INDIAN CARTOGRAPHER

Vol. 32, 2012

Focal Theme

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

XXXII INCA International Congress
11-13 October, 2012

Organised By
NATIONAL HYDROGRAPHIC OFFICE
107-A, RAJPUR ROAD,
POST BOX NO. 75
DEHRADUN – 248001

Journal of the Indian National Cartographic Association

Indian Cartographer
Vol. 32, 2012

Published by
Organising Committee
XXXII INCA International Congress
National Hydrographic Office
Dehradun-248001

Editor
Dr. U. K. Singh

Editorial Board
Capt. Sajeev K Nair
Dr. R. B. Singh
Dr. B. K. Ramprasad
Dr. V. V. L. N. Sarma

The views expressed by the authors are their own and INCA does not necessarily endorse them in part or whole

Copyright © 2013
Indian National Cartographic Association

ISSN: 0972-8392

Regd. Office: Room No. 234, 2nd Floor, APGDC Block
Survey of India, Uppal, Hyderabad-500 039 (A.P.)
Voice No. 044-27202217 Email: secretarygeneralinca@gmail.com
Website: http://www.incaindia.org

LOCAL ORGANISING COMMITTEE

PATRON

Vice Admiral S K Jha, NM, FIS
Chief Hydrographer to the Govt. of India

CHAIRMAN

Commodore Vinay Badhwar, NM

ORGANISING SECRETARY

Commander Sajeev K Nair

CO-ORGANISING SECRETARY

Dr RB Singh

TREASURER

Commander Deepak Sharma

EDITOR

DR. UK Singh, PCHO

MEMBERS

Commodore Ravi Nautiyal
Commander A K Kaul
Commander Peush Pawsey
Commander RB Menon
Commander Anand Narayanan
Commander Amit Pant
Commander Mahendra Kumar
Commander YV Ramakrishna
Mr. SS Chauhan (DyCCHO)
Mr. Rajesh Kumar (DyCCHO)

Dr. RA Prasad (ACCHO)
Dr. BK Ramprasad (PCHO)
Mr. MP Gupta (PCHO)
Mr. C Murugadoss (PCHO)
Mr. Sunil Dutt (PCHO)
Dr. VVLN Sharma (CHO)
Mr. PC Purohit (CHO)
Mr.RJ Kushwaha(CHO)
Mr. Devraj Singh (CD).
Mr. A Bhattacharya (CD)

EXECUTIVE COMMITTEE

President
Vice Admiral SK Jha, NM

Co-President
Surveyor General of India

Past Presidents
Dr. Surya Kant
Shri AK Malik
Maj Gen(Retd) Manoj Tayal

Senior Vice-President
Dr. VK Dadhwal

Vice-President
Shri S Subba Rao
Dr. Anuradha Banerjee

Secretary General
Shri RN Nanda

Past Secretary General
Shri KC Rout

Secretary
Dr. Muralikrishnan
Shri Rajesh Kumar

Treasurer
Shri G Devender Rao

Editor
Dr. UK Singh

Members

Prof. OP Sarna
Commodore Vinay Badhwar
Dr. JA Siddiqui
Shri Shyam Veer Singh
Dr. Jayashree
Dr. AK Sarkar
Shri G Prasanth Nair
Dr. Krishna Mohan
Commander Sajeev K Nair
Dr. T Neelakantan
Shri T Sanjeev Kumar
Dr. Rajendra Kumar Rawat

Shri. Amod Srivastava
Maj General PK Vacher
Maj General BD Sharma
Maj General M Mohan
Shri SK Sinha
Shri MI Malik
Dr. B Kartikeyan
Dr. Baisakhi Sarkar
Dr. AK Dasgupta
Shri SS Chauhan
Dr. RA Prasad
Dr. Balak Ram

CONTENTS

From the Editors ……(i)

INAUGURAL SESSION

Presidential Address …… (ii)
Keynote Address …….. (v)
Inaugural Address ……(vii)
Organising Secretary's Report ……..(viii)

MEMORABLE MOMENTS

Down Memory Lane: A few Glimpses and Memorable moments of XXXII INCA …….. (x)

MEMORIAL LECTURES

SP Chatterjee Lecture …….. (xxii)
Dr (Prof) VC Jha, Director NATMO.

Raja Todarmal Lecture …… (xxx)
Dr P Nag Vice Chancellor, Mahatma Gandhi Kashi Vidhyapeeth.

FOCAL THEME AND SUB THEMES OF THE CONGRESS ……..…(xxxv)

PAPERS PRESENTED DURING THE TECHNICAL SESSIONS OF THE CONGRESS

Cartographic Trends and Prospects in the 21st Century …… 1
Professor (Retd.) JL Jain,

Database Driven Cartography …… 6
Mathew Holland

Strip Adjustment of Airborne LIDAR Data …… 13
Anil Kumar G., Sadasiva Rao B., Gopala Krishna PVSSN.

Development in Cartography - A boon or bane ? ……..…… 17
Dr. VVLN Sarma

Adaptive Image Contrast Enhancement Technique on CARTOSAT-1 Stereo pair for DEM quality ……. 23
Improvement
Y K Srivastava, Arati Paul, VM Chowdary, A Jeyaram, Surajit Panda

Intensity Augmented ICP for Registration of Laser Scanner Point Clouds …… 30
Bharat Lohani and Sandeep Sashidharan

Mapping Groundwater Sources in NCT Delhi Using GIS for Sustainable Water Resource Management … 35
Dharini Dube

Study of Groundwater Status in Geoinformatic Environment - A case study of Roun Tehsil of Bhind ….. 40
District (MP)
Dr. M.K. Ozha, Dr. Shilpi Banerjee and V.K. Soni

Application of Remote Sensing and GIS Technique for Elucidation of Groundwater Potential …….. 42
Zones from a Part of Orissa Coastal Tract, Eastern India
Arkoprovo Biswas, Adarsa Jana and Shashi Prakash Sharma

Exploration and Management of Groundwater Resources by using Remote Sensing data and …… 49
GIS tools in and around Dehradoon Valley
Dr. DK Mandal

Morphometric and Hydrological Analysis for the Upper Part of the Dwarkeswar Watershed …….. 53
using Remote Sensing and GIS Techniques
Subodh Chandra Pal, Manisa Shit and Dr. Subrata Pan

Slope Identification with GIS & Remote Sensing on a Part of Bundelkhand Plateau- …….. 61
A Micro Level Case Study of Central Sind Catchment
Dr. Prashasti Ashok, Prof. S. P. Singh, Prof. Dheer Singh and Shakti Saxena

Urbanization and Size of Population in Burdwan City: A Cartographic Approach …… 66
Dr. Jitendra Shukla, Debashree Roy

Development of Land Based Mobile Mapping System …….. 70
Salil Goel, Manohar Yadav, Anjani Kumar Singh, Bharat Lohani

Surveillance System based on Flash LIDAR …….. 77
Bharat Lohani, Siju Chacko, Suddhasheel Ghosh and Sandeep Sasidharan

Comparision of Kinematic GNSS Processing: Relative vs PPP Approach for Processing of Airborne …… 86
Camera Data
T.E Rani, E. Anantha Padmanabha and S. Muralikrishnan

GPS Permanent Station (PS) Data Archival and Analysis …… 93
UN Mishra

Drainage Basin Analyses of Kaneri River Basin of Karnataka, India Using Visual Basic Programme …….. 99
bAd Calculator and GIS
AC. Dinesh, Vipin Joseph Markose and K.S. Jayapa

Study on GCP Configuration for Block Adjustment of Airborne Digital Data …… 107
E. Anantha Padmanabha, B. Narender, S. Muralikrishnan.

