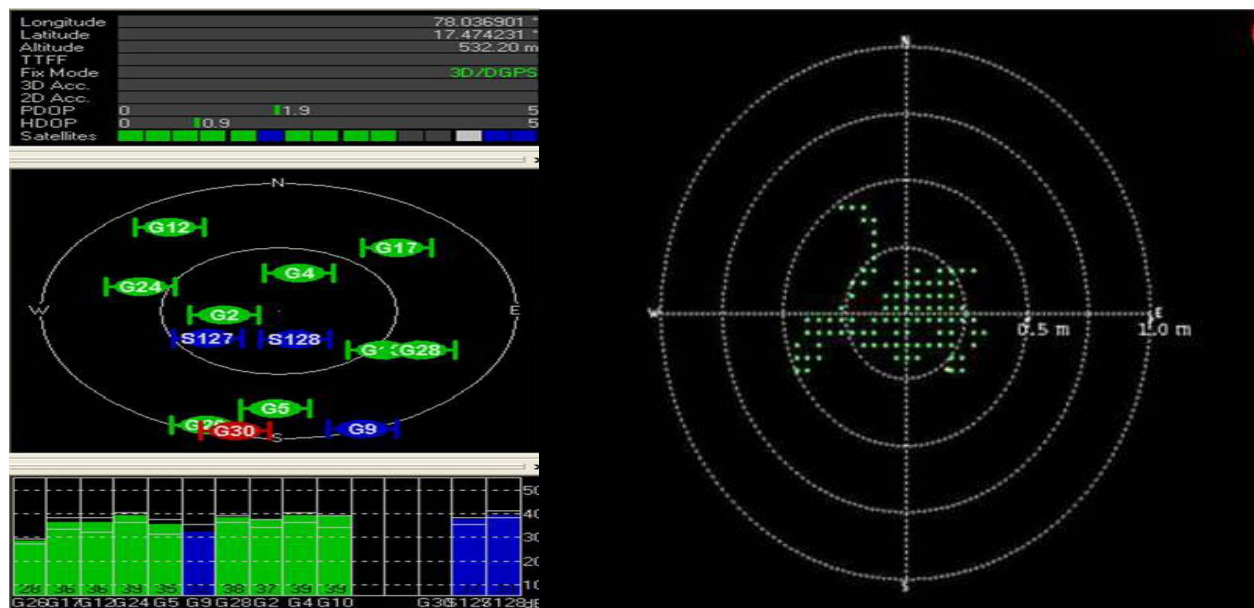


Fig. 3. GAGAN co-ordinate accuracy.

coordinate system (ITRF 2008). DEM and orthoimages are generated by using standard photogrammetric techniques. Primarily, triangulation of the stereo-pair has been carried out using Rational Polynomial Coefficients (RPCs), 170 automatic tie points and four GCPs collected from relative GPS. (Kalchang Di et al., 2003).

The RMSE of triangulation is 0.14m. DEM at 10m posting has been generated using stereo-pair by automatic photogrammetric process and subsequently orthoimage is generated using Aft image of stereo pair. Secondly, triangulation is also carried out with GCPs derived from GAGAN receiver along with similar configuration of tie points used for relative GPS technique. The triangulation is accurate to 0.18 m. DEM with 10 m grid and orthoimage using aft image of Cartosat-1 data are generated.

Validation and Results

GAGAN GPS receiver data is validated with relative positioning GPS data at different product levels such as GCPs, DEM, orthoimage and contours.

6.1 Location accuracy of GAGAN GCPs

Four GCPs are observed using both techniques to study the difference between the co-ordinates. The maximum standard deviation (SD) of GCPs derived with relative technique is

1.5 cm in easting, northing and height and for GAGAN derived GCPs 31 cm 55 cm and 1.08 m in easting, northing and height respectively. The difference of GCP co-ordinates in easting (dx), northing (dy) and height (dz) are shown in Figure 4. The maximum dx, dy and dz are 0.61 m, 0.59 m and 2.03 m respectively.

6.2 Height Accuracy - DEM

The DEM generated from Relative GPS and GAGAN-SBAS are evaluated at seven check points. The differences in elevation at check point with respect to Relative GPS DEM and GAGAN DEM are shown in Table 2. The maximum elevation difference (dz) with Relative GPS is 3.87m while with GAGAN is 4.81m.

DEM generated with relative GPS and GAGAN are shown in Figure 5 and Figure 6 respectively. It is observed that the variation in minimum elevation is 4m between two DEMs.

6.3 Planimetric Accuracy - Orthoimage

The planimetric accuracy of the Orthoimages is validated at seven check points. The difference in easting (dx) and northing (dy) at check points in the both Orthoimages are shown in Table 3 & Table 4. The maximum dx with relative GPS is 2.58 m and with GAGAN is 2.88 m. Similarly maximum dy with relative GPS is 2.26 m and with GAGAN is 2.80 m.

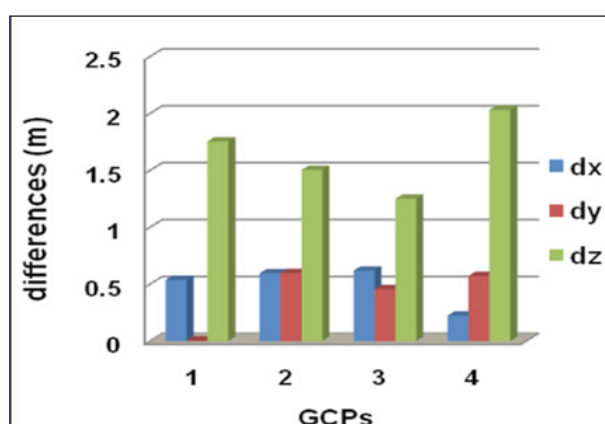


Fig. 4. Difference of GCPs (Rel vs GAGAN).

6.4 Comparison of contours with SOI map

Contours generated from GAGAN receiver height data in WGS84 datum are transformed to orthometric heights using global geoid model EGM2008 and compared with contours from SOI map at 1:25,000 scale. It is observed that contours in few areas are deviating by 5m. The results are shown in Figure 7. Contours

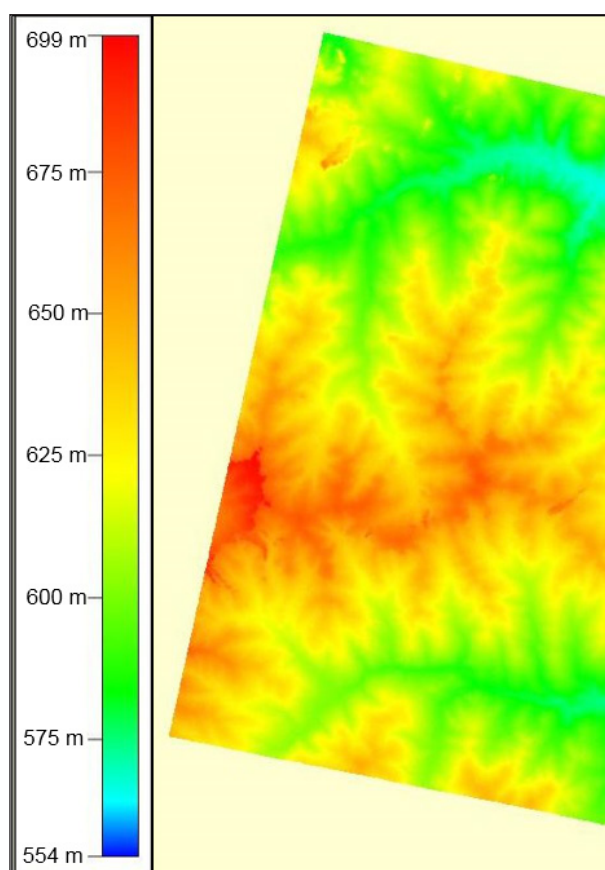
Table 2: Difference in Elevation (Rel vs GAGAN)

Check points	Z Check point (A)	Z DEM (relative GPS) (B)	Z DEM (GAGAN) (C)	A-B (mts)	A-C (mts)
1	527.72	523.85	531.45	3.87	-3.73
2	510.29	512.18	505.52	-1.89	4.77
3	565.44	568.10	569.68	-2.66	-4.24
4	552.52	550.29	556.02	2.23	-3.50
5	529.31	531.50	525.56	-2.19	3.75
6	520.73	522.41	523.84	-1.68	-3.11
7	526.98	530.62	522.17	-3.64	4.81

matching areas are shown in green circle and not matching areas are shown in red circle.

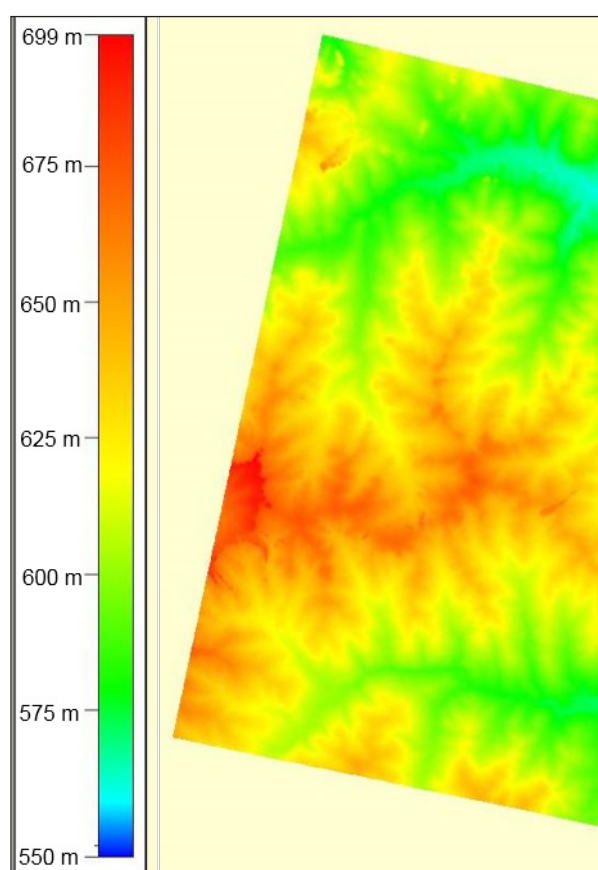
6.5 Validation of Orthoimages with field measurements

The road widths measured in orthoimages generated using GCPs in relative positioning and GAGAN receiver are compared with ground measurements and are shown in



Minimum elevation 554 m
Maximum elevation 699 m

Fig. 5. DEM with Relative GPS



Minimum elevation 550 m
Maximum elevation 699 m

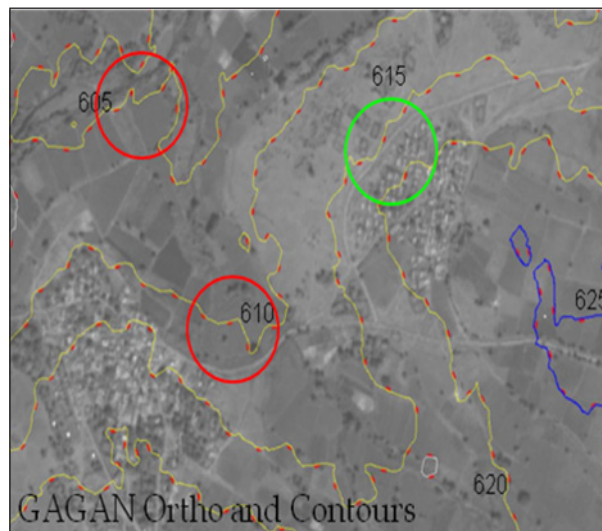
Fig. 6. DEM with GAGAN-SBAS.

Table 3. Difference in easting (dx) at check points (Relative vs GAGAN Ortho)

Point id	X Checkpoint (A)	X _{rel} GPS (B)	X _{GAGAN} (C)	A-B (m)	A-C (m)
1	XX79.06	XX77.21	XX78.78	1.85	0.28
2	XX95.69	XX96.85	XX93.62	-1.16	2.07
3	XX56.55	XX56.36	XX59.43	0.19	-2.88
4	XX16.77	XX17.07	XX15.62	-0.3	1.15
5	XX73.73	XX71.28	XX71.14	2.45	2.59
6	XX84.63	XX82.05	XX83.59	2.58	1.04
7	XX17.04	XX15.28	XX16.78	1.76	0.26

Contours overlay on GAGAN-Ortho

Location - 1



Location - 2

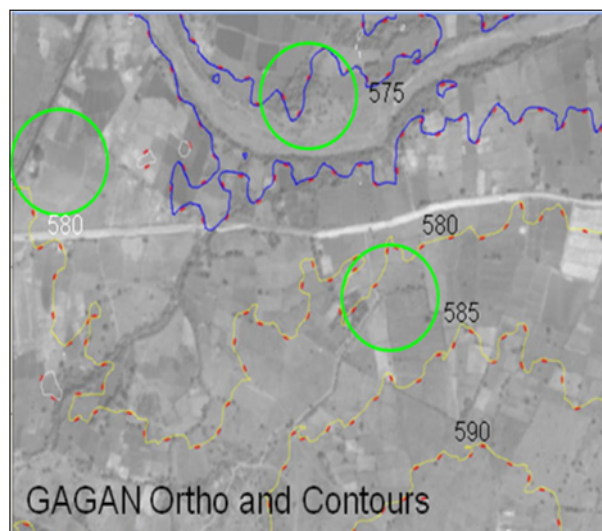


Table 4. Difference in northing (dy) at check points (Relative vs GAGAN Ortho)

Point id	Y Checkpoint (A)	Y _{rel} GPS (B)	Y _{GAGAN} (C)	A-B (m)	A-C (m)
1	XX22.24	XX23.87	XX24.82	-1.63	-2.58
2	XX63.01	XX63.59	XX60.21	-0.58	2.80
3	XX69.26	XX67.01	XX71.89	2.25	-2.63
4	XX74.96	XX75.48	XX75.40	-0.52	-0.44
5	XX12.93	XX11.12	XX10.85	1.81	2.08
6	XX84.88	XX82.98	XX84.48	1.90	0.40
7	XX20.45	XX21.47	XX22.03	-1.02	-1.58

SOI map 1:25,000 scale contours 5m

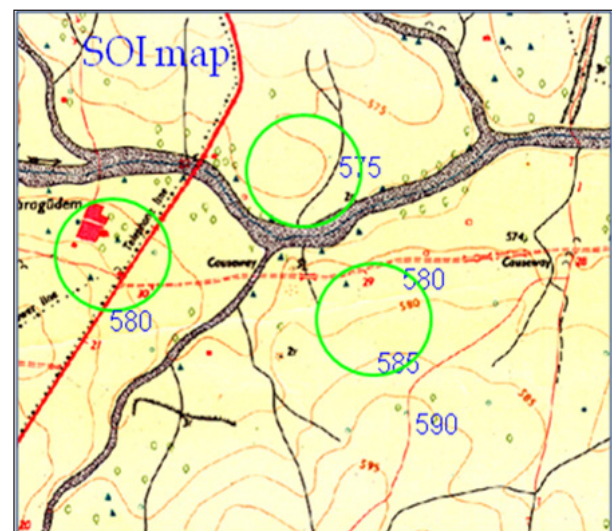
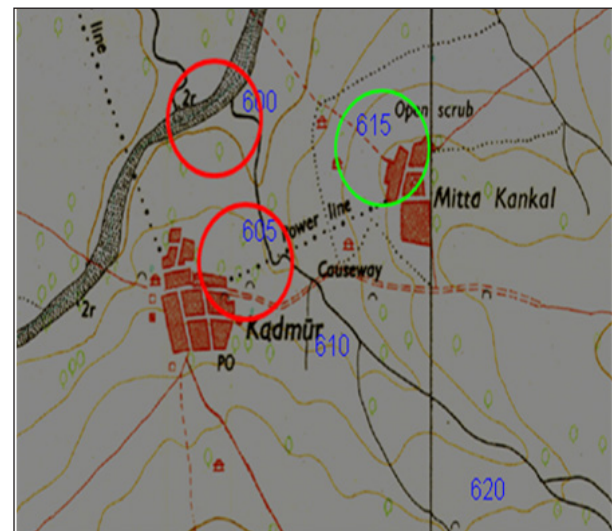


Fig. 7. Comparison of contours with SOI map.

Locations of Field measured points (blue color)

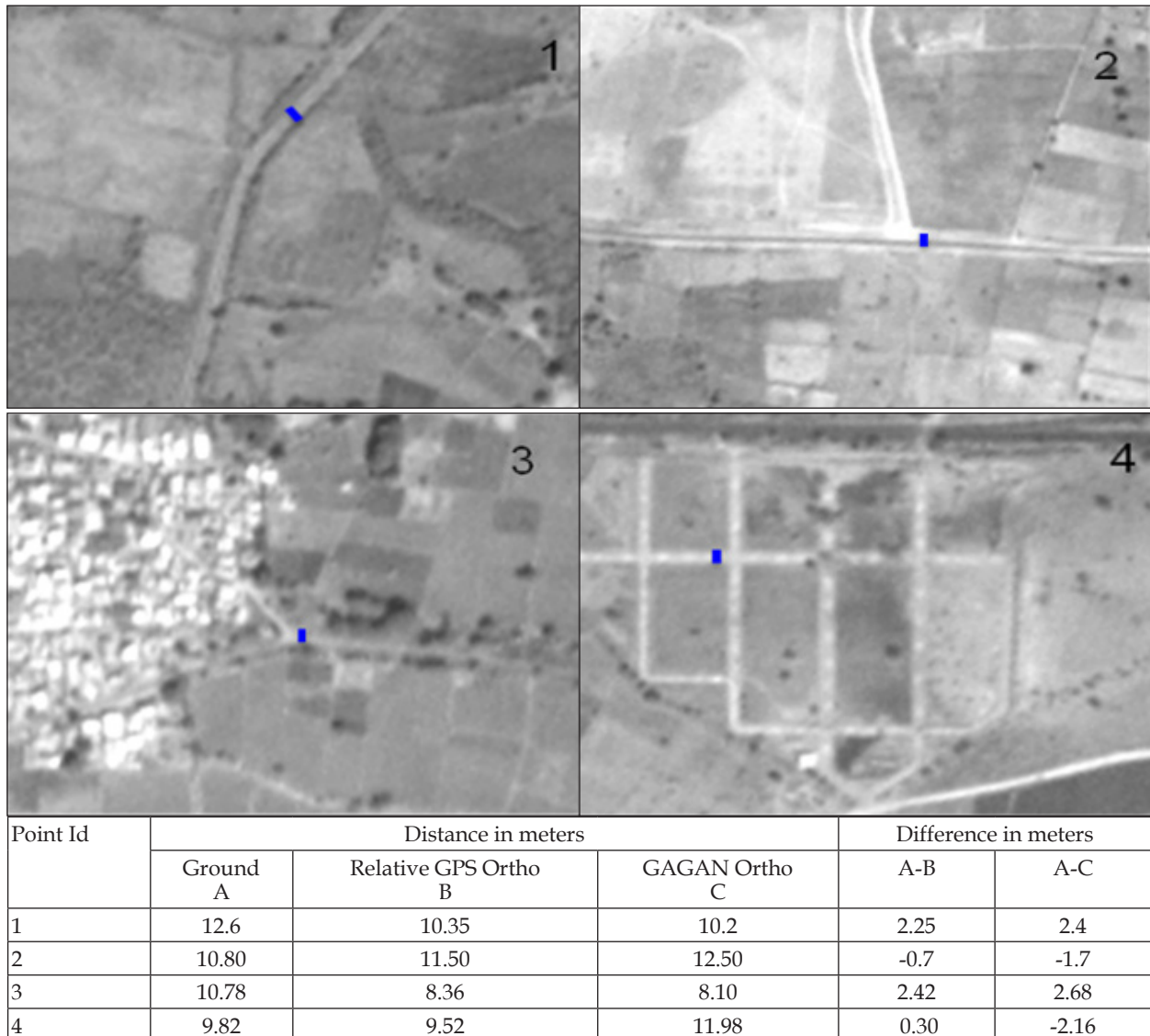


Fig. 8. Validation of Ortho with field measurements.

Figure 8. They are deviated by maximum 2.42m in Relative GPS and 2.68m in GAGAN.