Hydrographic Services: A Must for Vast Resource Management to Ensure Sustainable Growth for ……112
Nation Building
Captain (IN) Lochan Singh Pathania, Lt Cdr Raja Abdul Rahiman

Forest, Resource Bonanza and Cultural Biological Diversities in the Andaman & Nicobar Islands …….. 118
Dr. S.C. Chaturvedi

Use of Geomatics and Inland Water Transport to Enhance Sustainable Development and …….. 129
Growth of North East Region
Capt. (TS) G S Inda

Types and Distribution of Domestic Water Sources in Jorhat Town, Assam …… 133
Mayurakshi Bhuyan and Zahid Hussain

E-Governance for Monitoring of Water Bodies in Urban Areas- A Case Study of Barasat …… 138
Municipality, (WB)
Sri Debdip Bhattacharjee and Dr. Sukla Hazra

Studies on Drought Prone Areas of Palakkad, Kerala 144
Dani. V, Lekhsmi G.S, Veena Surendram, and E Savaranan

Applicatioin of Geoinformatics to Detect the Hotspot Regions where Human Responses 150
against Bank Failure is Maximum- A Case Study of Malda District,(WB)
Chhanda Dey and Dr. Jatisankar Bandyopadhyay

Nuclear Disasters and the Lessons Learnt 156
Dr. BK Ramprasad

Integration of Remote Sensing and GIS Analysis as a tool for Environmentally Sound Land Use 162
Planning
Bidisha Chattopadhyay

Mini Watershed Characterization and Prioritization using Spatial Information Technology (SIT): 170
A Case Study of Kansachara Sub-Watershed,(WB)
Kartic Bera, and Dr. Jatisankar Bandyopadhyay

Mapping Coastal Landforms at the Interface of Sheltered Lagoon and Open Marine Environment: An 176
Assessment of Morphodynamics at the ChilIka Shoreline
Sk. Majharul Islam and Dr. Ashish Kumar Paul

A Study on the change in the Shape of Coastline in Cochin City using GIS 179
Dr. Lancelet T.S.

Evolution of Balari Bar in the Estuarine Reach of the River Hugli 185
Dr. Aparajita Sen

LIDAR Bathymetry for Nautical Charting 190
Cdr Sanjeev Sharma, IN (Retd)

MSL Variation Along East and west Coast of India 197
UN Mishra. Dhiraj Shah, S.K. Singh, Rakesh Kumar and Sanjay Kumar Shandilya

GIS Mapping of Urban Deprivation and Construction of the Index of Substandard Living in Kolkata 205
Metropolis
Dr. Anuradha Banerjee & Miss Mala Mukherjee

Levels of Regional in Bankura District : A Cartographic Appraisal 210
Md. Azfar Mondal & Dr. Jitendra Shukla

Mapping of Housing Deprivation in Indian Megacities : A Comparision between Delhi and Kolkata 214
Metropolises
Pravin Kumar Shukla & Mala Mukherjee

Mapping Morbidity Pattern in India: Opportunities and Challenges 221
Dr. Vinod Kumar Mishra

Changing Pattern of Sex Ratio and Child Sex Ratio in India: A GIS Based Analysis of Urban and 229
Rural Areas
Dr. Rajesh Yadav and Dr. Pankaj Kumar

Geomagnetic Reversal: A Myth or Truth! 234
Rajiv Kumar Srivastava and Raman Verma

Resource Mapping for Sustainable Agricultural Planning in Nagalar Sub-Watershed 240
using Geospatial Technology
Bhaskaran G, Gobinath K and Rajalakshmi K

Spatial Variation of Cropping Intensity in Kerala- A Case Study 248
Lakshmi G.S. Dani V, Veena Surendaram, E Saravanan

Crop Combination Regions of Kerala 251
Lakshmi G.S. Dani V, Veena Surendaram, E Saravanan

Application of Geospatial Technology in Change Detection of Snow Cover Area of Great Himalyan 255
National Park, Himachal Pradesh
Ansul Sood

Impact of Indira Gandhi Nahar Pariyojana Stage II on Agro-Ecological Environment and Livelihood 260
in Arid Rajasthan
Balak Ram and J.S. Chauhan

Mapping of Urban Growth pockets, Hot spots of Poverty and Land Use Changes 266
in Kolkata Metropolis: Its Impact on Urban Resource Management
Mala Mukherjee

Spatial Pattern of Land Use in Theni District- A GIS Approach 273
V. Rengan

Geological, Geomorphological and Structural Studies of Mainpat Plateau, ... 277
Through RS/GIS Techniques
Trivedi, R. K., Adil, S.H., Soni, L.K. and Patel, V.N.

Understanding Land Gradation Scenario in Chambal, India: A Journey through Maps 284
Padmini Pani

Spatial Distribution of PHC and Identification of Major Diseases in Nilgiris District- 291
A Geo Medical Study
J. Ganesan & Dr. V. Saravanabavan

Geospatial Analysis of Infrastructural Facilities in Tiruchirappalli District, (TN) using GIS 296
M. Ashok Kumar

Studies on Spatio-Temporal Variation of Literacy in Kerala in GIS Environment 301
Veena Surendran, Dani V, Lekhsmi GS

Pedagogical Foundations for Effective Competency Building in the Hydrographic and Cartographic 305
Sectors
Shekhar Murhty, Ronald Furness, Duncan Wardie

The Quaternary Geological Map of North Bengal 312
Arunabha Das

Identification of Potential Stone-Quarry Sites for Sustainable Infrastructural Development in 322
Mizoram using RS and GIS
Swati Singh, Ajoy Mondal, A. Jeyaram

Mapping in National Waterways for Sustained Development 328
Cdr. P.K. Srivastava & Sh. G. Prasanth Nair.

Web-Mapping and Cartography for Sustainable Resource Management ……..331
Sujata Ghosh, PVSP Prasada Raju, J Saibaba, and Geeta Varadan

Urbanisation and Resultant Depletion of Water Bodies in Tollygunj Ward, Kolkata Municipal …….. 343
Corporation: 1935-2010
Sreetapa Nandy

Sprawl of Indore City and Deviation from its Development Plan …….. 347
Manish Pandey, Dr. Arti Kamediya & Dr. Devendra Kaur

A Case Study for Site Selection of Agroforestry of Umlangia Watershed in GIS Environment ……349
Ratul Arya Baishya, Chandra Sharma and Manoj Haloi

Spatio-Temporal Changes on Demographic Characteristic in 2001-11- A Case Study of Tamil Nadu …….354
S. Ravichandaran & Dr. I.K. Manonmani

Fluvio- Geomorphological Characteristics of Sapt Kosi River ……..360
RK Mahato & Dr. Jitendra Shukla

Poster Presentation in Thematic Cartography ……... 366
Prof. Premlata Singhi

Role of Outsourcing in Development of Resource Potential of Dhar District (MP) ……...370
Dr. Arti Kamediya, Manish Pandey, Dr. Devendra Kaur



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

From The Editors

We are glad that this 32nd Volume of the 'Indian Cartographer' would be in the hands of all the esteemed INCA members and all individuals concerned, prior to the INCA International Congress at Jodhpur in Sep 2013. The Volume contains various technical papers selected by the Technical Paper Sub Committee for presentation during the XXXII INCA International Congress organised by the Indian Naval Hydrographic Department at Dehradun, from 11-13 Oct 12. The main theme for the Congress was "Cartography for Sustainable Earth Resource Management" and was further divided into fourteen sub-themes on all contemporary cartography issues, related to the main theme.

The event was inaugurated by Honourable Governor of Uttarakhand Dr Aziz Qureshi in the presence of Admiral DK Joshi, PVSM, AVSM, YSM, NM, VSM, ADC Chief of the Naval Staff and other distinguished dignitaries, cartographers, professionals, research scholars and students. In his inaugural speech, Dr Qureshi stressed the need for those in power to accord cartography its due recognition as an important tool in nation building and hence offer necessary support for its growth and development.

The SP Chatterjee Memorial Lecture was delivered by Prof (Dr) VC Jha, Director National Thematic and Mapping Organisation on the topic 'Geomorphology and Thematic Mapping in the Twenty first Century'. The Todarmal Memorial Lecture was delivered by Dr Prithvish Nag, Vice Chancellor of Mahatma Gandhi Kashi Vidhyapeeth, on the theme 'Map- Text Interface'. Both the memorial lectures were well received and appreciated by the audience.

The publication of this volume would not have been possible without the whole hearted support of the authors, who submitted the full texts of their technical papers in time. In all 70 papers were presented, however most of the papers have been reproduced fully and faithfully, albeit with minor correction and modifications, where necessary, for elimination of syntax errors and to ensure smooth flow of thought and text. The editors believe that the valuable professional/technical information contained in these papers would go a long way in facilitating increased awareness of various facets of cartographic discipline among the readers, while also contributing effectively towards evolution of important national development projects

We are indeed grateful to Vice Admiral SK Jha, NM, Chief Hydrographer to the Govt. of India and President, INCA for his active, unstinted and sustained support and guidance throughout the publication process. Our sincere thanks are also due to the Executive Council of INCA, who by entrusting us with the important task of editing this volume, have reposed their full faith in us. Last but not the least, our appreciation goes to the Technical Paper Sub Committee, who did the herculean task of liasoining with the authors for seeking clarification on content and scrutinizing the texts of all papers, thereby making our job relatively simpler.

In the end, we assure all our valued authors that errors and omissions, if any, in the reproduction of their papers herein are fully inadvertent and are regretted.

THANK YOU

National Hydrographic Office
Dehradun-248001



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

INAUGURAL SESSION



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

PRESIDENTIAL ADDRESS

Vice Admiral S K Jha, NM

Chief Hydrographer to the Government of India & President INCA

His Excellency Dr. Aziz Qureshi, Honourable Governor of Uttarakhand, Admiral DK Joshi, Chief of the Naval Staff, Dr. Swarna Subba Rao, Surveyor General of India, Senior Officers from three Services, sitting Vice Chancellors and professors from various Universities, veterans from three services, Past Presidents, Honourable delegates, members of industry, members of media, ladies and gentlemen.

National Hydrographic Department of the Indian Navy feels much exulted today to host the XXXII INCA Congress, I personally feel greatly distinguished to address the august gathering of eminent scholars and professionals in the field of cartography and geospatial sciences. I extend a very warm welcome on behalf of the Indian Naval Hydrographic Department and Indian National Cartographic Association to all the delegates and guests who have assembled here in this beautiful serene city of Dehradun.

The focal theme of the congress is '**Cartography for Sustainable Earth Resource Management**' which will cover technological trends in cartography, coastal geomorphology, hydrography, application of Remote Sensing and Geographical Information System for resource management. I stand beholden to the Association for bestowing confidence in me as its steward, and for extending me full cooperation in piloting the Association through this one year that draws to a close. I have highly regarded this position as I also enjoyed carrying out its functions and obligations.

Ladies and Gentlemen, the Indian National Cartographic association (INCA) was constituted late in 1979 as a cross-disciplinary body essentially between the premier cartographic institutions like the Survey of India, National Atlas Thematic Mapping Organisation (NATMO), National Hydrographic Office (NHO) and the foremost academicians like Geographers who are inherently cartographers as well, to an appreciable extent. Other major professional bodies in related fields and particularly in the space technology applications fields soon joined it. It is today a truly multi-disciplinary vibrant body with membership in proximity of three thousand and fifteen branches in various states across the country. The main objectives of Indian National Cartographic Association are to foster cartographic research in the country, to cooperate with professional mapping organisations and enhance a sense of national responsibility and professional efficacy among the professionals who are engaged in cartographic activities.

Indian National Cartographic Association (INCA), over the last three and half decades has radically metamorphosed into a computer-suave, technical profession, and now largely driven by a more comprehensive, more general and functional technology called Geographic Information System (GIS). In fact the relation and difference between Cartography and GIS has well-nigh become an elusive, technical, if not pedantic, debate. All along, the pertinent departments have been endeavouring hard to come up with these technical developments by training their personnel and adopting newer techniques and procedure. NHO, the only authority mandated to nautical charting, has come a long way in the post independence era and today stands tall amongst one of the selected few maritime nations with full capability of producing their own Electronic Navigation Charts.

India despite it's extensive coastline is largely a continental country - with a major segment of the society focused on, land resources and socio-economic outlook hovering over land as the direct life support of the society. Coastal communities - their life and culture, their navigation technology which had faded and marginalized in the later phase of our history has gained tremendous importance from security to trade and commerce. In fact it is practically influencing every aspect of life. We would do well to recall that it is only among the coastal communities in this country that indigenous mapping and navigational technology was developed and preserved till late in our history. Coastal zone is always on the forefront of civilization and has been by far the most exploited geographical unit on the earth. It's easy access and resourcefulness have always attracted human activities, but its complexity in understanding has led to misuse and abuse. With the emergence of information technology, new and critical understanding of coastal zone is emerging and its importance is once again being recognised and assessed. Facts such as coastal water provides 90% of world fish catch, 60% of world population lives on the coast, 18% of global surface is coastal, 80% of global organic matter gets buried in the coast and about 90% of suspend river load with pollutants sink here are startling indication of the importance of coastal zone. In this milieu, the role of Indian Navy and NHO in coastal and marine charting, monitoring and national security from that front and

bringing these activities in the national mainstream becomes all the more significant.

I wish to mention here that National Hydrographic Office has been expanding and enhancing its role in the objectives and activities of Indian National Cartographic Association and this is the third time we are hosting and organising its Congress. While organising INCA congress under the aegis of the Indian Navy, it is our earnest effort to highlight the technological advancements made in the field of nautical charting in India and our endeavour to ensure the safety of navigation in our waters.