7. Conclusion

The location accuracy from GAGAN system after 15 minutes of observation is 50-60cms in planimetry and 1-2m in elevation. The DEM and Orthoimages generated with GAGAN GCPs are validated at check points and show 4.8m variation in elevation and 2.9m in planimetry. The contours generated from GAGAN GCPs are matching at few locations and are deviating by 5m at few locations when compared with 1:25,000 scale SOI map. Linear measurements on orthoimages generated from GAGAN

derived GCPs show a deviation of 2.68m when compared with ground measurements.

The results show that GAGAN derived GCPs can replace the existing practice of relative positioning GPS surveys for geo-referencing of Cartosat-1 data and to generate elevation products in quicker and efficient way.

8. Acknowledgments

The authors thank Dr.V.K.Dadhwal, Director, NRSC and Shri.P. Srinivasulu, General Manager, AS&DM, NRSC for providing encouragement during the course of study. The authors acknowledge the support received from Ground Survey team of AS&DM / NRSC.

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GIS/GPS Application, Cartography and Cloud Sourcing in Inland Water Transport

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Abstract: Inland Waterways Authority of India (IWAI) has been setup with the responsibility of development and regulation of National Waterways (NWs) in the country for shipping & navigation. IWAI has been maintaining the NWs by providing a navigational channel with targeted depth & width along with necessary infrastructure facilities for making Inland Water Transport (IWT) a supplementary mode of transportation. In this direction, IWAI has set up its own network of DGPS stations for providing real time position accuracy through GIS/ GPS application for water transport. Besides, IWAI has already published River Navigational Charts (RNC), River Atlas and River Pilots for the first 3 NWs and that of Sundarbans waterways. Electronic Navigation Charts (ENC) has also been released for Sagar- Farakka stretch of NW- 1. IWAI is in the process of implementing River Information Services (RIS) system in the above stretch. IWAI also developed a real time navigation software called 'IWN Software' for enhancing safety of navigation in NWs. The data taken from various bathymetric surveys has already been uploaded in the Authority's website www.iwai.nic.in. For facilitating cloud sourcing, these data is been uploaded through the NSDI portal shortly.

1 Introduction

1.1 Inland Water Transport (IWT) is an economic, fuel-efficient, environment friendly and employment oriented mode of transport. Inland Water Transport has maintained its edge over the other modes of transport in certain areas where it enjoys natural advantage. Today, it is recognized all over the world for its inherent advantage of being the cheapest mode of transport for bulk haulage over long distance between places situated along the waterfront. Its energy efficiency, low pollution and potential for employment generation are universally accepted.

1.2 Keeping the above aspect in view Govt. of India has set up Inland Waterways Authority of India (IWAI), a statutory body under Ministry of Shipping in 1986 with the responsibility of regulation and development of National Waterways in the country for shipping and navigation.

1.3 The following inland waterways in the country have so far been declared as National Waterways.

- a. Allahabad- Haldia stretch (1620 km) of the Ganga- Bhagirathi- Hooghly river system as National Waterway No-1;

- b. Sadiya- Dhubri stretch (891 km) of Brahmaputra river as National Waterway No-2;
- c. Kollam- Kottappuram stretch of West Coast Canal along with Champakara canal and Udyogmandal canal (205 km) as National Waterway No-3;
- d. Kakinada- Puducherry stretch of Canals and the Kaluvelly Tank, Bhadrachalam-Rajahmundry stretch of River Godavari and Wazirabad- Vijayawada stretch of River Krishna (1078 km) as National Waterway-4 and
- e. Talcher- Dhamra stretch of Rivers, Geonkhali- Charbatia stretch of East Coast Canal, Charbatia- Dhamra stretch of Matai River and Mahanadi Delta Rivers (588 km) as National Waterway-5

1.4 IWAI is taking up the development of the first three National Waterways in a phased manner with a view to provide it as an alternative mode of transport. Development of commercially viable stretches of NW-4 & NW-5 are being taken up under World Bank assistance/ resources from other sources.

1.5 Besides, IWAI is developing and maintaining the Indian side of Sunderbans waterways under the Indo-Bangladesh Protocol

for Transit and Trade under which the inland vessels of one country can transit through the specified routes of the other country.

2 GIS/GPS Applications for Hydrographic Survey & Cartographic activities in IWAI

2.1 Hydrographic survey

IWAI started using geospatial technology for undertaking hydrographic surveys in National Waterways and other waterways way back in 1990. Initially analogue satellite images collected from National Remote Sensing Agency (NRSA) was used for preparing base charts for survey purposes and the survey was conducted using conventional methods. With the advent of technology, IWAI started using Automated Hydrographic Survey System (AHSS) since 1996 for which digital charts generated based on the satellite images from the base charts. Horizontal control was based on Global Positioning System (GPS). Since 2002 digital imageries replaced analogue charts and the survey become more accurate. After the establishment of IWAI's own DGPS stations, DGPS rovers replaced ordinary GPS for position fixing thereby improved the position accuracy to sub-metre levels.

IWAI possess 19 state-of-the art survey vessels fitted with modern survey equipment. The Surveyors in IWAI are well trained in using these equipment as well as GIS/ Hydrography survey softwares. The following surveys are being carried out in National Waterways:

- a. **Thalweg survey-** single lane longitudinal surveys carried out along the deepest channel for channel monitoring and demarcation on fortnight/ monthly basis
- b. **Detailed survey-** When the depth started decreasing, such locations are identified and detailed surveys are carried out by taking cross-sections at the required interval. Subsequently river conservancy works like bandalling and dredging is undertaken to improve the depth. For monitoring the effect of conservancy works progress surveys and post bandal/ dredging surveys are also carried out
- c. **Terminals survey-** Detailed cross-sectional survey carried out at terminal locations to

assess the channel behavior twice in a year, prior to monsoon and post monsoon period.

- d. **Bank-to-bank survey-** Detailed bathymetric surveys carried out from bank to bank to assess the total river morphology. Based on this decision for appropriate River Training works for channel stabilization/ rectification are being taken. Besides updation of navigational charts are also done based on these survey results.

2.2 Cartographic Activities

- a. **River Navigational Charts (RNC) -** IWAI has already published RNCs for the entire stretch of NW-1, NW-2, NW-3 and Sunderbans waterways which is available on sale to prospective users/ operators/ agencies/ individuals. For details refer IWAI website www.iwai.nic.in. The charts were prepared using Caris software as per the international standards stipulated by IHO at par with the NHO charts.
- b. **River Atlas-** IWAI has already published River Atlas for NW-1, NW-2, NW-3 and that of Sunderbans which are available on sale. For details refer IWAI website. This gives general description of the waterway, A-3 size RNC for giving stretch details, two Regulations viz. Prevention of Collision on NWs Regulations-2002 & National Waterway, Safety of Navigation and Shipping Regulations-2002, facilities provided in NWs, contact details etc.
- c. **River Pilots-** River Pilots have already been published for NW-1, NW-2 & NW-3. River Pilot for Sunderbans is under preparation. This will act as supplementary documents to the RNC by way of providing sailing directions to the Mariners/ Users & Masters just like the Bay of Bengal Pilot.
- d. **Electronic Navigation Charts (ENC) -** IWAI has also released 45 nos ENCs for Sagar- Farakka stretch of NW-1. This has been prepared in S-57 format as per IHO standards. These products are available on sale. With the introduction of ENC, it would be easier for the Inland Masters to steer the vessel along the correct channel. This will avoid possible grounding and other mishaps.

e. Real-time Navigational Display software-

IWAI has also developed a modern real time navigational software called “Inland Waterways Navigation (IWN software) software” similar to that of Inland ECDIS for the stretch Sagar- Farakka of NW-1. Photographs of important features on the banks as well as across the waterway are tagged to the respective location in the software. Besides, narration on important locations/ features, cross-structures, obstructions etc have been incorporated in tri-lingual form (English, Hindi and Bengali) so as to provide caution to the Master of the vessel. This is available on sale to prospective IWT operators/ users. Usage of this software is possible if the vessel is equipped with the following minimum hardware:

- i. Digital Echo Sounder
- ii. DGPS/GPS Receiver
- iii. Standard PC with suitable display monitor loaded with Digital
- iv. River Charts of the waterway

Vessels of IWAI and that of M/s Jindal ITF are already equipped with this software which is navigating safely in the above stretch, even during night time. IWAI is planning to extend this facility to the other stretches of NWs in future.

3. GPS/ DGPS use for navigation in National Waterways

3.1 IWAI has been using various types of aids to navigation viz. lighted buoys, shore beacons, country boats fitted with lights etc. Besides, promulgation of navigational information by way of issuing River Notices indicating least available depth (LAD) available on various stretches of NWs has been implemented by IWAI to facilitate smooth and effective navigation in NWs. Pilotage assistance to operators during their voyage in NWs by way of escorting and/ or by deputing experienced persons on board the vessels is also being provided on need basis.

3.2 As more and more vessels started operation in NWs and also due to the difficulty faced in demarcating the channel (navigational channel is subjected to frequent changes during lean season in mighty rivers like Ganga and

Brahmaputra), there emerged need for a more accurate and reliable technique for navigation. Thus IWAI has decided to introduce “Navigation with DGPS technique” in NWs by establishing its own DGPS network.

3.3 Accordingly IWAI has already commissioned DGPS stations at Swaroopganj, Bhagalpur and Patna in NW-1 & Jogighopa, Silghat and Dibrugarh in NW-2. Commissioning/ Setting up of Varanasi station in NW-1 & Dhubri station in NW-2 will be done shortly. Each station will give a radial coverage of approx. 150 km and the vessels equipped with a DGPS receiver can fix their position with sub- metre accuracy thereby providing safe navigation.

4. Vessel Tracking System

In IWAI another important aspect of geospatial technology has been adopted with the introduction of a web based vessel tracking system for the vessels in the Patna sector, which is being extended to other sectors also. This is initially enabled with Google map, as background layer and is likely to be replaced later with ENCs.

5. Setting up of River Information Services (RIS) System

5.1 A tripartite agreement was signed between National Thermal Power Corporation Ltd (NTPC), IWAI and a private operator for transportation of 3 million tonnes of imported coal between Sandheads (Bay of Bengal) and NTPC Farakka Thermal power station. This commercial operation is expected commence by Oct, 2013. In order to enhance the safety and efficiency of vessel operation in this stretch IWAI is in the process of setting up of River Information Services system in Sagar- Farakka stretch (560 km) of NW-1 during the current financial year.

5.2 The RIS system is already implemented in European countries like the Netherlands, Belgium and Germany. RIS System provides harmonized services to support traffic and transport management in inland navigation, including interfaces to other transport modes. RIS have the goal of a safe and efficient transportation with the following major features:-

- a. Fairway Information service

- b. Traffic information
- c. Traffic management
- d. Calamity abatement support
- e. Information for transport logistics
- f. Information for law enforcement
- g. Statistics
- h. Waterway charges & dues.

5.3 The RIS System consisting of the following components

- a. Automatic Identification System (AIS) :- Installed on board the vessel and monitored through control stations established at Kolkata and Farakka via series of repeater stations approximately @ 60 km interval.
- b. VHF communication system: - On board the vessel for voice communication between the vessels and from shore stations to vessel and vice versa.
- c. DGPS receiver: - On board the vessel for giving accurate position of the vessel.
- d. Digital Echo sounder: - On board the vessel for giving real-time depth.
- e. Inland ECDIS:- On board the vessel (Navigational Display Software pre loaded with Electronic Navigational Chart).
- f. Hydro & Metrological sensors- at shore stations.
- g. Radar: - Fitted on board the vessel for giving real-time information on small vessels/

country crafts which are not fitted with AIS for night navigation.

Once operationalised, the RIS would provide a seamless integration of digital mapping tools with modern communication & IT technologies leading to more efficient navigation.

6. Cloud Sourcing of information

After conducting fortnight/ monthly thalweg surveys IWAI promulgate river/ waterway notices giving latest depth information on NWs. At present this is uploaded in the IWAI's website. Government of India already created National Spatial Data Infrastructure (NSDI) with a view to have all such data under one platform so that any user can access the data from a single portal. Like Survey of India (SoI), waterway data compiled and collected by IWAI is being uploaded in the NSDI portal shortly.

7. Conclusion

- Navigation in the National Waterways became more safe and easier with the adoption of modern GIS/ GPS applications.
- Use of modern Cartography techniques by IWAI facilitated production of electronic and analogue charts in the international standards.
- With the implementation of RIS system supplemented with Electronic Charts, inland navigation in India would be entering in to a new era at par with that of the advanced countries.
- Cloud sourcing of waterway information/ data through NSDI portal will facilitate data access in a user friendly mode

RAPID: Real-time Data Processing and Information Dissemination System

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Keywords: *Information Products, Data Dissemination, Event Driven Architecture, Web Mapping*

Abstract: This paper describes a novel data processing architecture that processes satellite data to generate information products in near real time. These alerts may be in the form of heavy rainfall, cloudburst, Fire, Smoke, but not limited to this. The software takes input the image data from Kalpana-1 and INSAT-3D. The software broadly contains three components: Information Processing Software (known as Rapid Processing Software), Information Dissemination Software and the web interface. The information processing software follows an event driven architecture, where alert events, as and when generated, get transferred to the central server from where they can be disseminated to the user as well as are accessible to the user via web interface. The data processing software is hosted on servers that are capable of running compute intensive information retrieval algorithms. The event-driven architecture helps to generate and disseminate alerts only when detected. The software follows a plugin based architecture allowing adding new information products as and when required. The web based interface provides access to the latest alerts, satellite data and model output. The web application uses MapServer for serving vector data, THREDDS (Thematic Realtime Environment Distributed Data Services) WMS (Web Mapping Server) services for satellite raster datasets and OpenLayers as front-end for providing web mapping capabilities to the user. The alert information provides details of cities affected and the time for which the alert is valid. The alerts are available for downloading as KML/ ASCII files. The proposed information processing architecture focuses on the quality, quantity, consistency and timeliness of weather related information to the user community. The users can subscribe to these alerts via internet or mobile (SMS). The data products related to alerts are also made available to user via FTP/ email

Introduction

Satellite remote sensing has seen lots of changes in terms of number and types of processed data that it makes available to the end users. The evolution has taken place mainly in three dimensions: spatial (kilometre to sub-meter resolution), spectral (from single band to multi-spectral to hyper-spectral) and temporal (some days repetivity to less than an hour repetivity). Further, the spectrum is being effectively utilized by using Infrared and microwave regions of electromagnetic spectrum in addition to the visible region. As the satellite data processing evolved the datasets from different platforms (rich in different features e.g. one with a better spectral resolution and another with a better spatial resolution) were combined to use the best of the each to generate merged products.

Now-a-days, satellite data is readily available. Lately there is increased demand for generating information from satellite data that can be easily understood and ready to use to the common man for making decisions (e.g. cloud burst prediction in a particular region valid for next 3 hours). This has given birth to the concept of Information Products (which is different from conventional satellite data products). This paper introduces the concept of Information Products. We also describe the design and implementation of data processing approach used for generating information products from satellite data known as RAPID (Real-time Data Processing and Information Dissemination System). Going further, we also describe the data dissemination approach developed for disseminating satellite derived information products. Section 2 discusses in general the concept of Information Products. Section 3 gives

an overview of RAPID (Information Product Generation System for satellite Data). Section 4 discusses the details of implementation of RAPID Processing Software. Section 5 discusses the design and implementation of Web application developed for providing users access to information and satellite products. Section 6 details the implementation of data dissemination approach developed and the various modes of data dissemination used. Section 7 summarizes and discusses the future work planned for extending RAPID.

II. Information Products

The concept of Information products has been conceived as a result of the need of generating information that makes more sense to the common man (as compared to satellite data products) for making immediate decisions (e.g. related to travel plans). This need dictates that information products should be specific and relevant to a particular region and for a given period of time. The information Products are derived by applying special retrieval algorithms on processed satellite data products. This output is generated in form of alerts (e.g. Fire, Fog, and Cyclone Alerts). These alerts are associated with the region and time period for which they are valid.

III. RAPID Overview

RAPID basically consists of three software components:

1. Core Information Processing Software (also known as Rapid Processing Software or RPS)
2. Web Application
3. Data Dissemination Software

Rapid Processing Software is heart of RAPID that generates the information products by running compute intensive retrieval algorithms on the processed satellite data products. These information products are generated at RPS central storage. These products are transferred from processing central storage to the Web server central storage by Data Dissemination Software (Fig. 1). The end user can use the RAPID Web application (web interface to the RAPID) to view the alerts. The data dissemination software is used to disseminate the alerts to the user via email and SMS.

IV. Rapid Processing Software (RPS)

Rapid Processing Software (RPS) is a Java based software that follows plugin based architecture (Fig. 2). All the alerts are added as plugins. The plugin based approach makes the software architecture extendable and easy to maintain. Whenever a new algorithm is developed to generate a new alert, plugins are developed to add it into the RPS. Similarly if there is a need to remove an alert, it is possible to do that by removing the corresponding plugin.

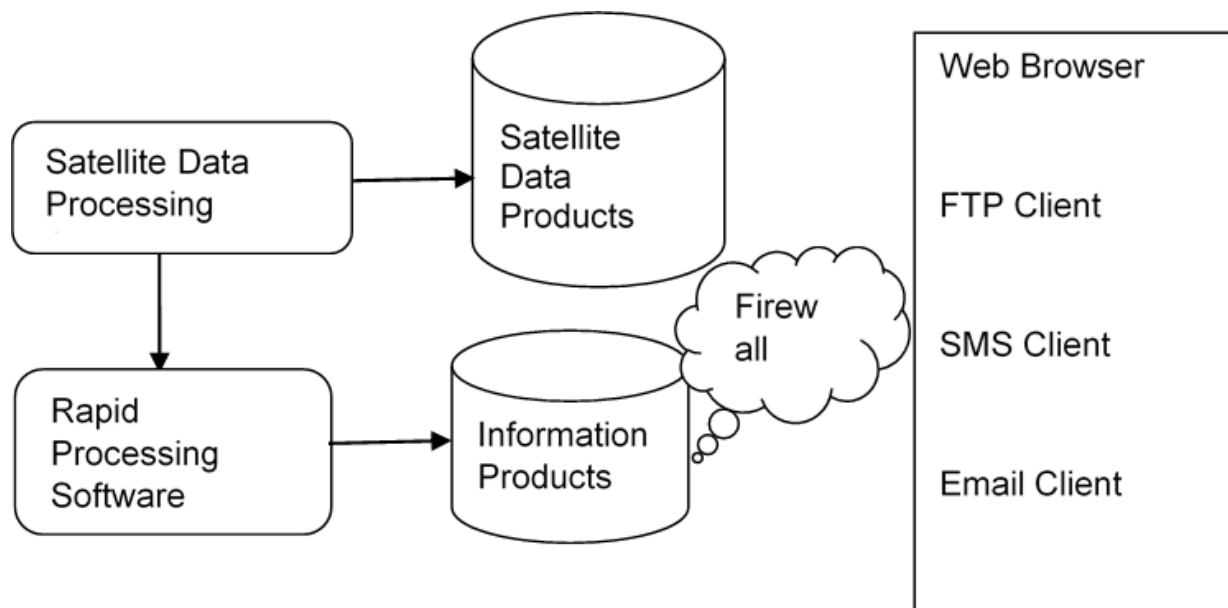


Fig. 1 Rapid Deployment.