Many and varied are the aspects as well as the application fields of geospatial technology which is particularly suited for comprehensive and continual monitoring of Earth environment and resources and we have accordingly chosen a very comprehensive and rather general theme for this Congress "Cartography for Sustainable Earth Resource Management". The aim is that researchers from a wide range of fields as well as those focused on the holistic syndrome of resources and their utilisation and management on a sustainable basis feel invoked to make good contributions out of their professional practice and research. Thus there is a wide range of sub-themes and sessions in the Congress program including those on academic and industrial interface with this practice and research. Multispectral Remote Sensing & Geographic Information System (GIS) is uniquely conducive to integrated studies and analyses of the entire complex of resources-base and resource management which can potentially lead to their sustainability.

While certain up-end institutions of the government, industry and academia stand out pre-eminent in the cultivation and application of this technological complex there are sizeable chunks of the society that are still gripped with a diffidence syndrome towards harnessing and utilising this most useful tool-kit for their purposes.

INCA is the only forum which aims at bringing the academicians, users and the technology together for benefit of the society. This obviously involves not only training and capacity building in these fields, but also incorporating its introductory education as part of general education system of the country.

Technologically, cartography and related science has been an immensely happening field since later decades of the last century. Several parallel and sub-parallel lanes of technological developments have well nigh convolved and compounded with Cartography and contributory sciences. Again digital Cartography and free access to global map and image form information on Internet Web are going to pose serious challenges to the future role and scope of cartographers. The future cartographer will be a professional navigator of spatial information highway himself, adept net accessing and utilising such information from public or corporate sources as well as customising and value adding it for more specific band ready use. However, there will coming up intermediary agencies to customise and value-add the basic cartographic information from Govt. or corporate sources. Value addition to the Electronic Navigation Charts is one such issue where various layers many of which are quite relevant to military are being developed by National Hydrographic Office. However there are issues related to data proliferation and therefore need to have regulatory mechanism. In many cases, Govt. Departments have themselves put some control and royalty over such use of their data. All these issues call for some legal apparatus for regulation of the generation, resale and use of this information. Further, there will be other issues pertaining to authenticity and quality of data, their format compatibility, metadata and many others, when data from diverse sources are involved. Establishment of National Spatial Data Infrastructure (NSDI) is one such initiative which is a step in the right direction at a national level. Serious efforts are already underway to come to a common platform and provide requisite data at various levels for desired purpose.

Notwithstanding such teething issues, it looks imperative that digital data, rather than the paper print map/charts, will rule the roost. In addition the cartographic professional and commercial mainstay will draw upon marketing, customization and value-addition of basic cartographic information derivable from Govt. or corporate sources.

With the articulation on the current traits and trends and near future imperative of cartographic professional presented in the foregoing paragraphs, a discussion and deliberation on certain topics looks opportune:-

(a) Feasibility and modality of incorporating introductory course on comprehensive and composite Geospatial Science in High School Education system of the country. For this appropriate syllabus as well as an integrated textbook on the subject, preferably in Hindi and some more regional languages, needs to be developed and submitted to appropriate Govt. agency for consideration.

(b) Serious deliberation on the future trends and imperatives of the Cartographic/Geospatial scenario, and the modality of the profession.

(c) Deliberations on regulatory frame work for utilisation of data by various sections of the society is yet another issue which needs deliberations.

We have therefore fixed the panel discussion at this Congress on 'Future Trends and Pointer of Cartographic/Geospatial Profession'. NHO and INCA

will earnestly extend their helping hand in collaborating endeavours on these fronts. Commitment of INCA at creating geospatial awareness amongst younger generation in the country is strongly manifested in its National Map Quiz programme, and also in the provision for a moderate GIS training for academic fraternity of INCA who may not have had any formal training in it.

On behalf of hydrographic and cartographic fraternity of Indian Naval Hydrographic Department, I once again welcome all the guests and delegates to this Congress, and hope they will have a comfortable stay as well as very fruitful deliberation over these days. Once again I wish to convey my heartfelt gratitude to the honourable Chief Guest Shri Aziz Qureshi, Governor of Uttarakhand and Admiral DK Joshi, Chief of the Naval Staff for having spared their valuable time to be here today. And before I conclude ladies and gentlemen my thanks to all for lending me a patient hearing.



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

KEYNOTE ADDRESS

ADMIRAL D. K. JOSHI, PVSM, AVSM, YSM, NM, VSM, ADC

Chief of the Naval Staff

His Excellency Dr. Aziz Qureshi, Hon'ble Governor of Uttarakhand, Vice Admiral SK Jha, Chief Hydrographer to the Govt of India, Shri Swarna Subba Rao, Surveyor General of India, distinguished guests, delegates, ladies and gentlemen.

I am extremely happy to be here, on this land mark occasion of the 32nd International Congress of Indian National Cartographic Association and feel honoured to deliver the key note address.

I am conscious that the congregation I am addressing consists of professional cartographers, Geographical Informational System (GIS) experts, scientists, academicians, administrators and practitioners of various disciplines related to cartography.

The focal theme of this Congress **'Cartography for Sustainable Earth Resource Management'** is a fundamental necessity for sustainable development. It is a subject of vital significance worldwide. I must compliment Indian National Cartographic Association for selecting this very topical theme.

I would like to dwell a little on **Sustainable Development**. The most widely accepted definition of sustainable development is the report **'Our Common Future'** from the World Commission on Environment and Development also known as the **'Brundtland Report'**. The report states that 'Sustainable Development' is a development that meets the need of present without compromising the ability of future generations to meet their own needs. It contains with in it, two key concepts. One is the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given. The second is the idea of limitations imposed by the state of technology on the environment's ability to meet present and future needs. This second concept is of significance to the theme of this Congress.

Development by nature also is spatial or territorial, since all development takes place at certain spots on Earth, which can be mapped and represented by co-ordinates. For any region there can be important spatial characteristics, which in many cases require that the spatial information is correctly communicated so that the territory is effectively utilised for development. It is in this context that cartography or to be more precise, modern digital cartography, steps in.

Cartography has been practiced since ancient times. For many centuries its highest application was the production of hand-drawn flat maps and charts assembled from information collected visually by explorers and observers. Joseph Schwartzberg, the Professor of Geography from University of Minnesota, believes that the Indus Valley Civilisation, dating back to 2500 to 1900 BC, may have known cartographic activity. His hypothesis finds root in excavated surveying instruments and measuring rods. However, the oldest surviving world maps are the Babylonian world maps from 9th century BC. Though these were not as accurate as modern maps, but are fascinating record of the knowledge and vision of that time.

Over a period of time cartography has evolved into a highly advanced graphic tool for visualization of spatial data. In fact from being difficult to access till a decade ago, today the common man is accessing spatial data like never before for his daily chores. Today Google Maps and GPS receivers are available on all mobile phones. Many therefore consider cartography to be a barometer of the evolution of civilisation and that it reflects the growth of myriad technologies such as, printing, controlled flight, space science, computers and above all, geographical exploration.

In cartography, technology has continuously changed in order to meet the requirements of cartographers and users of the spatial information. The ancient maps were manually created with brushes and parchment. Today digital cartographic techniques are being used to produce powerful and effective visual communication of spatial information and data. Modern cartography is closely integrated with Geographic Information Science and the theoretical and practical foundations of **Geographic Information System** have been the game changers. The evolution of **Geographic Information System** is the story of the growth of information and communication technologies application to geographical studies. Beginning with the use of computer graphics in 1970s, these days most maps and navigational charts are made using specialised software.

Geographic Information System and digital cartography provide essential tools for storing spatial information in database, analysing data and displaying spatial information in desired format on demand. Geographic Information System makes it possible for spatial information to be combined easily with associated non-spatial data, highlight mapped phenomenon with a large number of attributes, analysis and display of queries, and perform advanced spatial assessment. Thus Geographic Information

System affords increasingly dynamic, interactive maps that can be manipulated digitally.

This characteristic of Geographic Information System is making it the most preferred tool for mapping the scarce and finite resources on the earth for effective management. This would be extremely difficult with traditional manual or non-spatial informatics approaches. Consequently modern cartography, riding on Geographic Information System is overcoming the limitations of technology on the environment's ability to meet the present need of resources for development.

Today, geospatial information is fundamental to what happens or what is found, where, and why. Geospatial professionals have a vital role in sustainable earth resource management through the discovery, access and application of spatial data for policy-makers, planners and managers. The Government of India's Remote Sensing Data Policy adopted in 2011 aims to allow access to remote sensing data upto one meter resolution on an on-discriminatory basis. This has opened up a vast repository of information, hitherto restricted.

'Indian Navy–Maritime Power for National Prosperity', the theme adopted by us for the year 2013, is raison d'etre of our existence. The National Hydrographic Office, a vital element of Indian Navy in its unique way is a major contributor to **Earth's Resource Management,** Consequently national prosperity. The hydrographers of Indian Navy are the proprietor promoters of marine geospatial science in India. The world's oceans are yet to yield their full potential. With maturing of technologies for harnessing ocean resources, the maritime orientation of human activities is expected to increase exponentially. The valuable collection, collation, analysis and communication of spatial information and data from maritime domain, by Chief Hydrographer and his team, would be the driver of management of ocean resources by our nation.

I am sure that the papers being presented in the next couple of days are poised to provide insight into several issues vexing Earth's Resource Management. I am further sanguine that Congress like these provides a platform to experts and specialists in providing a firm direction to the policy makers, in mapping the future for managing and conserving of our scarce resources. While looking at sustainable development to meet the need of present, sustaining our environment for the future generations is also a priority for us.

I extend my best wishes to the organisers and delegates of the Congress and wish them fruitful deliberations. I am confident that the debates during the congress will help cartographer fraternity consolidate their learning.

Jai Hind

INAUGURAL ADDRESS

Dr. AZIZ QURESHI

Honourable Governor of Uttarakhand

Admiral Devendra Kumar Joshi, VAdm SK Jha, Dr. S Subba Rao, Shri Vinay Badhwar, Mayor of the Dehradun Shri Vinod Chamoli, Lt Gen Manvender Singh, Maj Gen Yadav, friends and comrades. It is a proud moment of my life to be amongst the bravest sons of India who are the guardians and defenders of our seas at the cost of their lives, they guarantee the sea coasts are safe and no intruder should be allowed to enter the Indian waters and violate the norms of peace and harmony and threat to our integrity. The history of Indian Navy is the history of valour, signifies bravery, courage and nationalism personified. We cannot forget the mutiny of brave soldiers of Indian Navy when they raised the banner of revolt against the mightiest imperialist power at times and supported the national movement to drive them out from our society. During the last two world wars and particularly in our conflict with Pakistan and China when we were at war with both of them, whatever history signifies is its bravery in the true spirit of illustrious traditions of Indian Navy, they have made Its soldiers, sailors and officers efforts is unforgettable. I salute them and bow my head and pay my deepest regards to their valiant services. In the high tides and sea storms against the enemy's invasion they will scribe entries with their blood twirled in tears and threats in the angry sea and became immortals.

I remember, who can forget the brave Kashmiri Captain of a ship who went down with the ship and I think it was during Pakistan war when his ship was hit by Pakistan torpedo, he asked everybody to abandon the ship and pushed them out to the water but himself went down keeping the valiant traditions of Navy that the Captain goes with the ship and gives away his life, who can forget him.

At the moment, it is really a proud occasion for Uttarakhand as the National Hydrographic Office, Dehradun is organising this three day international congress of the Indian National Cartographic Association of India. The focal theme of the congress "Cartography for Sustainable Earth Resource Management" is extremely relevant and sustainable development is not possible without assessing hazards minimising risks and enhancing awareness. All these are done by cartography. Cartography helps us to understand coastal changes and other tidal phenomenon and their management. Among other themes on which the congress will deliberate on technological trends in cartography, mapping for sustainable development, Cartography in environmental planning and advancements in marine cartography.

INCA is a non-profit professional body of cartographers established in 1979 at Hyderabad to foster cartographic research in India and provide academic interaction with the inter disciplinary frame. The INCA has to create awareness among the public, the INCA is shared by many public and private bodies. Since its inception Cartography in India had been many changes and the INCA has evolved greatly and is become multi dimensional. The host of the congress, Indian Naval Hydrographic Department under the Chief Hydrographer to the Govt of India, is a direct descendant of the Marine Survey of India founded in 1874 by the Britishers.

The Naval Hydrographic Office at Dehradun was established in 1954 which has been renamed as the National Hydrographic Office in 1997 in recognition of its national stature and stated international role. The Indian Naval Hydrographic Department has completed 300 yrs of hydrographic surveying in Indian waters and National Hydrographic Office celebrated 50 yrs of dedicated service to the maritime safety in Indian Ocean on the first of June 2004. NHO is the national authority for publication of Navigational Charts and Publications essentially required for safe navigation of ships. It provides liable and updated information for safety of navigation at sea. It interacts with various agencies at the national and international levels in hydrography and oceanography. The exhibition of maps, charts, globes, models and remote sensing equipment which have been organised as part of this international congress will be of great importance and benefits for the cartographic community present here. I appreciate the theme choosen for the congress and sincerely hope that the deliberations would provide the necessary thrust and directions in finding solutions for sustainable earth resources management through cartography.

While fully appreciating these three days international cartographic congress of the Indian National Cartographic Association, I sincerely offer and extend every support on my behalf and on behalf of the Govt of Uttarakhand to the association and I sincerely hope the thousands of people of India and particularly those who stay in Uttarakhand will benefit from this endeavour and it will write a new chapter in the naval achievements in the history of India.

I salute you all, Indian Navy Zindabad.

Jai Hind



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

THE REPORT OF THE XXXII INCA CONGRESS

Captain Sajeev K. Nair
Organising Secretary XXXII INCA

Indian National Cartographic Association (INCA) is a professional body of Cartographers, academicians, professionals and members of allied specialisation in India with its headquarters at Hyderabad. The XXXII Indian National Cartographic Association International Congress was held at Dehradun from 11-13 Oct 12. The congress was organised by INCA and NHO under the guidance of VAdm SK Jha, NM, Chief Hydrographer to the Government of India and President of INCA on the focal theme "Cartography for Sustainable Earth Resource Management". Admiral DK Joshi, PVSM, AVSM, YSM, NM, VSM, ADC, Chief of the Naval Staff was the Chief Patron for the event. The Congress was organised at AMN Ghosh Auditorium, ONGC Dehradun in a befitting manner.