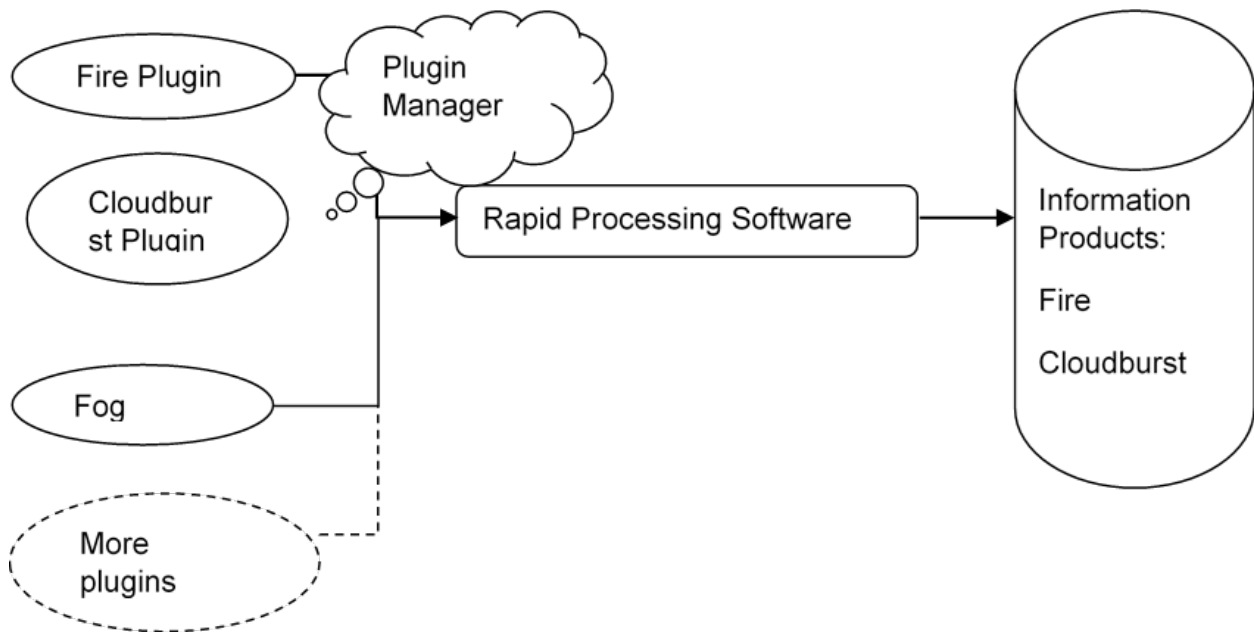


Fig. 2 Plugin architecture of Rapid Processing Software.

RPS follows an event driven architecture. RPS runs as a system service that keeps looking for newly generated satellite data products periodically at a particular location. As and when a new product is available, it runs the retrieval algorithms to generate information products. The information products generated are parsed to find whether alerts are required to be generated or not. The alerts generated are stored in different formats based on the spatial density of alerts (see Table 1).

Standard libraries have been used for writing the products in above described formats. NCSA HDF-5 C library (www.hdfgroup.org/HDF5/release/obtain5.html) is used for generating CF compliant HDF-5 products. An XML template based approach [1] has been developed for

generating HDF-5 products. KML writing library (JAK: available at <https://code.google.com/p/javaapiforkml/>) is used for writing KML libraries. These alerts are stored in the processing central storage. Currently Kalpana-1 VHR data is being used for generating Cloudburst and Heavy rainfall alerts on test basis. Fire, Smoke and FOG will be available by using INSAT-3D Imager data.

V. Web Application

To provide access to the user to information products in the form of alerts, a web application has been developed. The web application consists of following Software components:

1. THREDDS Data Server [2]
 - a. Running OpeNDAP [3] service
 - b. Running WMS Service
2. Rapid Web Application

TDS (THREDDS Data Server) is used as middleware infrastructure for hosting the earth science data products generated. It uses ncWMS [4] at the backend for serving WMS requests. All the satellite data products that follow CF Conventions can be hosted on THREDDS. In addition it also allows the user to plugin the datasets that don't follow any convention via extending the base classes. In addition to the

Table 1 Alerts Product Formats

Alert Name	Spatial Topology	Format	Derived from Satellites
Fire	Point	KML	INSAT-3D
Fog	Image	CF Complaint HDF5 Products	INSAT-3D
Cloud Burst	Point	KML	INSAT-3D, Kalpana-1
Heavy Rainfall	Point	KML	INSAT-3D, Kalpana-1
Smoke	Point	KML	INSAT-3D

Satellite products, model data outputs can also be hosted using TDS. TDS is able to ingest these products and provides them to the end user as various services:

1. OpeNDAP (Open Source Project for a Network Data Access Protocol)

2. WMS (Web Map Service)

THREDDS WMS is used by RAPID web application for providing access to the latest satellite data products. The alerts generated in KML format (as described in Section IV) are hosted on the web server. Rapid Web Application is written in JavaScript hosted on Tomcat (<http://tomcat.apache.org>) and uses OpenLayers and jQuery (<http://jquery.com>) for web UI components and reading configuration files from disk. Currently the web application supports Kalpana-1 VHRR and INSAT-3A VHRR and INSAT-3A CCD products. The satellite data products from these satellites are not CF Convention complied. Therefore the plugin architecture (extending ucar.nc2.dataset.CoordSysBuilder class) was utilized to ingest them into TDS. TDS uses NetCDF-4 [5] [6] that implements HDF (4 and 5) data model also. This plugin was used to convert satellite data products into CF complaint data products. These products are hosted on the TDS which are in turn available to the user as services (OpeNDAP or WMS). Currently the interface of the web application gives user control over following types of information:

1. Alerts
2. Vector Layers (World Maps, Countries Political Boundaries, State Boundaries, etc)

3. Satellite/ Model Products

Based on user choice, a given layer can be enabled or disabled. The alerts generated for a single class can be clicked over to get the information about that specific region. The information is provided in the following form:

1. Radius of Alert (Cities effected)
2. Date/Time at which the alert was generated
3. Date/Time upto which that alert is valid

All the vector layers are hosted on Apache web server (<http://apache.org>) and served using MapServer (<http://mapserver.org>). In addition to this we use the "Graticule" feature of OpenLayers to overlay the grid lines. For satellite/model data, user has been given the capability to select a particular time in multi-time dataset (wherever applicable) and a particular pressure level (wherever available). The user has also been given the control to interactively enhance the image by allowing him to set min/max of the image (Fig. 3 and 4).

VI. Data Dissemination Software

Data Dissemination Software is a Java based software used that basically is used at various places within the RAPID setup. It is used:

1. For transferring the Satellite Data Products to machine where RPS is running (Fig. 5).
2. For transferring the Information Products from RPS machine central storage to web server central storage (Fig. 6).

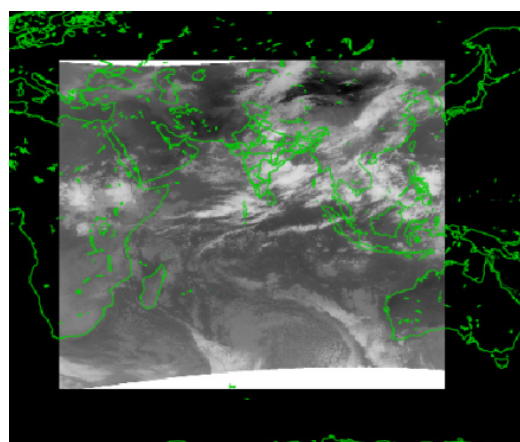
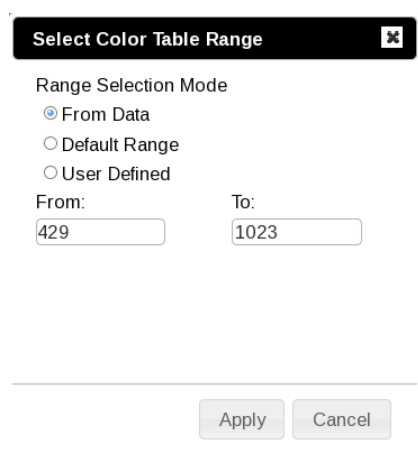


Fig. 3. Dynamic Image Enhancement Window.

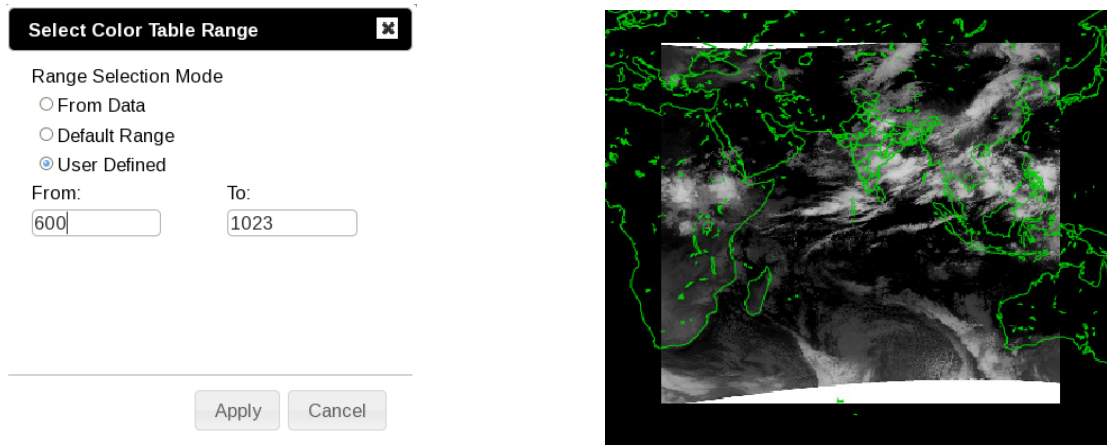


Fig. 4. Interactive Image Enhancement Window.

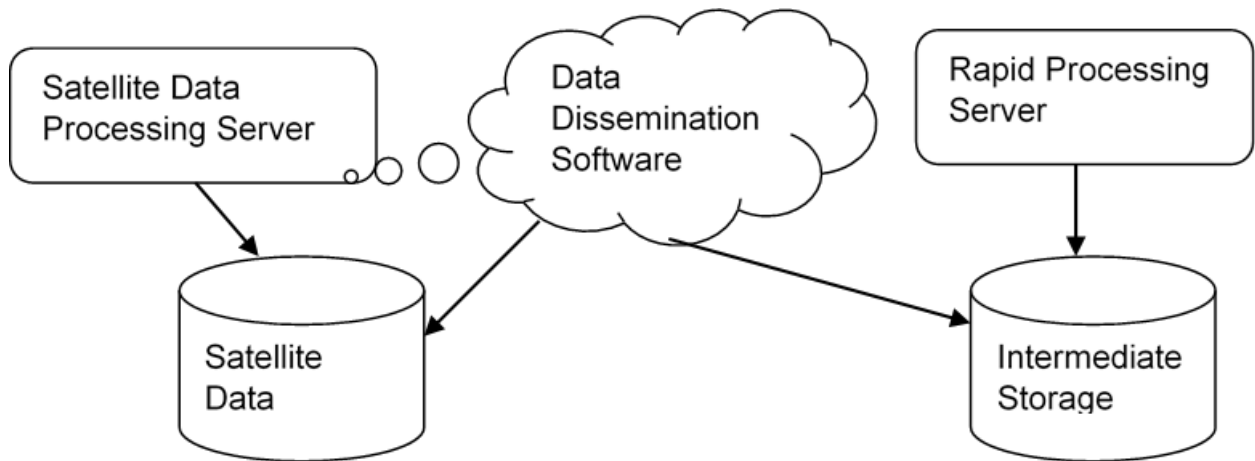


Fig. 5. Data Transfer from Satellite Data Products Storage to RPS Storage.

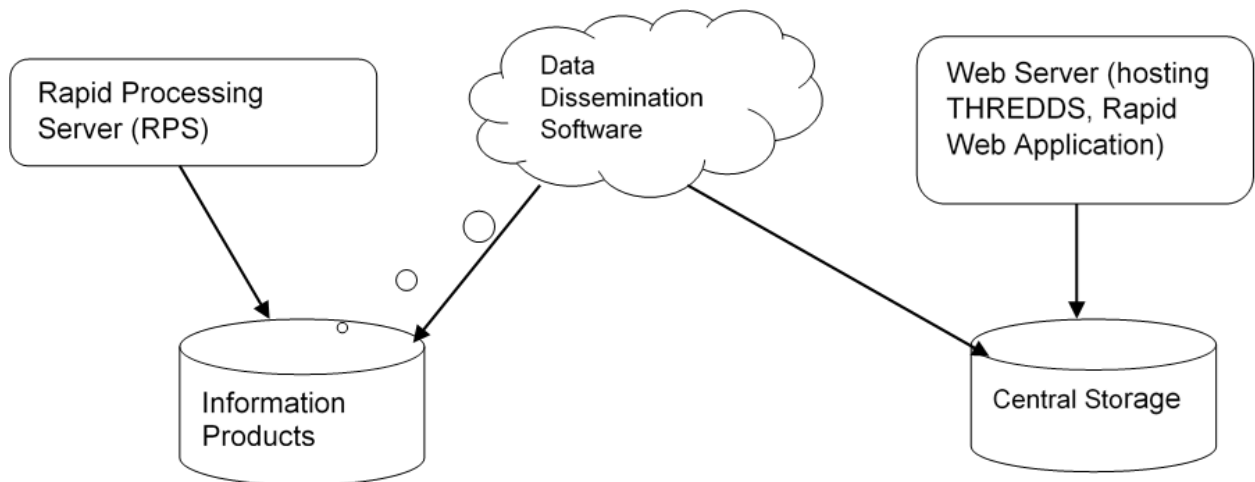


Fig. 6. Data Transfer from Information Products Storage to Web Server Storage.

This software uses rule for transferring the data. The rule describes following things about data transfer:

1. Source Directory
2. Source File Pattern
3. Destination Machine IP
4. Destination Directory
5. Destination File Pattern

The user can describe as many rules as possible and the software will start transferring all the files matching the criteria. This is customized software that searches for various types directory patterns to match the criteria. This software keeps monitoring the source directory for new files. As and when a new file is created, it transfers the file to the destination directory on the destination machine.

Coming to dissemination of information products, the dissemination via email is done by using another java based software component that uses Java Mail (<http://www.oracle.com/technetwork/java/javamail/index.html>) API to send the generated alerts to subscribed users. In addition, we plan to add Android based Mobile Application for RAPID that will give user access to the alerts generated by RAPID Information Processing System in near real time.

VII. Summary and Future Scope

Satellite Information Products are in demand these days. Information products provide the most relevant information to the end user based on which he/she can take decision. RAPID is next generation data processing and information dissemination system that uses most recently generated satellite data products to generate Information Products. It follows a plugin based architecture that gives it flexibility to add/ remove new/old alerts as and when required. The core data processing software runs in near real time to generate the information products as soon as the satellite data products are available. The web based interface developed as part of RAPID is interactive web application that allows user to access the satellite data as well as information

products in near real-time. The web server hosting the web application also hosts the TDS that enables users to access satellite as well as model data as different scientific data access services (OpeNDAP and WMS). Different instances of data dissemination software help to move the data from satellite data processing storage to RPS storage and from RPS storage to web server storage. In addition, another software component built on Java API is used for disseminating the information products via email to the subscribed users. Currently RPS works with Kalpana-1 and INSAT-3A VHRR/ CCD datasets. In the near future, we also plan to plugin data from INSAT-3D Imager and Sounder as many new alerts (like Fire, Smoke, Fog, etc.) could be generated from INSAT-3D data (due increased number of channels). We also plan to add WPS (Web Processing Service) as part of Rapid Web Interface which will allow user to run his own algorithms on satellite data to generate information. We also plan to use OpenLayers 3 which will allow user to 3D visualization on the web.

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Use of SIFT Feature Extraction and Image Matching for Automatic Orthoimage Generation for Cartosat-2

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Abstract: In today's scenario high resolution images are available through Indian satellites Cartosat-2, 2A & 2B satellites. Cartosat-2 satellite provides high resolution panchromatic data in three modes of imaging capability viz Spot, PaintBrush and Multi-View. Orthoimages are satellite or aerial images corrected for relief displacement. The orthoimages are much in demand for urban planning, cartography & other GIS applications. Generation of an ortho product from satellite raw data is a multi-step process, which involves registering an image using ground control points (GCPs) whose coordinates are well known along with Digital Elevation Model (DEM) corrected for relief displacement. System knowledge is improved with the help of only a few control points which are either available through a survey and hence have to be identified manually or a large number are generated and matched automatically using a reference image. With the advent of computers this process has been progressively automated through the use of feature based image matching techniques.

A technique is developed and implemented for generating scene based automatic orthoimages generation using Cartosat-2 data. Scale Invariant Feature Transform (SIFT) based technique is employed to generate dynamic keypoints, feature points or control points (CP's). These are automatically matched in the overlapping and comparatively low resolution registered orthoimages (CartoDEM) and their ground coordinates are computed. Using available satellite ephemeris and rigorous model their approximate ground coordinates are estimated in the reference orthoimage and automatically matched through image matching techniques. These CP's are then used in space resection (SR) to refine the input satellite attitude information and finally an orthoimage is generated using the DEM. Orthoimages are further evaluated with same reference data and the results are analyzed. This paper discusses the use of SIFT based technique for feature extraction and image matching adopted for automatic Cartosat-2 orthoimage generation.

1. Introduction

Orthoimages have today become the de-facto standard in satellite image processing. Identification of feature points or keypoints is an important step in the generation of orthoimage from raw satellite data. SIFT is used as to detect and generate feature points from any image. A variant of SIFT called ASIFT which is affine invariant is used for the identification of feature points or keypoints in the raw satellite image and the reference image. Image matching is then performed between the input raw satellite image and the reference image which helps in establishing the geometric transformation necessary in the generation of the orthoimage from the input raw satellite image. This is then used to rectify the Cartosat-2 satellite attitude which is then utilized to generate orthoimage product with improved geo-location accuracy.

2. ASIFT feature points or keypoints

SIFT was introduced by David Lowe in 2004 in his seminal paper [3] as a robust means of feature detection in an image. SIFT is used in feature detection algorithm in image matching, object or scene recognition, 3D structure determination from multiple images, stereo correspondence and motion tracking. SIFT is invariant to image scaling and rotation. Besides this, it is also partially invariant to illumination and imaging view angles to a certain extent. DOG (Difference of Gaussian) region detector is employed by SIFT transform to find and extract feature points in the image. DOG region detector is rotation, translation and scale invariant. Keypoint locations can be detected in an image by identifying stable features across the scale-space extremum of an image using the DOG function. The scale space function of an

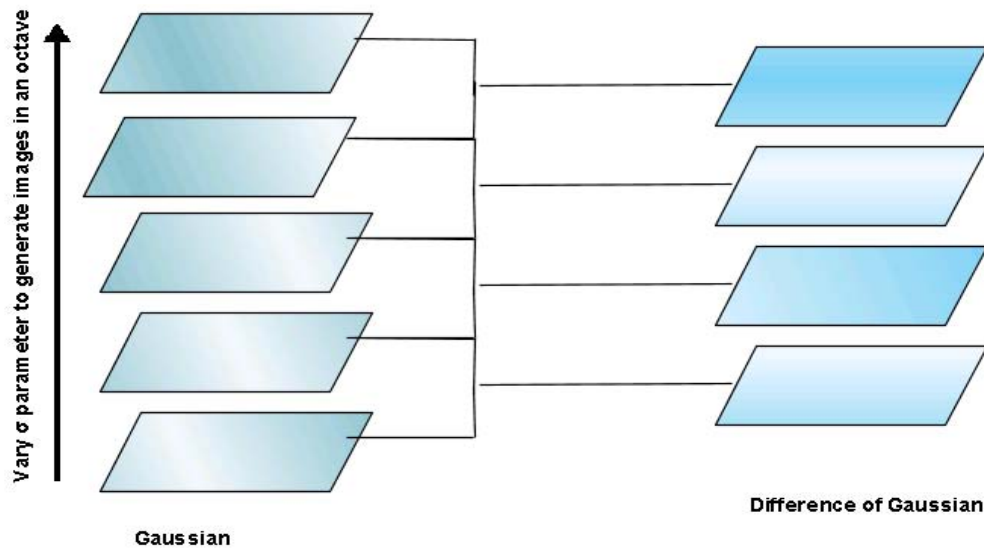


Fig. 1. Computation of Difference of Gaussians (DOG) of images for an octave.

image $L(x, y, \sigma)$ is obtained by convolving the Input image $I(x, y)$ with the variable scale-space Gaussian function $G(x, y, \sigma)$.

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

where the Gaussian $G(x, y, \sigma)$ is given by

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2}$$

The difference of Gaussian (DOG), $DD(x, y, \sigma)$ is obtained by subtracting the adjacent Gaussian images in an octave as depicted in Fig. 1 obtained by varying the σ parameter. This process is repeated across the scale space of the image each progressively down-sampled by a factor of 2 .