The main theme was further divided into sub-themes namely: Technological trends in Cartography, Integrated mapping and space technology, Mapping for sustained development, Geomatics in disaster management, Thematic map surveying and GIS, Cartography in environmental planning, Coastal and marine mapping, RS and GIS for water resource mapping, Hydrography for resource management, Cartography for urban and regional mapping, Natural Resource Management at sea and on land, Advancements in marine cartography, Land Mapping and resource management, Cartography for Human resource management, Industries Perspective-case study and application

About 300 delegates comprising of professional cartographers, professors, research students etc from various states of India, Union territories attended the three day Congress. The representation from the government organisations, such as Survey of India, Indian Space Research Organisation, National Atlas & Thematic Mapping Organisation, Indian Institute of Remote Sensing, Geological Survey of India was impressively large. In addition, faculty members, research fellows and students from universities and colleges participated in a big way with great enthusiasm.

The inaugural function commenced at 1130 hrs on 11 Oct 12 with the arrival of Chief Guest His Excellency Dr. Aziz Qureshi, Honourable Governor of Uttarakhand. The welcome address was delivered by Cmde V Badhwar, NM, Principal Director of Hydrography, Chairman, Local Organising Committee followed by the Presidential Address by VAdm SK Jha, NM, Chief Hydrographer to the Govt. of India. The Key Note Address was delivered by Admiral DK Joshi, PVSM, AVSM, YSM, NM, VSM, ADC, Chief of the Naval Staff, introducing the focal theme of the Congress "Cartography for Sustainable Earth Resource Management".

During the inaugural function, Souvenir of XXXII INCA International Congress was released by the Chief Guest, followed by the release of Indian List of Radio Signals Vol. 6 by Chief of the Naval Staff and Indian Wreck List by Dr.Swarna Subba Rao, Surveyor General of India. The Proceedings of the XXXI INCA International Congress, Indian Cartographer Vol. 31, organised at Chandigarh was released by the Chief Hydrographer to the Govt. of India.

INCA Map Quiz is conducted every year by various branches of INCA to increase the cartographic awareness of children wherein the qualifying schools compete at National level to generate interest of young minds in reading and making maps. Students at the school level participate in this. The schools which secured first, second and third position were awarded prizes this year,Team I of St. Xaviers High School, Patna stood first in the national level Map Quiz and was awarded the rolling trophy, by the Chief Guest. The second prize was shared by Rashtriya Indian Military Academy, Dehradun and Team II of St. Xaviers High School, Patna, the third prize was secured by DAV Public School from Bhubaneswar, Odisha.

The Chief Guest delivered the inaugural address emphasizing the relevance of cartography in today's world of depleting resources. He also highlighted the challenges faced by cartographers in collating data derived from various sensors and channelising them into products which can be rendered to planners for management of sustainable earth resources. Captain (Retd) NS Rawat, was felicitated during the function for his vital contribution for commitment towards Maritime community and Mr Rajesh Alla of IIC Technologies for their capability in varied field of marine, heritage and terrestrial mapping including geo surveys and software solutions and providing its expertise and support to numerous Hydrographic Offices around the world. The inaugural function concluded

with the vote of thanks delivered by Cmde KM Nair, NM, Principal Director of Hydrography wherein he thanked the dignitaries, guests, and delegates, he also expressed special thanks to the organisations and individuals who provided support towards successful conduct of the Congress.

The Chief Guest thereafter inaugurated the Congress Exhibition where various organisations had displayed their strengths in modernised mapping equipments to the latest advancements in charting and cartography. National Remote Sensing Centre, Hyderabad, National Atlas and Thematic Mapping Organisation, Kolkata, Survey of India, Inland Water Ways Authority of India, National Hydrographic Office had put up stalls in the Exhibition area close to the Venue. The state of art technology in field of remote sensing, GIS, and GPS were also displayed by various exhibitors from the Industry.

A few special lectures were delivered by imminent personalities as lead papers in areas concerning the theme/subtheme of the Congress, the lead speakers included Prof. J. L. Jain of Sagar University and Ex President INCA, Dr YVN Krishna Murthy, Director IIRS, whose topic was delivered by his representative, Dr AK Gupta Director of Wadia Institute of Himalayan Geology and Prof. (Retd) PS Tiwari. During the course of Congress, technical sessions were held on various sub themes where in 70 papers were presented by authors from national organisations, corporate representatives and research scholars from eminent institutions. The technical sessions were chaired by eminent scholars including Shri A K. Malik, Former President INCA and Joint Director, NATMO, Kolkata, Mr S Muralikrishnan, NRSC, Maj Gen RC Padhi, Survey of India, Maj Gen C Chatterjee, Survey of India, Cmde Adhir Arora, Principal Director Directorate of Hydrography, Cmde Ravi Nautiyal, Addl Principal Director National Hydrographic Office, Dr. Krishna Mohan, Punjab University, Dr. Anuradha Banerjee, Jawaharlal Nehru University, Prof. Jitendra Shukla, Ranchi University, Maj Gen A K Sinha Group Cdr 501 Field Survey Engr Group, Prof. R K Trivedi, Dr. H S Gour Central University.

Prof. V C Jha, Director, NATMO delivered the S P Chatterjee Memorial lecture on the topic 'Geomorphology and Thematic Mapping in the 21st Century 11 Oct 12 and Dr. Prithvish Nag, Vice Chancellor, Mahatma Gandhi Kashi Vidyapeeth delivered the Todar Mal lecture on 13 Oct 12 both the memorial lectures were well received and acknowledged by the audience.

During the closing ceremony of the Congress, the best paper presenters during the Congress were presented certificates and cash awards by VAdm S K Jha, Chief Hydrographer to the Govt. of India and the President of INCA. 05 past presidents of INCA namely Shri B.M.L. Sharma, Dr. P Nag, Prof. JL Jain, Shri AK Malik and Prof. Surya Kant were felicitated with shawls on the occasion. The outgoing president VAdm S K Jha, NM and incoming President Dr V K Dadhwal were also felicitated on the occasion. Towards the closure of the General body meeting Prof. Surya Kant, Ex- President INCA spontaneously congratulated and complimented the President and his team for organising the XXXII INCA Congress in a very successful manner. He described it as one of the best organised INCA Congresses in the true word and spirit of professionalism displayed, meticulous planning and execution giving consideration to the minutest of details.

Apart from the extensive professional deliberations the Congress also provided a cultural extravaganza with the Navy Band performance on 11 Oct 12 which was followed by cultural programme by a professional folk dance troupe from Rajasthan and a musical evening by a cultural troupe 'Swar Spandan' on 12 Oct 12.

Professional deliberations, social interactions, cultural events and the whole hearted participation and free exchange of thoughts including the way ahead for the profession of Cartography were the key milestones of the Congress.