2. The extremum for identification of stable keypoint locations is computed by difference of

the two nearby scales (octaves) by a constant factor k (multiple of 2).

$$\begin{aligned} D(x, y, \sigma) &= (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y) \\ &= (L(x, y, k\sigma) - L(x, y, \sigma)) \end{aligned}$$

An extension of SIFT (ASIFT) which is fully affine invariant was proposed by Jean-Michel Morel and Guoshen Yu [2]. Out of the six affine parameters ASIFT simulates three and normalizes the rest which means that it is invariant to all six affine parameters namely translation (2 parameters), zoom, rotation and two camera axis orientations [4]. This has the additional advantage SIFT being invariant to affine transformation. ASIFT keypoints are used as feature points in the generation of Cartosat-2 orthoimage. The ASIFT algorithm flow is shown in Fig. 2.

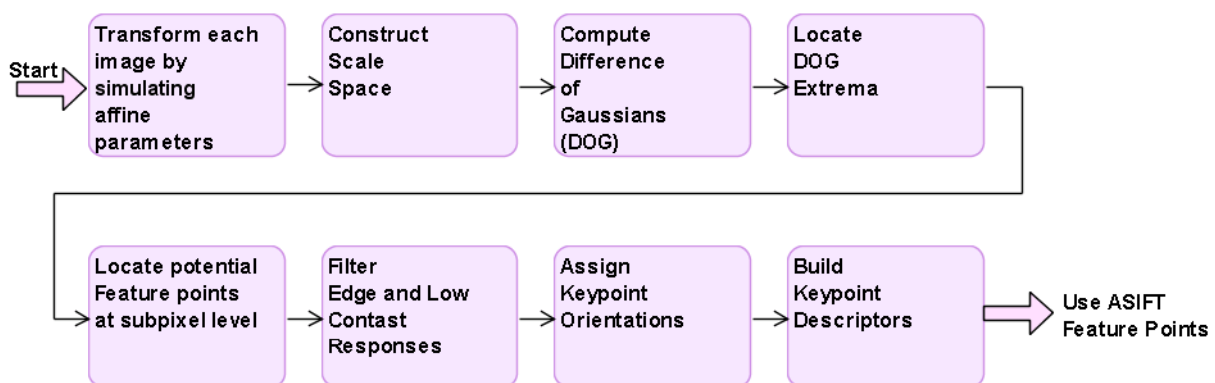


Fig. 2. ASIFT algorithm flow.

3. Image matching and outlier rejection

The Feature points or keypoints identified in the input image (Cartosat-2) have to be matched in the reference image (CartoDEM orthotiles). Using the Cartosat-2 satellite physical sensor model and the satellite ephemeris data the ground coordinates of the keypoint is computed. Using this ground coordinate the approximate image coordinates of the keypoint is determined in the reference image. Due to the inherent systematic and random errors in the satellite ephemeris data, the computed image coordinate of the keypoint in the reference image differs from its value. A suitable window around the feature is extracted from reference image and input image and image matching is performed to obtain precise image coordinates in the reference image. Classical correlation methods such as the area based Normalized Cross Correlation (NCC) method computes the correlation between the image intensities. The correlation coefficient is computed for the window pairs from the reference and input image. The reference window is explored within a larger search window from the input image and the correlation coefficient for each window pair is computed. The point of maximum correlation is taken as a match point.

The NCC performs well if the images are of same or similar resolution with a translation between them with only a slight rotation or scaling between them. Otherwise NCC gives very low match results. To overcome problems of low matching between the images, instead of matching the reference and input image windows directly, they are first converted into

a 'polar' image and then image matching is performed. The 'polar' image $P(r, \theta)$ from the Cartesian image $I(x, y)$ is computed as follows.

$$\theta = \frac{2\pi k}{m}, \quad x = r \cos \theta \quad \text{and} \quad y = r \sin \theta$$

m is the polar image size and k varies from 0 to m

$$\text{where } r = \sqrt{(x - x_0)^2 + (y - y_0)^2}$$

(x_0, y_0) is the midpoint of the Cartesian image

The 'polar' image is rotation and scale invariant and results in better matching since a rotation has the effect of only a shift in the 'polar' image and scaling. The Polar transform is a non-linear transform. The non-linearity is due to polar mapping. It is invariant with respect to scale and rotation. The algorithm for image matching is visually depicted in Fig. 3. The spatial resolution of Cartosat-1 image is 2.5m and that of Cartosat-2 image is 0.8m. Both the images are down sampled to an equivalent lower resolution and ASIFT keypoints are identified and image matching is carried out.

A crucial part of the image matching process is the detection of mismatches or outliers. This is accomplished by a two step image matching process. A keypoint is accepted only if it has passed both the image matching steps. The first image matching step is done by using the normalized cross correlation of polar images. In the second step the keypoints are matched by suitably adjusting the histogram of the search and keypoint windows. In this

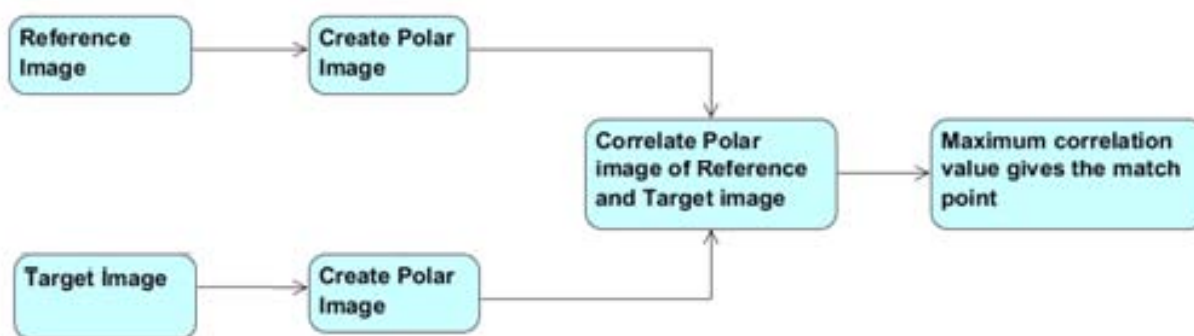


Fig. 3. Implementation of Polar based image matching for multi-resolution images of Cartosat-1 (reference) and Cartosat-2 (target).

the keypoint window from the input image is enhanced using the minimum and maximum pixel values from the reference image and then image matching is carried out using by the normalized cross correlation of the intensity altered keypoint and search windows. The two step matching process eliminates the outliers almost totally to less than 5 %. A mapping of the matched ASIFT keypoints between the reference CartoDEM orthotiles and Cartosat-2 scene is visually depicted in Fig. 4 by drawing a line between the matched keypoints in both the reference (Cartosat-1) and input image.

4. Cartosat-2 Orthoimage

Generation of orthoimage from raw satellite data requires image registration. Image registration is the process of finding the correspondences between the raw satellite image and an already registered image. The requirement is to register the input raw Cartosat-2 satellite image. The overlapping CartoDEM orthotiles are found from the Database and feature identification and image matching is carried out to generate the output Cartosat-2 orthoimage [1]. Image registration usually encompasses the following four discrete steps.

Feature identification: Distinctive and salient features in the reference (also registered) image are identified either manually or preferably detected automatically that are human relatable or interpretable and the coordinates are computed. These are called Control Points (CP). *Image matching:* In this process the correspondence or the spatial relationship between the detected features in the reference image and the input raw image is established. *Transform model:* The mapping function or model which establishes the relationship between the reference image and the input image is determined. *Image transformation:* The mapping function is used to transform the input image using an appropriate interpolation or resampling method. Feature Identification is a crucial step in the process of image registration. The feature points should be distinct and invariant to scale and rotation and immune to illumination and view angle changes as far as possible. The Affine SIFT (ASIFT) transform has these properties. ASIFT keypoints or feature points are identified automatically in the input Cartosat-2 image. The number of feature points that is generated in an image is controllable using a set of parameters based image smoothing, edge threshold, sampling,

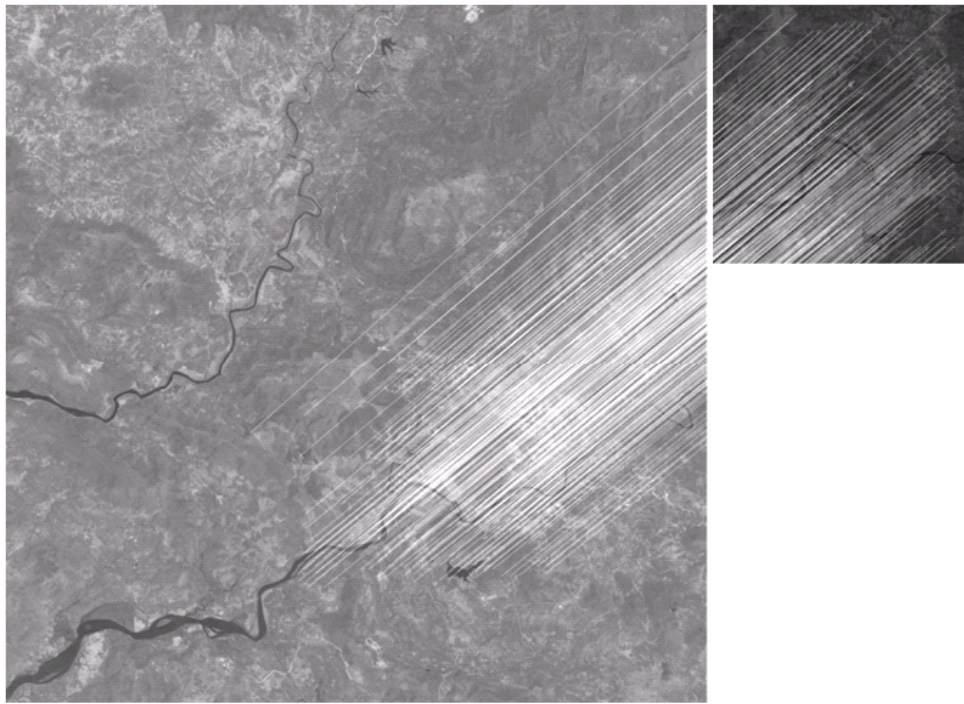


Fig. 4. Corresponding ASIFT feature points or keypoints matched in the Reference Cartosat-1 mosaiced orthotiles and Cartosat-2 scene joined by line segments.

Gaussian sigma ($\sigma\sigma$) etc and is usually very large typically of the order of thousands of points. But not all points are used in the image matching process. The image is divided into a grid of rows and columns and only one feature point or keypoint is selected which lies closer to the center of the grid is selected for the image matching process. This is done to obtain a fairly uniform distribution of points within the input image. Once image matching establishes the correspondences between feature points in the input and reference image, these correspondences help in computing the ground coordinates of the feature points, since it can be computed from the reference image using a projective transform. The next step is to establish the transform model between the two images. This is accomplished by using the feature points as control points in the Cartosat-2 physical sensor model. Space resection is used to rectify the Cartosat-2 satellite attitude using the control points, since the differences in image coordinates are attributed to the attitude error. The rectified satellite attitude can then be used generate the output grid which does the mapping from the Cartosat-2 input image to the output orthoimage. A suitable interpolation method like the cubic convolution is used to transform the input image to generate the final Cartosat-2 orthoimage.

5. Results

The number of matched points in a scene tends to vary from about 4% to about 35% of the total points used in the matching process

(841 points per scene). The matching results of the ASIFT keypoints is shown in Table 1. The two step matching process eliminates the outliers to a large extent and the number of correct matches is better than 95% in many cases and consequently the average number of mismatches is lower than 5%.

Cartosat-2 orthoproducts were generated using the above technique of detection of ASIFT keypoints and image matching. The reference images are the orthoimage tiles from the national level Cartodem project. The image registration exercise is done using the all the CartoDEM orthoimage tiles overlapping the input raw Cartosat-2 scene or image. The matched ASIFT keypoints were used as Control Points within the input image since their geo-coordinates can be determined from their corresponding image coordinates in the Reference image using a projective transform. The computed ground coordinates of the keypoints are thus used to rectify the input satellite attitude information using space resection. The refined satellite attitude information is used in the product generation chain to generate the final Cartosat-2 orthoimage products. The orthoimage products with their geo-location errors are tabulated in Table 2. The system level high geo-location errors which vary typically from about 100m to 800m show improvement in the orthoimage and their accuracy is now better than 10m (w.r.t CartoDEM). The Cartosat-2 orthoimage overlaid onto the mosaiced CartoDEM tiles is depicted in Figure 5. The continuity of the features in both the images can be readily seen.

Table 1. Table showing total ASIFT keypoints generated, matched and the no. of mismatches * The no. of ASIFT keypoints on which matching was attempted was only 841 for each scene

Date of Pass	Session, Seg, Strip, Scene No.	Total ASIFT Keypoints Generated*	No. of ASIFT points matched	No. of mismatches
26-FEB-10	1-1-1-7	7471	185	0 (0%)
17-FEB-11	1-2-1-5	11664	78	1 (1%)
26-JAN-13	1-1-1-5	2700	78	4 (5%)
21-JAN-13	1-1-1-2	11139	123	0 (0%)
21-JAN-13	1-1-1-7	3005	129	0 (0%)
28-DEC-12	1-1-1-4	3725	289	0 (0%)
28-DEC-12	1-1-1-2	1872	93	2 (2%)
19-DEC-12	1-1-1-5	1350	50	0 (0%)
24-OCT-12	1-1-1-2	5731	53	0 (0%)
15-OCT-12	1-1-1-7	5969	29	0 (0%)

Table 2. Cartosat-2 orthoproducts results with model level pre-resection, post-resection and evaluated geo-location accuracies

S. No.	Date of Pass	Session No., Seg No., Strip No., Scene No.	Model Level Accuracy										Product Evaluation Results (w.r.t. CartoDEM)			
			No. of Control points	Pre-Resection				Post-Resection				STD Deviation (m)		RMSE (m)		
				STD Deviation (m)		RMSE (m)		STD Deviation (m)		RMSE (m)						
				AL	AX	AL	AX	AL	AX	AL	AX	AL	AX	AL	AX	AL	AX
1	26-FEB-10	1-1-1-7	185	15.6	5.5	117.8	9.9	3.2	3.3	3.2	3.3	1.6	3.9	1.7	4.5	
2	17-FEB-11	1-2-1-5	78	15.2	22.9	26.3	25.9	3.2	4.1	3.2	4.1	3.9	4.4	3.9	4.5	
3	26-JAN-13	1-1-1-5	78	13.9	16.7	751.0	263.3	3.7	4.6	3.7	4.6	5.5	6.7	6.3	7.9	
4	21-JAN-13	1-1-1-2	123	185.2	135.9	188.7	160.7	6.0	5.8	6.0	5.8	2.5	1.7	3.1	3.7	
5	21-JAN-13	1-1-1-7	129	23.3	18.0	46.3	82.5	2.8	3.0	2.9	3.0	2.2	3.2	2.3	5.6	
6	28-DEC-12	1-1-1-4	289	10.4	9.4	354.2	56.2	5.8	6.7	5.8	6.7	2.0	5.9	2.2	6.0	
7	28-DEC-12	1-1-1-2	93	18.7	21.4	379.0	68.9	2.9	5.2	3.0	5.2	3.0	3.1	3.0	3.5	
8	19-DEC-12	1-1-1-5	50	7.8	9.5	522.4	55.1	5.5	6.8	5.5	6.8	2.2	5.6	2.3	6.6	
9	24-OCT-12	1-1-1-2	53	32.3	19.7	767.0	285.3	6.5	5.5	6.5	5.5	2.8	3.6	2.9	3.6	
10	15-OCT-12	1-1-1-7	29	20.8	18.6	668.6	308.0	3.2	4.6	3.2	4.6	3.9	2.1	4.1	2.2	

* AL – Along track and AX – Across track



Fig. 5. Cartosat-2 orthoimage overlaid onto mosaiced CartoDEM orthotiles

6. Conclusion

SIFT feature points or keypoints are a fast and efficient way of feature identification in an image. A variant of SIFT called the Affine SIFT or ASIFT which is also affine invariant is used in feature identification for

orthoimage generation. The image matching is done by extracting a suitable window around the ASIFT keypoints in the input image and a search window in the estimated image coordinates of the reference image and performing a normalized cross correlation of the polar images. Outliers are rejected

by performing a two step image matching process. The second image matching is done by suitably adjusting the intensity values of the input image w.r.t the reference image. This two step image matching process reduces the presence of outliers to less than 5% of the match points, thus improving the quality of the match points. These match points provide the necessary correspondences for generating the necessary transform between the input image and reference images which can then be used to generate the orthoimage from the Cartosat-2 input satellite image.

SIFT aids in the process of image matching in a big way since appropriate feature identification is an important step in the image registration process. SIFT keypoints are invariant to scale and rotation and are immune to intensity changes to a large extent which makes them good candidates for image matching. In addition to that they are also fast and efficient to compute, the reason why they are widely used.

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Fusion of ASTER Global DEM and Cartosat DEM for the Improvement of DEM Quality

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Keywords: *Fusion, ASTER DEM, CartoDEM, DEM Mosaic, Slope*

Abstract: Digital Elevation model (DEM) generation using stereoscopy is one of the vibrant photogrammetric processes. The DEM generated using different satellite datasets and different processes differ in elevation characteristics. Digital Elevation model (DEM) fusion is an approach to merge two or more DEMs for improving the overall accuracy of DEMs. Beyond simple merging, DEM fusion refers to the concept of optimally combining DEM data from different sources into a single seamless dataset. Fusion is very useful in DEM mosaicking where the DEMs in the overlapping area are to be mosaicked, Void areas and Occluded areas. When mosaicking different DEMs systematic vertical and horizontal errors can produce visible discontinuities along the borders of the overlapping areas. Standard mosaicking procedures try to reduce only the inconsistencies at the boundaries of the areas of overlap and provide results where discontinuities are no more clearly visible, but do not remove the systematic errors that cause the artifacts. The proposed technique exploits the information contained in the area of overlap between different DEMs in order to reduce horizontal and vertical systematic errors also outside these areas. The proposed fusion technique is based on the Slope, Aspect and terrain roughness. Slope is the amount of change in the elevation in the steepest direction up or down the DEM. Aspect calculates the downhill direction of the steepest slope at each grid node. It is the direction that is perpendicular to the contour lines on the surface, and exactly opposite to the gradient direction. The roughness of the DEMs is estimated locally by measuring the entropy. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input DEM. This paper provides a methodology to fuse two DEMs namely Advanced Spaceborne Thermal Emission and Reflection (ASTER) DEM and Cartosat-1 DEM (CartoDEM).

1.0 Introduction

Digital Elevation model (DEM) fusion is an approach to merge two or more DEMs for improving the overall accuracy of DEMs. Beyond simple merging, DEM fusion refers to the concept of optimally combining DEM data from different sources into a single seamless dataset. Fusion is very useful in DEM mosaicking where the DEMs in the overlapping area are to be mosaicked, Void areas and Occluded areas. When mosaicking different DEMs systematic vertical and horizontal errors can produce visible discontinuities along the borders of the overlapping areas. Standard mosaicking procedures try to reduce only the inconsistencies at the boundaries of the areas of overlap and provide results where discontinuities are no more clearly visible, but do not remove the systematic errors that

cause the artifacts. The proposed technique exploits the information contained in the area of overlap between different DEMs in order to reduce horizontal and vertical systematic errors also outside these areas. There are several procedure available in the literature on the DEM fusion. In Roth A. et al (2002) a technique to combine multisource DEMs is outlined, which is based on the concept of height error maps. Podobnikar T. (2006) use a method based on the weighted sum of the data source for the integration of vector contour lines from maps, hydrographic elements and other characteristic lines, automatically derived characteristic lines and geodetic points. In James D.J. (2003) a tool in the ESRI software ArcInfo, with extension ArcGRID, is used with a seven step methodology to fuse InSAR and Lidar DEMs. H. Papasika et al (2008) combined height values from different DEMs

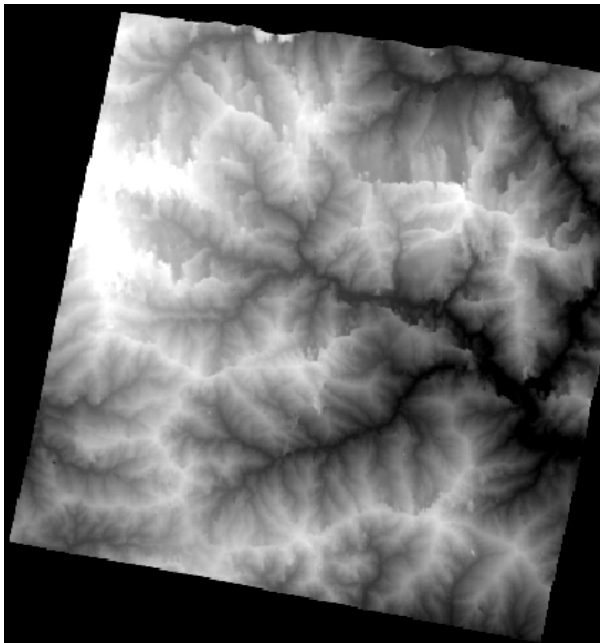
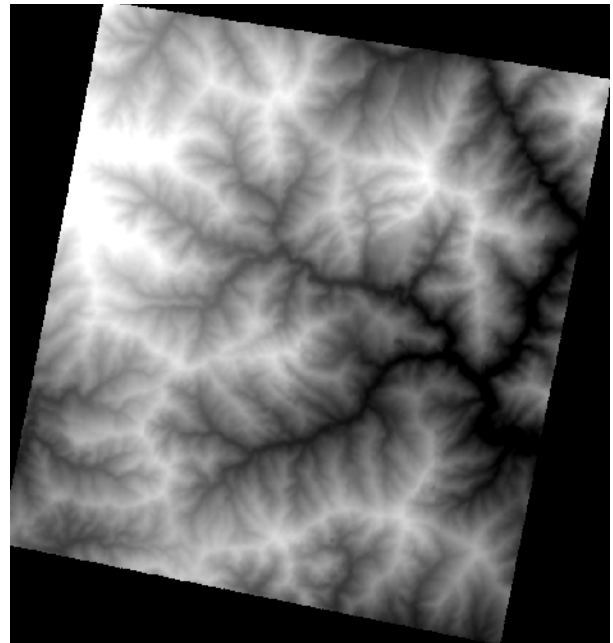


Fig.1 (a) Cartosat DEM



(b) ASTER DEM

using a weighted average rule. Our Proposed methodology is an attempt to produce a new DEM automatically by combining two DEMs based on their accuracies. The important point is the accuracy assessment of the individual DEMs has been performed without any priori knowledge of their accuracies. The fused DEM thus produced will be more accurate in terms of Geometry of land features, depicting correct height information, eliminating blunders and errors.