GLIMPSES - XXXII INCA



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

INAUGURATION



Lighting of Lamp by the Chief Guest



Release of Souvenir



Release of Hydrographic Publication



Felicitation of the Chief Guest



Inauguration Venue



Section of the Audience

EXHIBITION



Inauguration of the Exhibition



Exhibition stalls at the Congress



Walk around of stalls by Chief Guest



Chief Guest visits stall at Exhibition



Poster session at the Exhibition



Delegates at the Exhibition

MEMORIAL LECTURES



Dr. P. Nag, VC, MG Kashi Vidyapeeth delivering the Todarmal Lecture



President INCA felicitating the Speaker



Prof. (Dr.) V.C. Jha, Director, NATMO delivering the SP Chatterjee Lecture



Cmde K.M. Nair, Principal Director of Hydrography felicitating the Speaker

INCA MAP QUIZ - 2012



Winners -
St. Xaviers School, 'A' Team, Patna



Runner Up -
RIMC, Dehradun



Runner Up -
St. Xaviers School, 'B' Team, Patna

SPEAKERS

















SPEAKERS

















SPEAKERS

















SPEAKERS


















BEST PAPER AWARD WINNERS











FELICITATION OF PAST PRESIDENTS













FELICITATION BY INCA TO PRESIDENT XXXII INCA









CULTURAL PROGRAMME





Navy Band enthralls the audience





Musical evening by Swarspandan Group





Rajasthani folk songs & dances

MEMORIAL LECTURES



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

S. P. CHATTERJEE LECTURE

Geomorphology and Thematic Mapping in the Twenty first Century

Professor (Dr.) V.C. Jha
Director. (NATMO)

Respected and esteemed personalities present here today and honouring this thirty second Conference of the Indian National Cartographic Association (INCA) by their august presence, distinguished members of National Hydrographic Office (NHO), my dear young and budding cartographers committed to a larger vision for new dimensions and application of Indian and international cartography, Ladies and Gentlemen.

I deem it a great honour and privilege to be invited by the members of Organising Committee of the INCA to deliver "Professor S P Chatterjee Memorial Lecture" in this year's Conference at Dehradun. The honour is all the greater for the faith bestowed upon me the midst of many learned and stalwart cartographers. It is indeed, I honestly confess, a difficult task to address an academic association of specialist cartographers who enter into various disciplines of physical and social sciences including geography. It is true that Geography as a discipline has evolved to its present status basically from the background of cartography for drawing and mapping of the spatial details of a part or whole of the earth. Even in this age, the sustainability of geography depends upon the new and advanced techniques and tools of cartography. Our organisation, the National Atlas and Thematic Mapping Organisation (NATMO) is fully devoted to prepare a series of maps on various themes with their relevance for social well-being through planning and management of space. Thus, our Organisation has close relationship with your Association; because they are inseparable.

This is a Memorial Lecture in the memory of a stalwart in Geography, ***Professor Shiba Prasad Chatterjee*** (Feb.1903 – Feb.1989), popularly known as Prof. S. P. Chatterjee by most who belong to the disciplines of geography and cartography as well as other allied disciplines. Therefore, kindly allow me to offer a humble tribute to one of the greatest personalities in the world of modern Geography both in India and abroad.

An awardee of the prestigious ***Padma Bhushan*** in 1985 from the Government of India, Professor Chatterjee had a brilliant academic and research career. He was keen on innovation throughout, a person of unique and admirable quality, dedication, outlook, ambition and scientific skill. It was his zeal for research that he earned his D.Litt. degree from the *University de Paris* at Sorborne in 1936 for his pioneering work *Le Plateau de Meghalaya* under the guidance of the then celebrated French geographer *E.de Mortonne* after passing his masters in Geology from Banaras Hindu University in 1926 and teaching geology and geography from 1928 to 1932 in the University of Rangoon where he served as Head of the Department of these dual disciplines too. His love for geography was translated through the opening of the Department of geography under Calcutta University where he taught and developed the subject and the department as founder teacher and Head till his retirement in 1967; though he kept a lifelong attachment as Emeritus Professor with the Department.

Professor Chatterjee, from the very beginning, was a man of vision. He felt the necessity of establishing a Geographical Society in India. Calcutta being a premier centre for the study and teaching of Geography in undivided India was considered as an appropriate place to start a geographical society. Thus, the Calcutta Geographical Society, now known as the Geographical Society of India, was established by his efforts in 1936, which started publishing a research journal in late forties in the name of Calcutta Geographical Review, and afterwards Geographical Review of India which is perhaps the first of its kind in the country.

Professor Chatterjee's reputation as a teacher went far and wide. Invitations came from Universities all over the world. Assignment came on to him as Visiting Professor at the Universities of Georgia (Athens) and Austin (Texas) in the USA in 1963, at Moscow University and at the Universities of Paris and Heidenberg in 1963 and at the California State University during the period 1970-72.

Professor Chatterjee was a nationalist first. It is evident from his creation of National Atlas & Thematic Mapping Organisation which I belong to. It is considered to be a brain child that was nourished and developed to world standard and reputation by his ceaseless efforts, utmost care and dedication and above all his towering personality, expertise and experience gained through as a visiting academician almost all over the World and interaction with great personalities. Prof. Chatterjee formulated for the first time, a proposal for the compilation of the National Atlas of India, containing maps on various features of the nation. The authorities in the Central Ministries were highly impressed and convinced about the essentiality of the project. It was at the instance of Pandit Jawaharlal Nehru, the then Prime Minister of independent India, that National Atlas Organisation was established in 1956 under the second Five Year Plan. Professor Chatterjee was appointed the first Honorary Director of the Organisation. This

organisation produced Bharat Rashtriya Atlas (in Hindi) in 1957. It was this mission that led Prof. S. P. Chatterjee an educationist par excellence and the head of Department of Geography, Calcutta University to take up cartography as the bridge between geographers and social scientists who could now come together on a common platform and solve issues related to land use, resource extraction and utilisation, demography, disaster prediction and management and till date newer uses of cartographic data for planning and nation building. In 1978, the name of the Organisation became National Atlas & Thematic Mapping Organisation (NATMO) in order to widen the scope of activities. Under his direction, its activities multiplied and status was elevated to a renowned mapping organization of the world. It is his inspiration that NATMO is progressing with innovating themes, techniques and tools till today. His contribution to the cause of geography and cartography is countless. He was a man of large vision. However, I would like to pay my humble tribute to Prof. Chatterjee by emphasizing on ***his basic interest, geomorphology*** the platform which he would used to build upon his greater interest in Geography.

The modern times have witnessed a multitude of changes which have taken place in our quest for a better quality of living. We have learnt to predict natural disasters to a large extent, analyse causes for the calamities that have taken place and undertake rebuilding and relocation of the infrastructure and populations to safer and stable grounds. As the modern age demands, it is the quick distribution of data that is easily understood that makes all the difference to any nation to gain success as a developed nation. To be more simple it is how simply, technology can be a part of lives of the nation's populace in an easily comprehendible format that gives a better quality of life to all. Most of the problems facing the Earth today can be related to those arising out of climatic change, problems of adaptations and change in habitats within our biosphere. The quality and nature of terrain, its location and its potential that can be utilised as a resource, is definitely crucial to pave the way for welfare of the common people. Our country has a vast and diverse array of natural resources .They are located in both easily accessible and distant places which are difficult to reach .Yet the modern methods available now seem to offer immense support for such investigation of natural spaces, eco-zones, climatic processes which influence us and the geomorphology of the terrain altogether.

Mapping of any region can thus be considered as an important factor to carry out any investigation based upon areal qualities and analysis can be based upon the attributes gathered. Layers of information can be incorporated in a single map or in a particular theme based one that can be brought under scrutiny.