This paper provides a methodology to fuse two DEMs namely Advanced Spaceborne Thermal Emission and Reflection (ASTER) DEM and Cartosat-1 DEM (CartoDEM). An important objective of preliminary Digital Evaluation Model (DEM) validation efforts is to characterise the Cartosat-1 DEM (CartoDEM) in terms of specific features, such as artifacts and residual anomalies, that may affect the overall accuracy of the dataset, impede its use for certain applications, or just render it cosmetically unappealing. The Cartosat-1 was the first Indian satellite exclusively launched for cartographic applications in the year 2005. This satellite has a pair of Panchromatic cameras with along-track stereoscopic capability using its near-nadir viewing (-5 degree) and forward viewing (26 degree) cameras to acquire stereo images with a base-to-height ratio of about 0.63. The spatial resolution is 2.5 m in the horizontal

plane. Each camera has a pixel array of size 12000 giving a swath of about 30km [Srivastava et.al. 2006].

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) was developed jointly by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA) [Michael Abrams et.al.].

2.0 Test Data

The test site is an area in Himachal Pradesh in India. This area is characterized by steep mountains with or without forest, smooth hilly regions including some flat areas as shown in fig.1. The height range in this area is more than 3000 m. The land cover of the area consists of dense forest, open areas, few buildings, rivers and a lake. Cartosat-1 orthokit stereo images (fore & aft) acquired on 22nd May 2010 and the same area ASTER DEM (ASTGTM_N30E077_dem.tif) were obtained from the ASTER GDEM download website. The DEM has been generated from the Cartosat-1 stereo datasets by automatic image correlation (matching) technique. The orthoimage was also produced using the same model and DEM. Table 1 provides the characteristics of the two DEMs.

Table 1 Characteristics of DEMs

DEMs	Grid Size	Mean	Std. Deviation	Min. Height	Max. Height
Cartosat DEM	10 m	1841.14	486.69	627	3505
ASTER DEM	30 m	1832.13	496.63	637	3455

3.0 Methodology

For the fusion of DEM the procedure shown in figure-2 is utilized. Using this methodology we have fused two DEMs, Cartosat DEM (Grid Size: 10 m) and Aster DEM (Grid Size: 30 m) and produced a new DEM with grid spacing 10 m. The ASTER DEM was co-registered to the CartoDEM planar coordinates and the height values of the ASTER DEM are converted to the near absolute value of the CartoDEM by shifting the histogram to the average elevation. The Quality analysis of the DEMs have been based on the Slope, Aspect and terrain

roughness. Slope is the amount of change in the elevation in the steepest direction up or down the DEM [H. Papasaika et.al.2008]. The Slope function $S(x,y)$ is defined as the magnitude of the first derivative of the DEM function T :

$$S(x, y) = \frac{360^\circ}{2\pi} \arctan \left[\sqrt{\left(\frac{\partial T}{\partial x} \right)^2 + \left(\frac{\partial T}{\partial y} \right)^2} \right] \quad (1)$$

Aspect calculates the downhill direction of the steepest slope at each grid node. It is the direction that is perpendicular to the contour lines on the surface, and exactly opposite to the gradient direction. The Aspect $A(x,y)$ is calculated from the estimates of the partial derivatives as:

$$A(x, y) = 270^\circ - \frac{360^\circ}{2\pi} \arctan2 \left(\frac{\partial T}{\partial x}, \frac{\partial T}{\partial y} \right) \quad (2)$$

The roughness of the DEMs is estimated locally by measuring the entropy. Entropy is

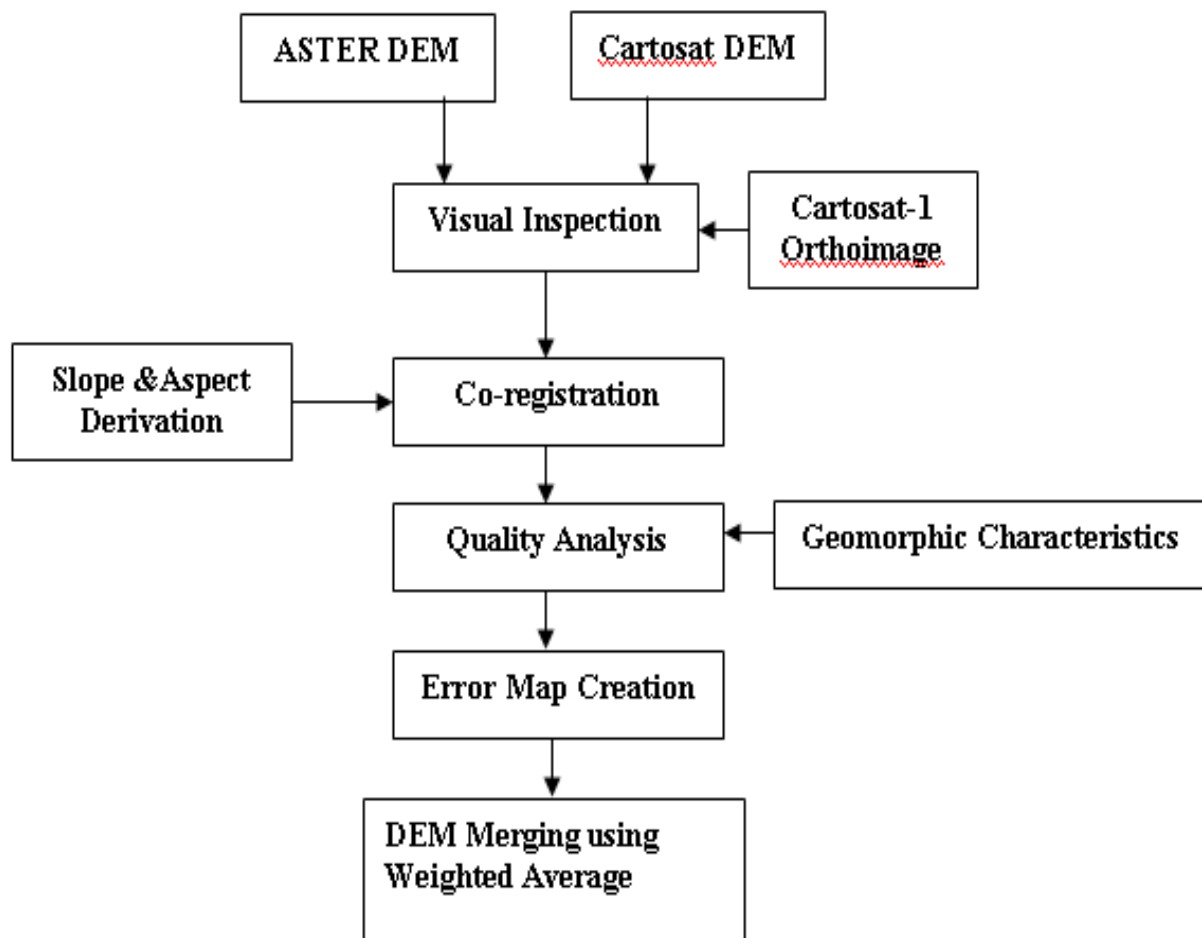


Fig. 2 DEM Fusion Methodology

a statistical measure of randomness that can be used to characterize the texture of the input DEM, T . Entropy $E(x,y)$ is defined as

$$E(x,y) = -\sum(p \cdot \log(p)) \quad (3)$$

The voids in one DEM were then filled through interpolation using the slope and aspect from the other DEM and using the elevation of surrounding pixels. Finally, the higher frequency components and lower frequency component heights of DEMs are filtered out, as they are more erroneous. The filtered DEMs are then combined to generate the fused DEM. This approach increases the reliability and applicability of the DEMs.

The weighted average formula used for the DEMs fusion, is taken as:

$$H_3 = \frac{w_1 H_1 + w_2 H_2}{w_1 + w_2}$$

Where H_1 and H_2 are the heights of Cartosat DEM and ASTER DEM respectively while H_3 is the height of the output fused DEM. w_1 and w_2 are the weights based on error maps of Cartosat DEM and Aster DEM.

4.0 Results

Figure 3 shows the height (3D) error map generated using the differencing of Cartosat DEM and ASTER DEM by accounting Slope,

Aspect and Roughness. The height error more than 10 m was plotted over the Slope map of both the DEMs to find the major contributor (fig. 4). It has been observed that most of the Cartosat DEM contributions in the error budget are the south north slopes while ASTER DEM contributed mostly in north south slopes and nearer to water bodies. The voids in one DEM were then filled through interpolation using the slope and aspect from the other DEM and using the elevation of surrounding pixels by weighted averaging technique. Finally a better DEM was generated with corrected slope as shown in fig. 5 and fig. 6.

5.0 Conclusion

DEM accuracy assessment is carried out without having any priori knowledge of the individual DEMs. Our approach to improve the DEM quality is purely based on geomorphological characteristics viz. Slope, Aspect and roughness of the DEMs.

In this approach we demonstrated to use of these characteristics to fuse the two DEMs and produce a third DEM which is better in quality as shown in figure-6. The red spots (height difference >10 m) is only 0.04% of the entire area in the final DEM. This has been observed that weighted average is a satisfactory function for fusing two DEMs. Land cover map of the same area can be used to further improve and understand the DEM fusion outputs in future.

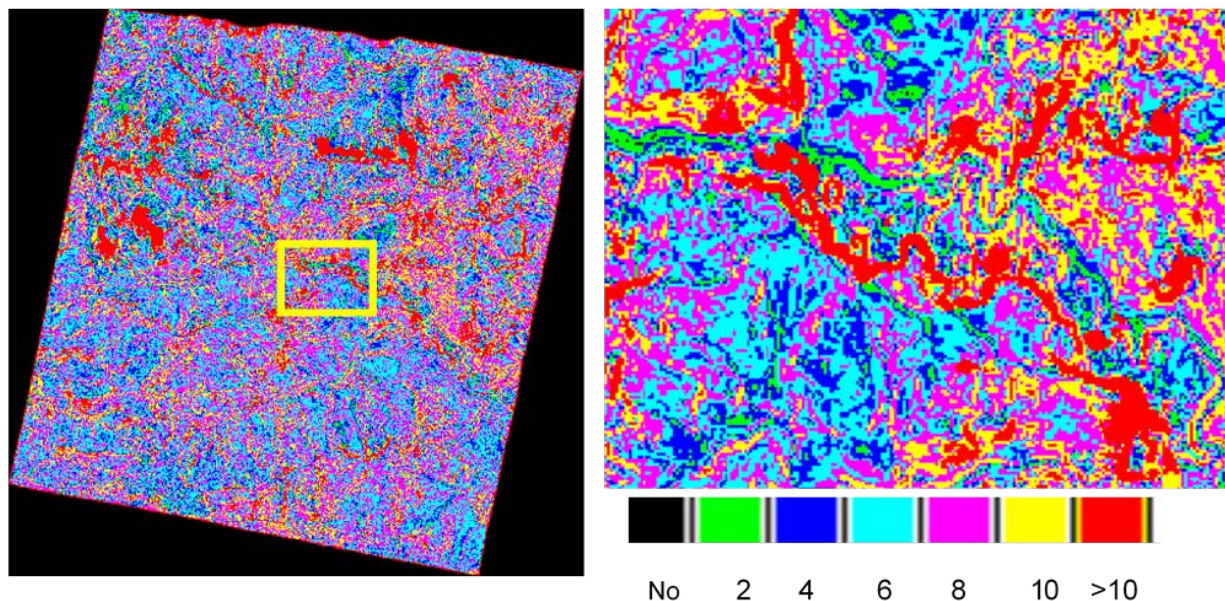


Fig. 3 Consolidated 3D Error Map of Cartosat DEM and ASTER DEM

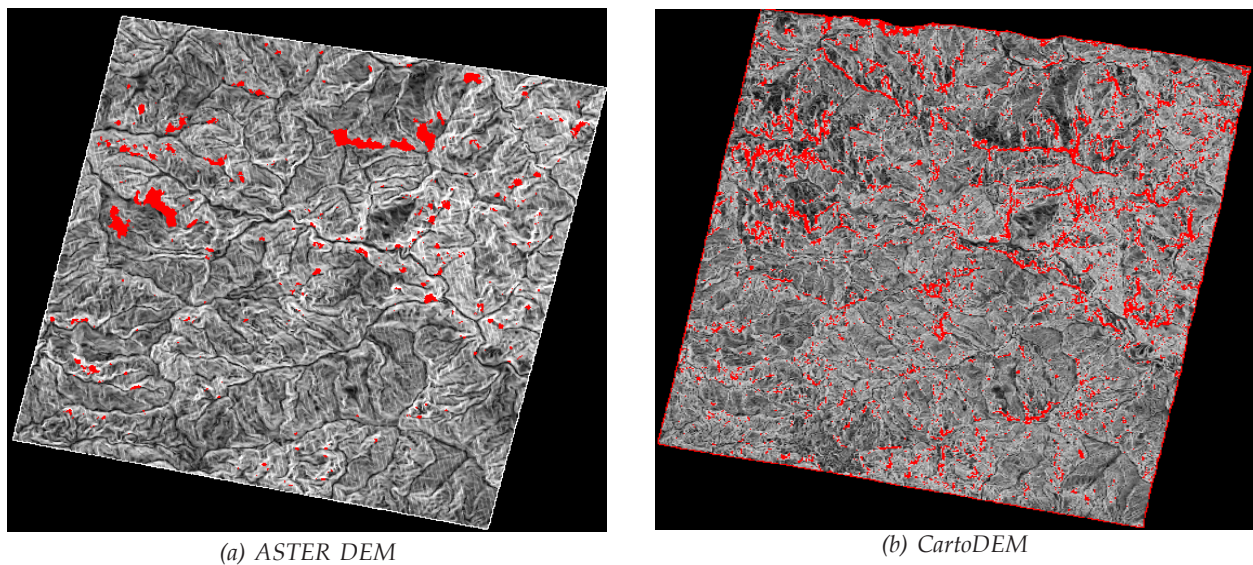


Fig. 4. Problematic areas (Height Error contributor) in Aster DEM & Cartosat DEM based on Slope.

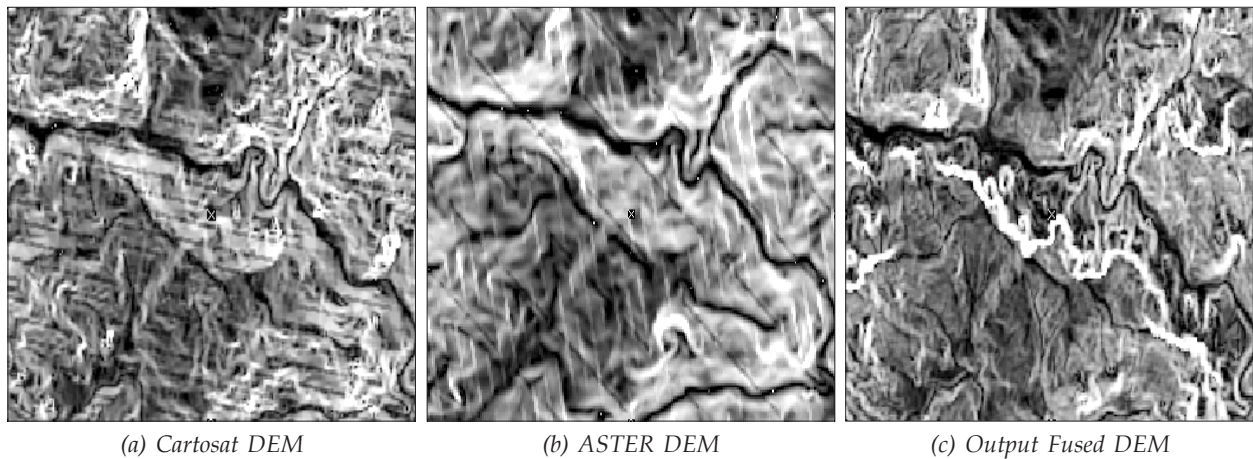


Fig. 5. Corrected Slope and Aspect.

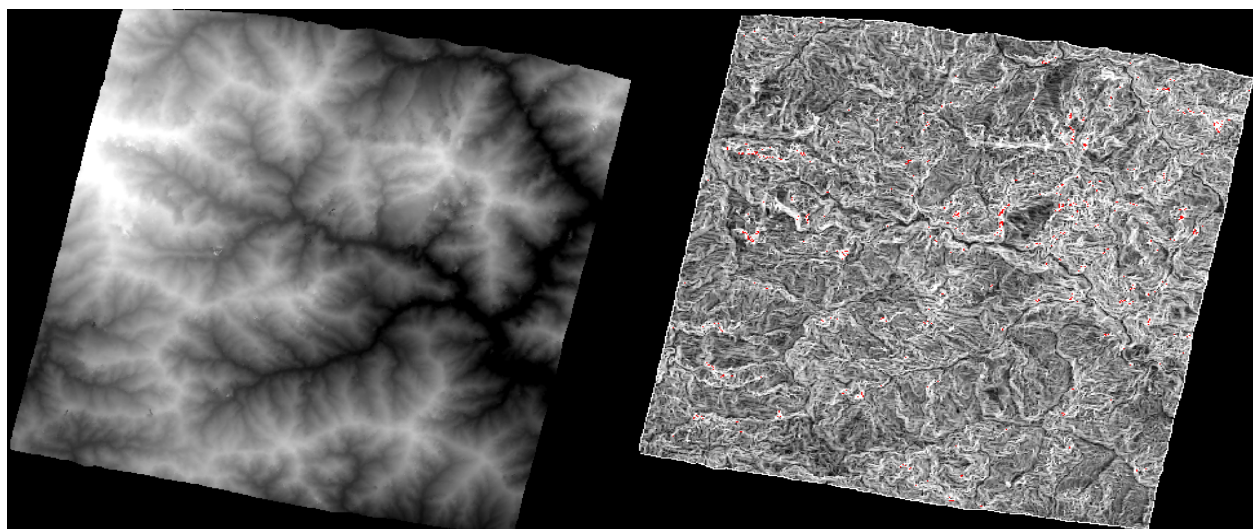


Fig. 6. Overview of Output Fused DEM and corrected Slope.

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Role of GPS in Monitoring Livestock Migration

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Abstract: Satellite-based technique of global positioning systems (GPS) is useful for tracking long-distance livestock movement across the grazing routes and to study the specific needs of livestock herders. There are two kinds of GPS tracking systems: live and real-time tracking, and passive tracking. Real-time GPS tracking is used to keep an eye on livestock and it has the ability to monitor spatial movements and spatial activities. Such GPS devices provide information for multiple benefits i.e., movements of livestock throughout the landscape, grazing and watering patterns, and areas where the livestock deplete nutrients in the soil. Passive GPS tracking systems are able to record information on livestock mobility and identify key areas actively utilized by livestock. In the present study, Clark Animal Tracking System (Clark ATS Plus) was deployed to study the migration pattern of livestock (cattle, sheep and goat) of Western Rajasthan, which records data at hourly intervals and position (latitude and longitude), date, time, fix quality, and animal velocity on secure digital cards in the collar. Present paper discusses the use of satellite tracking in studying animal migration by elucidating migration routes, stopover sites, average speeds, and total migration time and distance for formulating appropriate range management strategies.

Introduction

In western Rajasthan pastoral system of livestock rearing has evolved over the last five centuries. The system has developed traditional migration routes and a partition of responsibilities, with some castes specializing in animal herding and others with crop production (Malhotra and Mann, 1982). Because forage resources develop and change with the seasonal monsoon and its effects across the regional landscape, the livestock production system includes migration (Kavoori, 2005). Animal migration mitigates impact from drought, lack of forage, and ephemeral water resources for pastoralists allowing them to lead productive lives.

The recent advances in animal tracking technology have resulted in large volumes of data becoming available for analysis. Telemetry systems based on the Global Positioning System (GPS) is a relatively recent development (Rodgers and Anson, 1994; Rodgers, et al.,

1996; Agouridis, et al., 2004) for monitoring movement (Brosh, et al. 2006), their activity (Ungar et al., 2005), and resource use by medium- to large-sized animals (Moura~o and Medri, 2002; Bailey, et al. 2006). The GPS technology has enabled researchers to record the sequential movement patterns of animals and compile datasets with many observations compared with older tracking techniques over a similar period of time (Jonsen, et al., 2005). GPS-enabled livestock tracking system (LTS) can be used to monitor the activity of livestock (i.e., walked distance, speed, grazing and resting time (Trotter, et al., 2010)), the habitat preferences (i.e. grazing sites and intensity, resting sites (Putfarken, et al., 2008)) and thus to support the herdsman. In several cases the LTS was additionally supplemented with sensors for heat and/or health monitoring (Nagl, et al., 2003).

GPS receivers in a lightweight collar or harness can be deployed for extended periods with little effect on behavior. Units



Fig. 1: Clark ATS Plus GPS Collar

derive coordinates from an internal receiver tracking an array of 24 earth-orbiting satellites. Coordinates are stored in onboard memory for later retrieval to the computer.

Historical Perspective

Satellite-based global positioning systems (GPS) have provided novel and unique data. These have been used to track animal movement. Livestock scientists have used GPS data to understand behavioral differences in free-grazing experiments. With a shift in focus, from the environment to the animal, brings the challenge of ensuring independence of the experimental unit. Social facilitation challenges independence of the individual in a group. The use of spatial modeling methods to process GPS data provides an opportunity to determine the degree of independence of data collected from an individual animal within behavioral-based studies. By using location and movement information derived from GPS data, researchers have been able to determine the environmental impact of grazing animals as well as assessing animal responses to management activities or environmental perturbations. Combining satellite-derived remote-sensing data with GPS-derived landscape preference indices provides a further opportunity to identify landscape avoidance and selection behaviors.

The first study to use GPS in locating animals began in March 1994 using collars designed and manufactured by Lotek Engineering Inc. (Newmarket Ontario, CA; Rodgers and Lawson, 1997). GPS has been used successfully to track domestic sheep (Roberts et al., 1995; Rutter et al., 1997; Hulbert et al. 1998) and cattle (Udal et al., 1998; Turner et al., 2000; Schlecht

et al. 2004; Ungar et al. 2005; Ganskopp and Bohnert, 2006) as well as numerous wildlife species (Austin and Pietz, 1997; Mech and Barber, 2002) with spatial accuracies never before possible (Tomkiewicz, 1997; Hulbert and French, 2001).

GPS Collar Sampling Protocol

The Clark ATS+ collar rigging consists of a collar belting assembly and an electronics enclosure. The enclosure is a two-piece, polycarbonate, water-tight box which houses and protects the electronics package of the collar. The belting assembly serves to attach the electronics enclosure around an animal's neck and it also houses and protects the GPS and satellite modem antennas and associated cables. GPS collars are supported by an 8-channel receiver (Lotek HGPS2200 LR; Lotek Engineering Inc., Newmarket, Ontario, Canada) is capable of simultaneously tracking #8 satellites. Records are written to onboard, non-volatile random access memory retaining a maximum of 5028 differentially correctable coordinates. Each record includes collar number, date, time, longitude and latitude, elevation, a dilution of precision value (an index of satellite geometry reflecting position accuracy), a 2- or 3-dimension fix status (2-dimension records are derived from a minimum of three satellites with no elevation estimate, whereas 3-dimension records use 4 satellites and generate an elevation measure), ambient air temperature, and satellite information used for differential correction (Fig. 1). Figure 2 displays components of GPS positioning and data storage in the collars which is suitable for deployment in livestock herds.

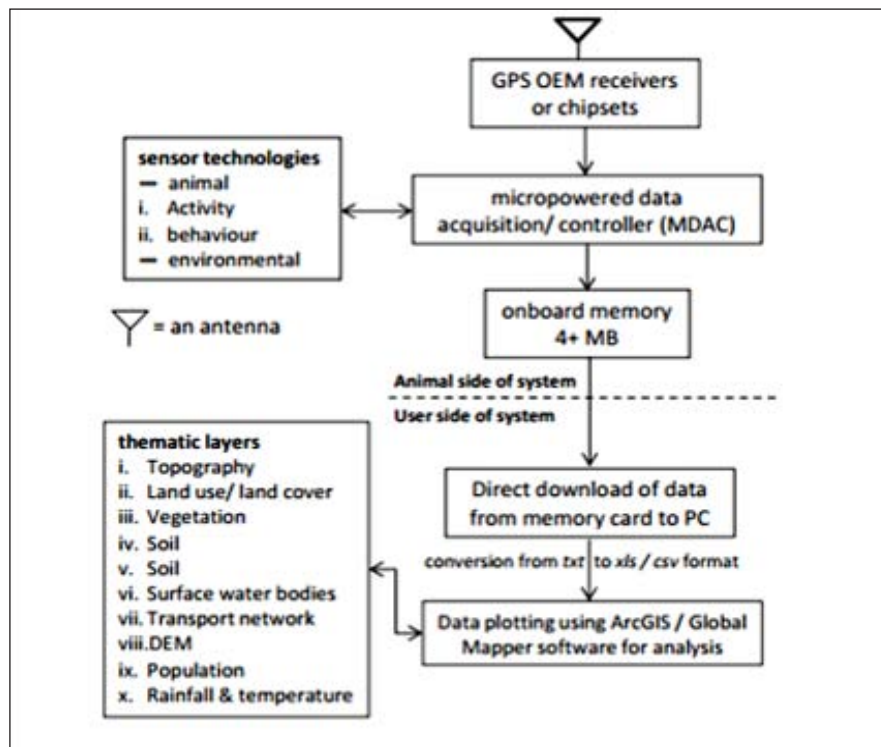


Fig. 2. Block diagram showing the components of a GPS positioning and data collection system suitable for deployment on animals. (Source: Tomkiewicz, et. al., 2010)

There are two kinds of GPS technology available for livestock monitoring: real-time and passive. Real-time GPS monitoring is used to keep an eye on livestock having the ability to monitor spatial movements and spatial activities, information that can provide multiple benefits. GPS live monitoring data transmitted from livestock helps herders understand a great deal about how livestock interact with the precious lands and also gives them the ability to discover a farm animal's precise location. Passive GPS tracking systems gathers information about livestock. The tracking collars are worn on the animal as a collar, and if or when the herder wants to collect and review that recorded tracking data, the collar is manually removed and the stored data is downloaded. It allows them to view the movements of the livestock, in retrospect. However, it is believed that there will be a dynamic shift and movement toward real-time solutions as the technology becomes more tailored and cost-effective. It is useful to track the movement and grazing behavior of cattle flock and sheep herds. It helps to understand the way herders manage their cattle in large herds. Distances and speeds travelled by the cows and sheep, including how long the cows

spend lying down, grazing, and, importantly, the number of hours during the day that they are unable to either feed or lie down.

Rajasthan Study

Four districts from western Rajasthan (Pali, Jodhpur, Barmer and Jalore) with significant numbers of migratory cattle or small ruminant flocks were selected for study. Cows and sheep were fitted with Clark Animal Tracking System (ATS) collars that recorded date, time, and position at 1 hour intervals during migration. People from Jodhpur, Barmer, Pali and Jalore districts generally migrate towards Uttar Pradesh, Madhya Pradesh and Haryana. The exact routes of cattle migration, time taken to reach watering points as well as the total distance travelled has been mapped and calculated through GPS Collars.

Analysis of a 20 km land use/land cover buffer on the migration route reveals that 0.06 per cent of the urban land, 29.06 per cent of cropland and 48.57 per cent of fallow lands was utilized by migrating animals for grazing and resting purposes. It has been observed through the GPS data analysis that animal drink water once a day and if available, it may be twice

a day. Sometimes, they have to cover 18-22 kms, from the migration route, to locate a water body. The animals on an average travelled 7.09 km before migration, 8.8 Km during migration and 8.71 Km /day across the entire observation period. Further, cattle have travelled from Motisara village (Siwana tehsil, Barmer district) to Jajjar (Haryana State) covering around 1550 kms from January, 2013 to June, 2013.

Limitations of GPS Collars

It was not until the end of the 1990's that animal born satellite receivers catapulted range cattle ecology into the 21st century world of microchip technology with all of its opportunities and challenges. With the global navigation satellite system (GNSS), insight about how cattle use a landscape is being revealed from previously unknown temporal and spatial behaviors. The most common system to date for studying ungulate movement is the global positioning system (GPS). With its use has come a clarity and completeness in documenting spatial and temporal data in new and exciting ways that offer almost unlimited possibilities to better understand and manage economic and societal returns from animal dominated landscapes. However, its use on free-ranging cattle is not without challenges, some of which are yet to be optimally solved. To maximize the usefulness of GNSS data, consideration must be given to: (1) developing a standardized protocol for reporting and analyzing research that facilitates interpretation of results across different ecosystems; (2) develop optimum ranges over which to collect satellite fixes depending upon the particular behaviors of interest; and (3) concurrently develop electronic hardware and equipment platforms that are easily deployed on animals and that are light, robust, and can be worn by cattle for extended periods of time without human intervention (e.g., changing batteries). Once data are collected, appropriate geographic information system (GIS) based models should be used to produce a series of products that can be used to implement flexible management strategies, some of which may support methodologies that are yet to be commercialized and adopted into future plant-animal interface management routines.

Tracking animals with GPS provides useful information, but the cost of the technology often

limits experimental replication. Limitations on the number of devices available to monitor the behavior of animals, in combination with technical constraints, can weaken the statistical power of experiments and create significant experimental design challenges.

As spatial livestock monitoring tools become more widely used, there will be a greater need to ensure the data and associated processing methods are able to answer a broader range of questions. Experimental design and analytical techniques need to be given more attention if GPS technology is to provide answers to questions associated with free-grazing animals.

Conclusion

GPS-based, animal tracking technologies has been invaluable in studying animal migration by elucidating migration routes, stopover sites, average speeds, and total migration time and distance. It has made it possible to make season-long evaluations of livestock distribution and activity patterns at very fine-scale temporal (300 sec) and spatial (<1 m) resolution. Particularly in conjunction with biotelemetry, it can provide valuable information on the study of migration physiology. It is also possible to conduct shorter-term intensive evaluations (e.g., 1-sec sampling interval) of behavioral and energetic differences. Since movement of animals is an important component of many ecological processes, combined with remote sensing and GIS data and analysis tools, GPS tracking technologies provide a powerful means of monitoring or assessing animal behavior within both research and management contexts. It further provides data on barriers to migration as well as allows researchers to devise strategies to minimize anthropogenic impacts on migratory livestock.

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Capacity Building and Awareness Generation on 'Open Source GIS' for Rural Development Sector of India - A Case Study of NIRD Jaipur Center

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Introduction

Training and capacity building is the prime need for propagation of software/utility to the common users. Open Source projects are voluntary driven and most of the persons involved in these projects have their responsibilities somewhere else to earn their living, so for these projects, training and capacity building is relied upon forums, mailing lists, IRCs etc. On these platforms, answers depend on time availability, expertise and interest of other users, so need is there to have organisations with clear-cut mandate to support Open Source GIS projects/users, with need based, class room trainings for providing direct contact with participants and create confidence in them towards working of software/utility. National Institute of Rural Development (NIRD) is an apex autonomous organization under the Ministry of Rural Development, Government of India. In its regular mandate, it has training and capacity building programmes for Rural Development and Panchayati Raj functionaries, elected public representatives, functionaries of line departments, reputed NGO representatives, research scholars, faculties etc. As sub centre of NIRD, at NIRD Jaipur centre training and capacity building programmes for Rural Development sector in the area of Open Source GIS are conducted along with its other regular programmes. Since November, 2010 total 26 programmes of 5-6 days duration, with 631 participants, 139 training days and 3391 training man days, have been conducted at NIRD Jaipur centre, mainly for applications of Open Source GIS in flagship schemes of Ministry of Rural Development, Government of India like MGNREGS and Watershed etc.

Need of Open Source GIS for Rural Development Sector:

Open Source GIS is not a new word to the persons involved/known to GIS. With the support of reputed and dedicated organisations and universities, it is growing very fast and widely popular in GIS users especially in Government, NGOs and Researchers/Scholars. Commercial applications/software cannot satisfy the needs of large rural development sector of India from 35 States/Union Territories (UTs), 640 Districts, 5924 Sub Districts [1] and 2,56,000 Gram Panchayats (Lowest administrative unit in India with population more than 750) [2]. Commercial software/utilities may be suitable for National/State headquarters of Departments but not at lower administrative levels (Districts/Blocks/GPs) levels, due to large and scattered requirements and constraints related to budget, operation, maintenance and upgrade etc., whereas Corporate or business sectors can afford to have commercial software/utility for GIS & Remote sensing operations due to profits in projects.

Today GIS users are well equipped with good quality Open Source GIS software and codes for further development. Moreover, Open Source GIS is now being supported by dedicated non-profit international organisations like OSGeo Foundation [3], Free Software Foundation (FSF) [4], Open Geospatial Consortium (OGC) [5], and Open Source Initiative (OSI) [6] etc. so users can remain assured about perpetual support and development of standard Open Source GIS projects. Easy availability of pirated products and more possibilities of jobs with

knowledge of commercial GIS software, and myths about Open Source GIS are some factors which limit adoption of Open Source GIS in general.

Training/Capacity building in Open Source GIS:

Training and Capacity building with commercial GIS products is generally bundled with the product for a limited period and upgrade of product or release of new version is always associated with a cost, while in Open Source GIS products the support is limited to forums, mailing lists, IRCs etc., but upgrade/new version does not bear cost.

Further Open Source GIS projects are voluntary driven and in this situation trainings/capacity building part of Open Source GIS becomes critical. It is required to have sufficient training and service support individuals/organisations for this sector to sustain users, helping them in their day to day work and create faith in prospective users.

NIRD & NIRD Jaipur Centre:

National Institute of Rural Development (NIRD), Hyderabad is an apex autonomous organization under the Ministry of Rural Development, Government of India. It has mandate of providing Training, Research and Consultancy to Rural Development sector of India and partner countries. Through its training and research activities, NIRD endeavours to upgrade the knowledge, skills and to bring in required attitudes among its clientele group. The clientele of NIRD include rural development functionaries at district level and above, elected representatives of Panchayati Raj Institutions, NGOs, Bankers, Community-based Organizations, Research Scholars and Academicians from Universities and Institutions. [7]

To cater the regional needs, a centre of NIRD was established at Jaipur with the name of NIRD Jaipur Centre. The centre is currently engaged in various activities, facilitating capacity building of various stake holders in the field of Rural Development. Since its inauguration on 22nd August 2010 by the then Union Minister of Rural Development, Government of India and the then Chief Minister, Government of Rajasthan State, It has embarked on a set of

key initiatives focusing on capacity building, knowledge building, participatory research and citizen centric rural development. With a combination of training, research and consultancy, the Centre is actively engaged in capacity development of the functionaries of various sectors of rural development in the fields of Rural Development namely Watershed Management, MGNREGS, Open Source GIS, Livelihood, Microfinance, Rural Entrepreneurship, Panchayati Raj, Gender Empowerment etc. The centre is also in the process of taking up certain research studies in the relevant fields [8].

Open Source GIS Trainings at NIRD Jaipur Centre:

Open Source GIS Applications in Rural Development schemes of Government of India is major area which is being dealt by the Centre. Trainings are provided at free of cost to the regular clients of NIRD, but some trainings are sponsored by respective organisation, if related to their specific needs.

Since November 2010 total 26 practical lab based training programmes with 631 participants, 139 training days and 3391 training man days, have been conducted at NIRD Jaipur Centre on 'Applications of Open Source GIS (QGIS) in various Rural Development programmes/schemes of Government of India', for senior and middle level functionaries of client departments/organisations. Out of these trainings, three trainings were conducted in collaboration with university and research institutes namely Maharana Pratap University for Agriculture and Technology (MPUAT), Udaipur, Arid Forest Research Institute (AFRI), Jodhpur and Department of Forest, Government of Rajasthan and one training was conducted under sponsorship of Department of Watershed Development & Soil Conservation, Government of Rajasthan, for their specific needs.

About Open Source GIS trainings, an article has been published on main Website of QGIS project, available in case studies section [9].

It has been observed during trainings that Open Source GIS can satisfy all the GIS related needs of Rural Development Sector of India at District and below. It is being messaged and advised in all trainings that no commercial GIS software should be purchased at District and

Year wise trainings conducted, with further details, are shown in the table below:

Details of Trainings Conducted through NIRD Jaipur Centre Based on Open Source										
Financial Year	Participants Category								Number of Training Man Days	
	Number of Training Conducted	govt. Officials	ZP & PRIs	Vol. Orgns/NGOs	Natl./State Instts for Res. & Trg	Univ./Colleges	Total number of Participants	Training Days	Female	
2010-11	4	101		3			104	23	7	603
2011-12	8	168		11	7	22	208	46	25	1190
2012-13	9	182		19		7	208	46	17	1061
2013-14 (Upto Nov, 2013)	5	97	1	4	2	7	111	24	5	537
Total	26	548	1	37	9	36	631	139	54	3391

below, if real requirements are not felt after exploring Open Source GIS. This saving may be used for purchase of hardware like GPSs, computers etc.

Procedural Details & Major Areas Covered:

Trainings are conducted with practical/hands-on, and seeing the practical nature of trainings almost all the trainings are conducted as single/main resource person by author. As exercises are based upon previous exercises, it does not allow interference or deviation from sequence of sessions, however, some eminent resource persons working with Open Source GIS from agencies outside, like OSGeo, Regional Remote Sensing Service Centre, Jodhpur, and State Remote Sensing Application Centre, Jodhpur, are invited for special lectures. The trainings are conducted with 5-6 days duration (including one day for handheld GPS practice in field).



The thematic areas for the trainings mostly remain related to flagship schemes of Rural Development sector of Government of India like Watershed and Mahatma Gandhi Rural Employment Guarantee Scheme (MGNREGS) etc.

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) is an Indian job guarantee scheme, enacted by legislation on 25 August 2005. The scheme provides a legal guarantee for at least 100 days of employment in every financial year to adult members of any household willing to do public work-related to unskilled manual work [10]. It is supposed to be the biggest scheme of its kind in world (Reference is not available)

OSGeo incubated QGIS software is used for practical hands-on during trainings as development of OSGeo projects are faster, choices of suitability are wide and associated with large number of users and developers. Moreover QGIS is user friendly software with capability of linkage to GRASS, SAGA, SEXTANTE and R software.

Freely available Raster and Vector data of nearby area are used in exercises. General contents of trainings remained as possibilities and status of use of GIS in respective departments, introduction to geo-informatics, GIS data types, projection systems, working with raster/vector data, geo-referencing, clip/merge operations, creating/editing vector data, working with tables/attributes, vector layer properties (style, labels), print composing etc.

One day is kept to make participants aware and capable of using handheld GPSs in field and download and synchronise GPS data to QGIS/Google Earth etc. utilities, which ensures enhanced utilisation of GPS hardware available with client organisations/departments.

Broadly the training contents are finalised based on level of participation, previous feedbacks/observations, and duration of trainings.

Participants are encouraged to come with their own or departmental data, if available, to increase the interest in exercises. Trainings are provided at NIRD Jaipur Center in computer lab equipped with 15 computers of i5, 8GB RAM and Windows7 32 bit OS. Per training number of trainees remains 20 to 30.

Certificates are provided to the participants after completion of training. Presently tutorials and handouts are being provided to the participants in hard copies, latest version of software and practice data are being provided in DVDs, but plan is there to create screen-recorded lectures/demo of various topics in Hindi and English language. Graphic User Interface (GUI) of QGIS software is also being translated in Hindi by the centre. Author is official coordinator for Hindi translation of QGIS interface. Latest translation status may be found, and used in latest weekly releases of QGIS software [11].

Utility of Trainings:

In official guidelines of Rural Development schemes (MGNREGS, Watershed etc.) mandatory uses of GIS and Remote Sensing are mentioned at several places [12,13] and in accordance to those instructions most of the States have got various thematic layers prepared through capable agencies like RRSSCs, SRSACs etc. These GIS databases are lying at District, Block and Project levels with limited or no use due to lack of relevant software and expertise at lower levels. Moreover the work of agencies is being checked and approved mostly by the GIS illiterate officials posted at District and Project levels. A proper strategy is required to make the field executors capable of understanding and editing/modifying/analysing these data as per their local needs, which can be concretise only thorough use of Open Source GIS software and proper capacity building of functionaries.

These programmes at NIRD Jaipur centre provide participants an introduction to GIS with practical hands-on. Participants' myths related to Free and Open Source GIS Software is also cleared. Consequently the message goes to their offices and colleagues, towards strength and power of Open Source GIS and they can compare Open Source GIS with Commercial GIS vis-à-vis their requirements.

The immediate outcome of trainings is to remove fear of officials from Geo-Informatics and breaking the myth that GIS work can be handled by costly commercial software and highly trained personnel only. Eventually this leads to considerable saving of public money.

Post Training Support:

For helping the users each OSGeo project is having separate user and developer mailing list and IRC. 'Geographic Information Systems Stack Exchange' web site is also a dedicated and free site to solve queries related to Open Source GIS as well as Commercial GIS software [14].

Apart from introducing participants with regular helps, author has created a group 'My GIS (Open Source) Training Participants' on LinkedIn Website to provide post-training support platform to training participants [15]. The group is presently having 270 active members with growing numbers. Further, if participants stuck somewhere in the task at their place and need immediate help during office hours, online support is provided by remote access to their systems using remote support software like Team-Viewer.

Road Ahead & Expectations:

- To conduct seminars/workshops on use of Open Source GIS in various thematic areas of rural development sector
- To make NIRD Jaipur Centre as a hub of professional short and long term courses on Open Source products of Desktop/Web utilities, Open Database (PostgreSQL/PostGIS) Management, GIS Customisation using open Languages like Python etc., to provide a committed and competent cadre of Open Source GIS experts for serving Government and Corporate sector

- To translate manuals, GUI, website and other related documents in Hindi and other major languages of country. The work of QGIS GUI Hindi translation has been started and mentioned in previous sections
- To create pool of Open Source Professionals from India for helping organisations in selecting professionals according to services required by them
- To generate awareness in schools upto XII standards, towards Geo-Spatial. It is already planned to hold 'Geo-Spatial Awareness Day' in some schools of Jaipur city initially, which will be extended to schools of rural areas also
- To provide Virtual training support to the participants
- To promote FOSS4G/OSGeo activities at NIRD Jaipur Centre

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Community Based Participatory Resource Mapping

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Introduction

It has been observed that the development, conservation and management of natural resources can best be done if local populace is involved. A proper blending of modern technologies and community knowledge can lead to optimal use of natural resources. Participatory mapping involves spatial drawing of an area, drawn on ground, paper or other material by local people to show and depict their locality and other related areas. Proper blending of some of the simple techniques may lead to better management of the resources. Venn diagrams are visual methods to indicate mutual relationships and role of individuals/institutions/groups in decision-making. The method of joint walk relates to learning about selected areas from local communities through undertaking joint walks to those areas. Vector scoring is a visual method and involved scoring of criteria items for assessing their relative importance so as to prioritize problems, benefits, dangers or damages or opportunities. This method can be used by individuals as well as groups. It involves listing of criteria and scoring of such criteria/item using indigenous materials. The methods help in decision making by prioritizing concerned criteria.

Community Driven Resource Mapping

In India during the mid-1980s, investigators found that many large-scale, government-initiated development programs, such as, schooling, health, credit, irrigation systems, are not performing as envisaged. Many a times they are rapidly degrading common pool of resources in addition to creating negative environmental and poverty impacts. In their opinion the top-down perspectives were both disempowering and ineffective. Community-

driven development is the fastest growing mechanisms for channeling development assistance. It refers to community-based development projects in which community have direct control over key project decisions, including management of investment funds. It acts as catalyst for enhancing sustainability, improving efficiency and effectiveness, allowing poverty reduction efforts, making development more inclusive, empowering poor people, building social capital, strengthening governance.

In Indian culture there is a long history of community driven development. In recent years clearly significant movement is the Gandhian notions of village self-reliance, small-scale development and cooperative movement. The participatory development approach may solve some of these problems to small-scale development in ways that would allow the poor to be informed participants in development, with external agents acting mainly as facilitators and sources of funds. The inclusion of participatory elements in large-scale development assistance came quickly at the World Bank, in social investment funds and other forms of assistance. Initially focusing on targeting, these projects have moved toward a more holistic attempt at inducing participation through institutions that organize the poor and build their capabilities to act collectively in their own interest. Community-based development relies on communities to use their social capital to organize themselves and participate in development processes. Thus, concepts such as participation, community, and social capital are critical to how community participation is conceptualized and implemented.

Participatory mapping involves map making of an area by the community to show

their locality and other natural resources. It is a simple drawing which may be drawn on ground, paper or any other material. Participatory mapping may include a variety of themes for example, such as households, livestock, farm size, water bodies, field, forest, trees, road, amenities, and literacy. Such mapping can be theme-specific such as a resource map indicating natural resources of the area or a social map showing households and other buildings in the area. In participatory mapping community is actively involved. Some one from the community starts preparing the map. Other members contribute by extending active facilitation to those who draw it. Other watches it getting done and reminds them the details if leave out. Community members also cross-check map such prepared. Hence, although at times, the key informants are those who actually do the mapping, others around them help in such drawing by providing clues and suggestions and even drawing a part of such a map from time to time. The persons who draw the map and other community members present during mapping sessions discuss and explain the map so drawn.

Possible Application Areas

The areas for application of community based mapping are varied and large. It may be used for depicting community habitat, natural resources, forest land, households, trees, water bodies, soil, farms, amenities, hand pumps, schools in the locality, land-use of the locality, spatial areas of people-forest conflict, cooperation, grazing areas, areas for social forestry, common property and wastelands, Areas for collection of fuel wood, and Water. Community based maps are mental maps of individual, group, community and are different from professionals' maps. They reflect relative perceptions of individual, group of the items mapped and hence, are different from professional maps which carry explicit reference to size and scale. Mapping on ground involves active participation of greater number of people than mapping on paper, the latter, however, is convenient to retain. Process of participatory mapping, once started, can continue on its own.

It will be of much use if participatory mapping to also carried by different groups. Participatory mapping may be influenced by

other community group. Maps made by men and women, child, old and young, rich and poor can vary widely depending on their relative perceptions leading to differential analysis of the same theme. Data generated through participatory mapping may vary from individual to individual, group to group and community to community, depending on their knowledge base and experience. Illiterate people can draw maps and explain different items with selected symbols. Sometimes it is difficult to map big localities as a single entity due to insufficient knowledge of key informants.

Sometimes on account of relatively big size of a locality such mapping is not efficiently manageable at a single location or by a single group and such activity may also become time consuming. This can be suitably done by mapping (locality) in parts, mapping of localities by different individuals, maps carried from one part of locality to another for further additions and alterations. Participatory mapping can be presented to community in different sessions and cross-checked on that basis. It can also be checked from household to household for validation of various kinds of data. If many enthusiastic people are available to map, they may be involved in different ways in the mapping process. One way for them is to help these persons who do the mapping. The other way for them is to get involved in their own mapping. Hence small groups can be initiated for mapping on ground or paper rather than many trying to get involved in mapping done by one or two persons. Different maps so generated may be used for mutual cross checking. Those not wishing to map may like to remain as on-lookers, intervening from time to time.

Community Groups

From social considerations community is generally heterogeneous. There may be different groups, sub-groups within the same community. It is important to recognize their identity to the extent possible. Amongst local communities, diversity of perceptions can significantly differ from group to group. There can be different ways of doing it, some of the ways are as detailed below. Key informants can be asked about socio-economic relationships and existing groups in a community. One

can elicit views of key informants regarding different groups/sub-groups in an area and then find out about local group dynamics and cross-check the results from other sources. Similarly other target groups e.g, poorest of the poor or marginalized women group in a community can also be identified by key informants.

Community social mapping is another method which can indicate existence of different socio-economic groups in an area. Based on which further probing can be undertaken to learn about criteria for such grouping. Such mapping can be undertaken to learn about criteria for grouping. Such mapping can be of significant use in identifying different social groups. The lowest strata of poverty or the bottom group included widowed households and single widows who were maintaining livelihoods with practically no assets, no regular source of income and not enough to eat throughout the year. Such group also included agricultural labourers neither having any land, nor any regular source of income or food. The number of dependents may be taken as an indicator for socio-economic grouping.

Wealth ranking is another method which can be used for group-identification. Card-sorting is a method for wealth ranking where a list of households is prepared with each household having a separate number along with the name of head of that household. Each household's name and number is transferred on a separate piece of paper and these papers are ranked by key informants according to their criteria. In the process, a set of criteria for wealth ranking emerges where each household has an allotted rank. Wealth ranking helps in understanding socio-economic disparities amongst households and reveals local criteria for wealth classification. Venn diagramming session on groups and their relationships help in identifying groups. Venn diagram can be used as a tool to show the existence and importance of different groups in a community. It helps in learning about social relationships and groups at local level so as to create space for electing different viewpoints in a local community for further interaction.

Social matrix is yet another method for identifying groups and their characteristics. In a grid-like set-up, different criteria of different groups can be listed by key informants, which

can then be scored. This would provide a rough idea of the existence of different groups. This can then be cross-checked from other members of that community. Diversity of perspectives and existence of groups is a reality in local participation and often participatory processes get jolted by heterogeneous forces within communities. Hence it is important to appreciate local level diversities as reflected through local groups and their dynamics.

The Experience

Community Based mapping is concerned with the community development. It helps in rapport-building within the community. It also helps developers to learn from a community and furthers mutual interaction. It involves local communities, groups and empowers them to map, illustrate and explain their own region. It enhances group participation particularly when maps are drawn in open spaces and common meeting places. It helps in foretelling spatial view of localities and related natural resources. It helps in generating a wide variety of data in a relatively short period of time. It provides an overview and background material, data significant for probing into any relevant theme.

Venn or "CHAPPATI" diagram

Venn diagrams, also known as "chappati" diagrams are visual methods to indicate mutual relationships and role of individuals, institutions, groups in decision-making. Circles of different size representing different individuals, institutions, groups show their importance in decision-making. Such circles can be drawn on ground, paper, or alternatively, circular shaped papers of different size can be used for symbolizing such relationships. The distance of the circles indicate the relationship of individuals/institutions/groups which such circles represent. Over-lapping of circles indicate their over-lapping in decision-making. The length of the lines of different organizations may shows the social distance of individual organizations from them. Whereas, the size of such circles represent "closeness" or importance of such organizations for the village community.

Walk through surveys

Walk through surveys relates to learning about selected areas from local communities

through undertaking joint walks to those areas. Such walking with communities helps in observing different aspects of a selected area in a locality which require greater attention and detailed discussions with community members. For example, a degraded forest area, identified through a map can be jointly surveyed by community members and outside agencies for discussion in terms of causes, nature and action for regenerating such forest area.

The walk may be summarized as per land-use, where for each land-use, the summary table describes soil conditions, trees, crops, animals, birds, kind of soil erosion, water sources, fodder species, problems and opportunities. Joint walk with local communities helps in directly observing and probing on different issues. In such a method an outside team of professionals walk with local community members from one selected point in an area to another selected point and talking while walking. The community members explain and discuss the nature of the issues related to that area, whether of natural and or social resources involved in that area, the problems, priorities and opportunities. Such joint walks involve detailed understanding of issues related to selected areas from local people. A sequence of such joint walks can be organized depending on locations in question.

The Significance

It helps intervening agencies to observe directly and to have a first-hand knowledge about any location/item/situation/condition. It leads to in-depth probing of an area and intricacies of the issues involved. It takes account of micro-environments in a locality which tend to get overlooked in maps. It helps to directly observe, describe and cross-check points for discussion with local community members. It helps in concretising discussions and demonstrates ability of local people with local knowledge to show physical locations/items while describing them verbally or through maps. It also helps in improving communication likes with local communities.

Walk through Surveys may be undertaken to have better physical understanding of an area. The area for joint walk is generally selected in consultation with local community, either on the basis of group discussions, semi-structured interview or on the basis of participatory

mapping. Some areas for joint walk are natural resources mapping, land degradation mapping, land use planning, Environmental mapping.

Experience Gained

An area for joint walk with local people is required to be within manageable limits of walking so that in-depth observation and discussion can take place without such walk becoming tiresome. It can involve joint walking to selected spots and covering areas which constitute focal points for discussion. Joint walks with men and women, young and old, rich and poor tend to give widely differing perceptions and hence, can raise points for differential analysis. Joint walks with different key informants from a local area can help to explore a topic from different angles. Joint walks with different key informants from a local area can help to explore a topic from different angles. Joint walks in people-forest conflicts in an area with different parties to the conflict can enable a mediator to directly observe and discuss different aspects of such conflicts and their spatial basis. A joint overview of the area concerned whether by participatory mapping or otherwise helps in selection of an area/spot for joint walk which leads to better probing of that area under discussion. A joint walk can be repeated if required. For large areas involved, multiple joint walks over a large area can be tiring and time-consuming.

Vector scoring

Vector scoring is a visual method and involved scoring of criteria/items for assessing their relative importance so as to prioritise problems/benefits/dangers/damages/opportunities etc. This method can be used by individuals as well as groups. It involves listing of criteria and scoring of such criteria/item using indigenous materials. The methods help in decision making by prioritising concerned criteria/items.

At the beginning, intervening agency's team to local community, generally take help of semi-structured interviews with groups of local people who generate different criteria/item which they think are important for consideration by groups. The groups subsequently score on such criteria. Such criteria can be either a set of problems, a set of benefits, a set of preferences, a set of activities/items, on which a group

wishes to score according to its priority. Once a tentative list of such criteria is prepared it is re-checked for additional criteria, if any. Such a list of criteria is placed before the group members who are concerned with such scoring. They can make further deletion or addition to the list or criteria according to their views. It is often observed, that, local groups add new points to a list of criteria while not scoring for those criteria which they do not consider to be relevant. Such scoring can differ individually and also in groups. Such a list of criteria also tends to differ with age, gender, caste, class etc. Hence, the method of vector scoring involves considerable flexibility in generating criteria and also flexibility in terms of scoring.

Once probing starts, it is best to arrive at an agreed theme on which community members wish to generate criteria, for example, problems in a locality, problems in people-forest relationship in a locality, benefits flowing from a project etc. Once such a list of criteria is generated, it can be transferred to the ground, in a column or a row, either on small pieces of paper or with the help of different indigenous symbols (as agreed with the group/groups). It is quite important to have agreed symbols for representing criteria especially where group members are illiterate or semi-literate. This would empower them to understand each criterion on their own and think about it before scoring. The individual/groups may use seeds, stones etc. to score on criteria.

Scoring for criteria placed in a column can be explained to group/groups involved by asking them to place highest score on a criterion which they consider to be most significant and then on a criterion which is less significant than the former and then on others according to their intensity. The individual/group either score, or alternatively, rank criteria instead of scoring them. This leads to prioritization of such a list of locally generated criteria.

To start with, scoring of criteria can be done separately by individuals in a group before they rank or score them as a group. This helps individuals in their thought-processes so as to start thinking with regard to the criteria generated. This also helps in "warming up" for group scoring. In such a case, there exists scope for individual scoring to be influenced by each other. However, individuals desiring

to score can be reminded by facilitators of how important it is important to know the age and background of those engaged in the scoring process since that helps in explaining the relative importance of individual scoring. Once scoring takes place, the individuals may be approached to explained the kind of scoring that they undertook.

Individual scoring can be followed by group scoring. The individuals may be requested to perform group-scoring of criteria, either by falling into one group or in different small groups as per their preference. Much depends on how the community wishes to fall into groups. In any case, it is important to encourage group-interactions and discussions before group-scoring takes place. Once such scoring takes place, the group/groups can explain the basis of such scoring.

Scoring by seeds, stones, pebbles or other indigenous material can indicate the relative importance of a criteria. Scoring of criteria can be free or fixed. Infixed scoring, a fixed number of scores say ten scores are used while in free scoring the number of scores are set free without any limit. In free scoring, the relative amount of scoring for each criterion shows its importance. Fixed scoring is fixed in terms of the number of scores used an also shows relative importance of criteria. Free scoring has no limit on scores used for each criterion, and greater scoring indicates relatively greater significance of a criterion under consideration. Much depends on what local people prefer to adopt. In case they find difficulties with fixed scoring, they go in for free scoring. Much depends on their choice and convenience.

Significance of Vector Scoring

The method of vector scoring helps in generating list of criteria whether in terms of problems/prioritizing can be done by both individual and group. It provides a flexible way of scoring where both free and fixed scoring can be used and scores changed, if required. It helps in arriving at group consensus.

Experiences of Vector Scoring

Greater the clarity in discussing issues relevant to local communities, greater is the clarity in listing of criteria and scoring them. It is important to spend adequate time in

conducting discussions with different groups in learning about an issue and in listing of relevant criteria for scoring. Scoring is best achieved when focused on a theme with comparable criteria. Focusing upon a them is important in arriving at meaningful results through scoring.

If scoring is not focused in terms of a comparable set of criteria then it may become difficult for people to prioritise their criteria through scoring. The method is a powerful one and can involve a large number of individuals, within a given space and time. It also simultaneously raises community expectations especially in case of scoring done for prioritizing its problems.

Such expectations are generally to do with the solutions to the problems where community might expect some action to take place as a

result of such an exercise. The method has great scope for involvement of individuals and groups to enable them to score (by visual scoring or cast vote for a problem) and field experience shows that it is better to conduct such scoring/voting in an open setting where many can be involved especially for validation of such results of scoring. Scoring on the ground can be changed an revised by individuals as well as by groups as and when they wish to do so. It is a relatively simple method unlike other methods like matrix scoring (discussed later in this chapter) since it is choosing between one column of criteria which makes matters easy for local community members. It is transparent and offers scope for many to participate and present their views on a selected list of criteria, add/delete criteria from the list and also refrain from scoring on particular criteria

Take Geospatial and Earth Sciences to Schools to put Decentralized planning on Sound a Footing

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Abstract: Amid loud drum beating about what Geospatial technology can contribute to decentralized planning as also to umpteen other fields of application, there is much talk of training, education and capacity in this technological complex in the higher echelons of education. All these efforts will however fall short of their cherished aims because there are focused merely at the limited target groups, and do not cater to the root segment of technical and generally educated gentry. The present paper therefore proposes to introduce Geospatial and Earth & Environmental education at High or Higher Secondary school level, which will enable the general educated public to support and appreciate decentralized planning process at the district level and further down. It will in fact create a public mindset conducive to spatial thinking and poised to participate in the local planning process.

Rest of the paper presents approaches and strategies of implementing the geospatial education at Higher Secondary School level and grapples with the problems and gropes the prospects thereof. It conceives a bold new subject group with Geospatial Science, Earth & Environmental Science, and Advanced General Science as its principal subjects, principally available to all students passing out high School with good grades, who will be geospatially oriented and may further pursue pertinent subjects for higher studies. It is our basic conviction that only such a radical approach will provide the broad societal base to the otherwise high position of Geospatial technology in the country, and also infuse geospatial thinking among the people at large, so essential for the successful implementation of decentralized planning process.

Introductory – Several components of what is now called Geospatial Science/Technology are already full-fledged fields of study, e.g. Remote Sensing, GIS, GPS, Mobile Mapping, etc. and their umpteen applications. And there are coming up full-scale programs like PG Diplomas or Masters programs in this complex of technologies and its application. As this subject complex is essentially based on science, all these programs are naturally oriented to science streams of students. This deprives a large section of society from an exposure to this upbeat science and undermines its universal applicability and ubiquitous position.

Universal Applicability of Geospatial Methodology Warrants its Access to All – However as science & technology of universal applicability, Geospatial methodology is pervading all spheres of life in its application. And the tools of its application are now

part of everyday and everybody's personal gadgetry. Hand-held smartphone with Internet connectivity, GPS and some mapping or GeoWeb tools is soon going to be the total outfit of personal equipage. Practitioners and professionals from vastly diversified fields need must utilize these modern tools and techniques. However a great number of practitioners and professionals just are cordoned off from any training in these tools and techniques. Moreover, not everybody going in for higher education is likely to be exposed to its training. It is therefore imperative that an exposure to Geospatial education should be made part of the general education to all students at High or Higher Secondary school level; and then avenues should be open for all for higher education in it at graduate or post-graduate level. General educated gentry with this educational background will better

appreciate and participate in decentralized planning as is purported in this XXXII INCA Congress at Jodhpur in 2013 and as stipulated in development planning process.

Other contributions of Geospatial School Education - Besides helping decentralized planning process in the country, the implementation of geospatial education in schools will bring about geospatial thinking at the societal plane, will render very high position of ISRO and other pertinent institutions of the country commensurately broad-based also, predispose the common people to Earth & Environmental management concerns, and in the overall effect will bring the geospatial revolution full-circle in the country with a measure of parity between the ways of offices/institutions and the ways of the people at large.

Problems of Geospatial School Education - School education in India is a rigidly structured system, more so in its higher segments. Already newer branches of learning are clamoring for some space in the High or Higher Secondary school syllabi, which are already jam-packed, particularly in science streams of subjects. Again there is need to train select faculty of schools to sustain this program in the long run. Also, the appropriate data, S/W and H/W may also need to be provided. However, the most resilient problem will arise from the non-geospatial outlook of people and parents who may not readily appreciate or opt for the new move. Even the school setup may feel ill disposed to support the move. This has deep historic roots in our cultural outlook, further accentuated by the colonial British rule. Of course, the pertinent websites show some latest topics, like Geo-Web, as part their syllabi in the some top-notch public schools. My conviction and contention on the point is that these few top-end schools cannot and will not produce the mass impact so indispensably needed.

Geography at Odds in Schools - So far all geospatial or map concepts have been left for Geography to take care of and explicate them at the very introductory level at least; and it would be naturally the parent subject from which the Geospatial Science would branch off. However, and ironically enough, whereas the level and content of geospatial concepts has only advanced in recent years, the position of Geography as an important universal subject

of school teaching has visibly dwindled and declined. At high school Geography is included as a part of Social Studies, which is often taught by a non-Geography teacher who just cannot do justice to the intricate geographical concepts, nor do they requisition proper wall-maps, atlases, globes or other equipage. These students hardly will opt for Geography as a major subject at the Higher Secondary level, nor is the subject frequently available in schools at this level. Perhaps one pragmatic reason for this is that Geography does require a good deal of maps and other equipment for its teaching, whereas other components of Social Studies e.g. History, Economic, Civics hardly require any special equipage for their teaching. Therefore most schools find it more convenient to offer these pure social science subjects and dispense with Geography among the optional subjects. Thus, it is against all such odds that one has to make a head start for bringing in geospatial education in the school system.

Approaches and Modalities - Three approaches are contemplated for incorporating geospatial education in Higher Secondary level.

1. Geospatial Science as an extra subject available for students of any stream.
2. A new stream of science with Geospatial Science as a major optional subject, like Biology or Agricultural Science, to be combined with Chemistry and Physics.
3. Geospatial Science, Earth & Environmental Science, and Advanced General Science (a integration of Chemistry, Physics and necessary level of Mathematics) available and digestible to all streams of subjects - Science, Humanities, Commerce, or any other.

Each approach has its greater or lesser impact and contribution and commensurate problems of implementation. First approach is but a moderate, experimental beginning; but makes Geospatial education accessible to all students. The second approach only introduces a new stream of science students without much problem. Only, the Geospatial stream should look worthwhile and promising enough (which it certainly is), and should have enough avenues for higher pursuits. It serves its purpose well; only it does not address the basic cherished aim of reaching the geospatial exposure to the students of all streams.

A New Stream of Subjects – The third one envisages a bold new and radical approach conceiving a new stream of students moderately or fairly versed in basic Science and Maths and having a good exposure of not only Geospatial Science but also of Earth & Environmental Studies (including earth resource management). These two broad subjects are to be founded on an Advanced General Science base as a generalized integration of Chemistry, Physics and Mathematics. It is our firm conviction that this way it will be accessible and acceptable to all good students passing high school. It is also supposed that proper avenues in these subjects will be available to matriculates passing with this subject group. It has great potential to impact the Geospatial as well as Earth & Environmental management scene of the country. It will potentially effects the geospatial mind set and attitude among the educated public at large, and will help geospatial revolution come full circle in the country. It will thus serve the twin purpose of catering to both, geospatial as well as the earth environmental & resource management concerns.

Specific Challenges of the Proposed New Stream – However the problems and challenges besetting it are quite daunting indeed, as spelled below:

- a. It calls for integrating all geospatial technologies and applications into one organized discipline; and the whole thing brought to the Higher Secondary school level.
- b. Similarly, the Earth, Environmental & Resource management topics are also to be properly integrated as one subject, and simplified appropriately. It covers Earth Science as well as Environmental & Resource Management.
- c. Finally, combining Chemistry, Physics and Maths as one Advanced General Science is again an equally challenging task.
- d. Even after this exercise and preparing faculty to sustain these new syllabi, it still remains a bold, mute question: will these matriculates find proper avenues of higher studies and amicable job eventually; and will this new stream command adequate respect among all concerned.

- e. The Geospatial school education should be broad-based – emphasizing conceptual clarity and explication in general terms, so that it is affordable and intelligible to all students of good caliber.

New Geospatial Stream is Worth the Challenges – It is again our firm conviction and contention that there is immense demand for professionals in geospatial and environmental & resource fields – with jobs of many and varied grades. Rather the geospatial revolution is hampered in India for lack of proper manpower to support it. So far only science & technology people have monopolized the training & education in it and hogged all the burgeoning jobs stemming from geospatial methodology; but they alone cannot meet the great and diversified demand. Again they often do not have proper grounding in social and economic-commercial application areas. Therefore, besides B Tech. and such other technical programmes, there is need for rather more conceptual programmes at graduate and PG levels for students of this new stream, who can man many a teaching, research and application position, which is technically less demanding.

The New Stream to Redress Tardiness of Some Subjects – Moreover, this radically new stream of subjects available to good students at the High school, will redress one more major lacuna of our education system, e.g. improving teaching-learning attitude of the so-called non-science students and teachers, so far marked with utter tardiness, and thus bring these students nearly at par with the patent science streams. The callous, tardy and lack-luster attitude towards teaching of so-called non-science subject, typically found in many a teaching institution, greatly accentuates the initial insipient differences of mental levels of students, and leaves them rather unfit for any serious higher studies or for any worthwhile jobs.

Science/Non-Science Dichotomy Overdone – The dichotomy of students with and without Sc.&Tech. moorings has too much and too rigidly marked our school education system; and this has done serious damage to the education as a whole, and particularly to subjects like Geography, which are rooted both in the natural as well as the social

sciences. Stark difference in the gravity and earnestness of education of science subjects on one hand and of the so-called non-science subjects on the other, as seen in many an educational institution, is utterly baffling and bewildering. This monstrous dichotomy stands overdue to be replaced with a trichotomy – adding a new stream with conceptually sound, moderate science background, and conversant with concepts and applications of geospatial methodology as well as with the Earth environmental & resource management. Earth Science component redresses umpteen Geo-Carto. Glitches in the build up of umpteen resource scientists branching off from basic science stem.

This stream will not only redress the utterly tardy attitude to studies by a large section of students and teachers and bring them in the main stream of vibrant progress, but will also eventually eliminate the unhealthy, eliminative competition between the science and non-science lobbies – because the science people are hogging very many of the jobs that traditionally belonged to the so-called non-science professionals; and that is solely by virtue of the geospatial methodology from which latter people are cordoned off.

Tragedy with Geography – Slotting Geography with Social Science or Humanities has bereft geography of its scientific analysis and insight, and rendered the subject more descriptive. Nevertheless, the subject and its proponents remain much interpretative and have sound conceptual understanding. In the final analysis, Geography – the mother of all sciences of yore – has its core concepts rooted in science, but it has lately has come to have its very huge body or superstructure extensively extended over the realm of social sciences and humanities. And this has rendered Geography rather ambiguous and lop-sided. An essentially and innately spatial subject dealing with most diverse aspects and therefore most widely interfaced with geospatial methodology thus stands divorced from its most inherent ally, e.g. the geospatial science.

The overly technical garb of geospatial training & education, and the internal hitch and diffidence syndrome of geographers have conjoined to keep geographers out as ringside viewers of these newer developments in this

country. This may partly be ameliorated by highlighting the innate advantages of geographers with their early grounding in most of the geospatial concepts, and the stumping success of very many geographers in Europe, America, Australia, China etc.; and by underscoring that application of geospatial tools and technique is often not a highly technical job. The real redress will, however, come through combining Geographic and geospatial education with some moderate level of science education and a touch of humanities as well.

Catering to Earth & Environmental Concerns as well – This idea of a new stream of subjects covers another urgent areas of universal concern, e.g. the Earth & Environmental management concern – issues, strategies, methodology and life styles that make them sustainable on a long-term basis. These topics scattered over other subjects may be clubbed here and ease the jam-pack elsewhere. Needless to say that Geospatial methodology comes most handy and useful in managing earth environment & resources. Moreover, the Earth Science part covers well much of Physical Geography and all the vital Geo-Carto, concepts so essential for Geospatial sciences. It may be underscored here that Earth & Environment includes its resources management also. Actually a demand for incorporating pertinent geographic or geospatial concepts in the syllabi of sciences is occasionally heard, because most of them have to face them squarely in their profession through geospatial methodology i.e. rather early in the build-up of the potential geospatial or resource scientists. Many a practical points like these are to be covered well in the Earth & Environmental segment of this stream.

Roadmap of Geospatial and Earth & Environmental Stream in School Education – As noted earlier, introducing Geospatial Science as an extra subjected available to all is only a minor experimental or exploratory move. It only involves developing a moderate level syllabus, a textbook, a set of experiments, and some extra source material for teachers. Most of these things can be culled out from existing sources at higher levels. Introducing the subject a new science stream like Biology is perhaps simpler still. Only it should be ensured that these matriculates have an amicable position I other science streams. Its impact will be limited

to only science students and will only cater to Geospatial Science.

The radical, new line of a whole new stream of subjects available to all good students throws many daunting challenges, and we focus our tenor at materializing it. It will be rather long-range program, as outlined below:

- a. Apprise and liaison with policy and decisive bodies like NEUPA, NCERT or State Boards, with a draft curriculum and draft textbook, and seek appraisal of the pertinent bodies to run it eventually in select schools with good computer resources.
- b. Generalizing broad and complex sciences like Geospatial, Earth, and Environmental, as well as integrating Chemistry, Physics, and Mathematics as Advanced General Science call for very bold efforts. At least some draft version of text/source books and workbooks must be presented to these bodies and they may give it a final touch.

These books must earnestly integrate components of their subject matter, and be simple yet conceptually sound, and technically less daunting, so that students are not bogged down in formulae and calculations but can deploy the concepts and methods in applications.

- a. Seek funding for some guest resource persons and all along train at least a local teacher in each select school – tapping retired local faculty of pertinent teaching institutions. Local members of bodies like INCA, ISRS, etc. can be of much avail.
- b. Procure other illustrative reference source materials, which are now easily available.
- c. Periodically evaluate the scheme and it's functioning.
- d. Prepare a textbook in Hindi, or in English-Hindi by-lingual mode with face-to-face or close-by presentation – as an auxiliary resource. Such a text is usually structured and organized as a series of rather short topics which are each presented as one- or two-page spreads; each to be followed immediately by its Hindi version or rather Hindi rendering. Figures, diagrams, tables, etc. may be sorted and presented as two-page spreads in between.

Such a textbook should be conceptually explicative and technically less demanding. Hindi version of the by-lingual textbook may be replaced with other major regional languages in respective regions of the country.

- a. Mobilize specific Computer S/W and S/W for schools for EDUSAT facilities and for geospatial exercises.
- b. DECU or UGC may be requested for presentation of somewhat simplified lessons on pertinent sciences on regional channels for schools.

Asset Situation for Implementing the New Stream in School Education –

- a. Computer education and computer lab. is usually available in good schools. Only it may be enhanced with some specific items.
- b. Good quality geodata is readily, and rather inexpensively, available from our own IRS series, and from Survey of India, NATMO, or NSDI
- c. Like Google Earth, ISRO has launched its own free geoportal, e.g. the BHUVAN.
- d. NM Short's 'Landsat Tutorial Workbook' can be adapted for teaching and can be supplemented with Charles Sheffield's illustrated twin books, 'Earth Watch'. Besides several Satellite Atlases of the World, NATMO has published a moderate 'Satellite Image Atlas of India'.
- e. 'Landsat TM Data Applications' and 'Remote Sensing Data Users Sourcebook' from NRSA are good, simple sourcebooks. Similarly 'Working with Maps', and 'Map Education' are good popular books from Survey of India.
- f. Indian Geomorphologist, R. Vaidyanathan, has brought out 'a Set of 60 Topo Maps', and 'A Set of 70 Steropairs' of typical Indian landforms, which are excellent teaching resources.
- g. Commercial GIS S/W's were white elephants to procure and run. Major vendors like ESRI and ROLTA are providing working or demo./simple versions of their major S/W's gratis for schools – sometimes with data sets for exercises – and at very subsidized rates

for other teaching institutes. ILWIS from ITC is now freely downloadable. ESRI of US started a newsletter, 'Arc School Reader' for promoting GIS in schools; its ArcView S/W is fairly suitable for schools and colleges. ROLTA India has entered MOU with the CBSE to train school teachers/students and to provide its Geomedia S/W gratis to all CBSE schools that would exert to get students and the concerned teacher trained in that S/W.

- h. Some geoportals offer advanced feature like DEM, and virtual flu-through over 3-D image.
- i. There are good electronic Atlases, like Encarta's 'Virtual Earth'.
- j. NRDS of India has developed its own working GIS S/W package, e.g. GRAM++, and P. Vankatachalam has developed a 'GISTUTOR based on it.
- k. NCGIA in US and AGI in UK have had commissions on GIS in Schools since long – D R Green has edited a landmark book 'GIS: A Sourcebook for Schools'.
- l. Excellent electronic atlases like MS Encarta Virtual Earth.
- m. Local teacher at school can help students play with geospatial data from GeoWebsite.
- n. Local teacher at school can help students play with geospatial data from Geo Websites or avail mashups.

Conclusion – Thus we find that radical idea of introducing a whole new stream of subjects with a moderate base of science but available and digestible to all students passing High School with overall good grades can cater to: 1. Poise and orient the senior students to geospatial concepts and method as well to Earth and Environmental issues and concerns; and 2. Also take upon the monster of Science-non-Science dichotomy and turn it into a more conducive and amiable trichotomy. It thus brings both the geospatial revolution full circle and brings it and the earth environment & resource concerns to the entire educated public of the country, which then better appreciates and participates in the decentralized planning, and also supports cherished policies like sustainable development.

Obviously, the proposed idea is fraught with daunting challenges; however, given the urgency of situation and the earnest societal will to do it, there are leads to be explored and headways made. Also, there are ample assets and opportunities for carrying out this radical, bold idea. The old order – of dichotomy – must change, yielding place to the trichotomy fresh and new and in tune with the changing times.

Anticipated Criticism

1. My conservative science chauvinist friends may feel shaky that a diluted/simplified teaching emphasizing conceptual understanding that essentially circumvents analytic part dealing with formulae and derivations, indiscriminately to all will only produce a mushrooming boom of dubious, rather spurious, quality – something like 'jhola-chhap doctors', which will do dis-service to both the sciences and student so taught. They would not budge an inch from their genetic conviction that some people are 'science-wise disabled'; and it is no use pouring science on them as they cannot imbibe it.
2. Many segments of Geospatial Science are involve advanced concepts and notions based on several up-end technologies; as such it would be rather premature to expose the school students to it them, and they may find difficult to grasp them. They may then perforce just mug up things, and will only carry some tit-bits of some concepts and lots of names in their heads, rather than grasp the whole thing properly. It would be better that they continue to grasp the fundamentals of basic sciences, through the school stage, and then take upon the geospatial sciences on their sound foundations of basics sciences, as the current arrangements provide for.

A Firm, Humble Reply – Firstly, even if their genetic conviction partly – yes, only partly – holds good, their stance in the matter is untenable. Mathematical derivations of a subject and its sound understanding are not synonymous things. Conceptual explication, while navigating mostly clear of the mathematical whirlpools by just telling their essence in general terms, is neither spurious nor even a black box approach. There are other scientists of different genre and caliber

to design satellites or sensors, or launch and control satellites, or even to receive and process the satellite signals at the receiving stations. In essence, geospatial application, by itself, is not an extremely technical job. Suffice it usually for them to know the potentials and limitation and other characteristics of their tools and techniques as well as the methods of their application field. They should however explicitly understand the concepts without ambiguity or confusion. Even then, there are various types of educational programs for people with different backgrounds and orientations, and befitting many and varied shades and grades of jobs in this vast and varied world.

Secondly, in India the schism between the Sc. & Tech. subjects and other subjects is too conspicuous, doing great harm to the intellectual health of the country. In the modern usage of high-tech. tools/gazettes in all walks of life by common man, it is imperative that the general education system of the country should enable average educated person to use them efficiently. And that is one of the guiding tenets behind this presentation. Therefore, transforming the dichotomy of Higher Secondary school subject into a trichotomy is itself a major redress of our school education system, which will be a milestone in its march with the modern times. Certain Boards of schools (such as ICSE) actually continue all subjects as compulsory right up to class XII. Other contributions include helping geospatial revolution run full circle at societal plane in the country. Earth environment and resource management constitute the primary, vast field of application of geospatial technology; and the two go harmoniously and hand-in-hand with each other.

In the incessant progress of knowledge, many new things are making headway in the school curriculum. In today's world of Sc. & Tech.-based life-style, people must perforce grapple with concepts and technologies and their application in all walks of life. Today this is best manifest in the little, hand-held thing called smart mobile phone, which is going to be the total personal out-fit for everybody, as its umpteen applications are pervading all walks of life. Therefore, our school education must enable every educated person to deal or handle this little gadget to one's best

advantages. Moreover, living in the geospatial era, every educated person should be enabled to successfully move in this era and surf the surging geospatial waves successfully; or be downed under them. We do not question the value of sound foundation in basic sciences. We do not denigrate or underrate the value of such a foundation for solid breakthrough in fundamental research. Only, it is immensely due and desirable that the science/non-science dichotomy need must be replaced with a trichotomy – admitting a new stream with a moderate base of science but exposed to new, more relevant subjects like geospatial, and earth environmental sciences.

It is our conviction therefore that this science of universal applicability should be part of the general, besides specialized, education. And it is the onus of the pioneers of this move to simplify and generalize the subject – concepts, notions and methods – to the Higher /Secondary school level, and prepare the curriculum, textbook, exercise-workbooks, and other resources accordingly, and preferably in the regional language medium, or in the bilingual arrangement of English and some regional language, for the benefit of most student of India.

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