The power of mapping in the days to come was envisaged by Prof. S. P. Chatterjee the founder – Director of National Atlas Organisation. At the time of Partition of our country Prof. Chatterjee prepared a map of undivided Bengal showing the distribution of population based upon religion within the region which was a great help to analyse the mass migration of population due to religion based issues on both sides of the border. This map was jointly published with the help of Survey of India the pioneer in those days for mapping and resource explorations. In 1950 Prof. Chatterjee was the first Geographer to carry out a survey based upon landuse solely in the district of Howrah, West Bengal and was thus appointed as a member of the Damodar Valley Survey, Board of Landuse Committee on National Resources of the Government of West Bengal and the Executive Committees of Indian Council of Social Science Research. His close association with the Damodar Valley Corporation resulted in the preparation of the Planning Atlas of Damodar Valley Region much later in 1969 as multipurpose river valley projects that gained importance as the sole way to ensure continuous irrigation to the agricultural fields during erratic monsoons in post independence.

The National Atlas of India was compiled and published in eight volumes (in English).These atlases were enthusiastically received and highly appreciated which led to Prof. S.P. Chatterjee to receive the Murchison Grant from the Royal Geographical Society of London in 1959,which was indeed a rare honour for any geographer. The 21st International Geographical Congress organised by Prof. Chatterjee in 1968 brought about a large number of publications covering various aspects of Geography of India and the other developing countries of our subcontinent. He was entrusted to write about the progress of geography on behalf of the Indian Science Congress Association. Later the same year he was approached by the International Association of the Agricultural Economist based in Italy, to contribute a chapter on India for their publication entitled Atlas of Agriculture. He contributed a chapter upon 'Himalayan Mountain Ranges' in the new Encyclopedia Britannica. Prof. Chatterjee's explanatory notes in the national atlas plates are being used till date, which help a number of geographers and researchers.

The National Atlas Organisation gradually became the foremost organisation to employ the largest number of geographers in the world, owing to the tireless efforts of its founder and first Honorary Director, Prof. S. P. Chatterjee. The Irrigation Commission of India in the late 1960s approached Prof. Chatterjee to prepare irrigation atlas of India which would facilitate the distribution of irrigation waters, given our erratic monsoons in a nation which is chiefly dependent upon agricultural produce. The first ever 'Irrigation Atlas of India' was published in 1970 with collaborative data from the Irrigation Commission by the National Atlas Organisation though Prof. Chatterjee had retired in the year 1969 as Director. He continued his association with the

Organisation as the Chairman of the Advisory Board of the Organisation.

National Atlas and Thematic Mapping Organisation (NATMO) as National Atlas Organisation is now known, has to carry forward the legacy of excellence and the vision of nation building as thought of by its founder. Cartography, is the backbone of this organisation and that supplies crucial information to all planners in the form of maps for problem analysis of any region, to formulate policies and suggest solutions, ranging from urban to rural problems of traffic congestion, pollution, irrigation networks for planning crops, setting up of industrial sites, mineral extraction and a multitude of other theme based data. In this modern age with the availability of satellite images, mapping and cartographic applications have taken up a new dimension altogether. This tool is not the prerogative of a select few but widely available and popular among the common man. The speed and precision with which one can have access to reliable data is worth awe.

Mapping offers a tremendous potential for development as it offers a variety of theme based information, and with the modern age of digitisation, data dissemination after preparation of suitable map is more precise and quicker. What mapping using satellite data can actually do is reduce the manpower, time and costs that have to be allocated for ground surveys. Thus both initiation and completion of projects can now be done with fewer burdens upon our nation's expenses. Satellite images over a period of time can be compared to note any changes in terrain quality and also the changes that can take place in the times to come. This will help to plan and execute any long lasting infrastructural development accordingly.

Taking up the subject of thematic mapping in the present times I wish to deliberate that a specialised exercise like this needs precise inputs from an allied subject like geomorphology. Geomorphology and thematic mapping in 21st century together have a crucial role to play as far as nation building is concerned and beyond .Today the horizons are limitless with terrain evaluation being the foremost prerogative for any developmental project visualization for the nation. The problem starts with space- its paucity, proper utilization, its potential for further development, accommodating the growing masses in a planned way, what risks it can face and hence an alternative. These questions, as raised, have to be addressed within a particular time limit too. Geomorphology which dealt with land surface configuration is now offering answers to these problems in modern times with applied geomorphology. Applied geomorphology by its own merit has opened up a new vista for resource mapping and management, disaster estimation and prevention and impact minimisation. Today land systems and resource mapping is an integral part of applied geomorphological studies.

The central theme of my address therefore, is ***Geomorphology and Thematic Mapping in the Twenty-first Century*** as the INCA and NHO are good and appropriate platforms for it, where intellectuals or trained academicians have the capacity to generate and assimilate ideas and articulate them. An intellectual geomorphologist is assumed to be a person whose stand on the thematic maps and thereby societal issues in particular is taken on the basis of reasoned thought. I, therefore, request you all to allow me to express my views incorporating some ideas drawn from the past, recent trends and future course of action on my theme.

In this case listeners are never consulted; they simply have to accept the whims of the speaker, although they may, of course, fall asleep in protest.

Geomorphology offers limitless opportunity in the form of land-surface studies. Landforms are a result of forces operating both on the surface as well as beneath. Geomorphic ideas can be noted in the works of *Aristotle, Leonardo da Vinci* from the past. This aspect of analysis can be extended to other planets now with the intensive exploration studies being carried out in the recent decade. It is not only the shape of the landforms already existing but how they have been brought about and the possible shapes in future are a part of investigation in geomorphology since the advent of the 18th century. Crustal instability, interspersed by relative phases of stability, climatic processes on landforms where major concerns and considerable period of researches where devoted. Later on, since the 1960s the contribution of geomorphology to geo-technology and environmental management was accepted widely. Thus applied geomorphology has opened up a new vista for resource mapping and management, disaster estimation and prevention or impact minimization, upon us. There is no dearth of funds for research positions in universities and organisations dedicated to such a purpose .With the rapid progress in planetary investigation, geomorphology by its own merit will pave the way for newer opportunities in planetary surface morphology as well.

Geomorphology today is standing on the threshold of a new era where the pulsating problems of changes in temperature and precipitation regimes, environmental hazards and climatic changes leading to slope instability, soil erosion, land degradation, desertification, river floods, rising sea levels and submergence of coastal areas together with the burgeoning population has fuelled the imagination the resolve of geo-scientists, geo-technologists, geomorphologists, hydrologists, soil scientists, researchers to think of a plausible alternative which shall be beneficial to mankind.

The possible landform shapes evolved due to specific climatic regimes and physical processes have been investigated for our planet and this knowledge

requires to be used as platform to study the natural processes that shape the craters, the plains, the ice covered depressions on the planets which are subject of study now and being probed by the instruments sent by us. It needs to be emphatically mentioned that geomorphology today in this century stands a fair chance to deliver the much needed answers to the questions rising out of today's landform and landscape problems accentuated by anthropogenic factors. It is not a single search engine to find answers to geomorphic problems but encompasses the whole gamut of interactions between the hydrosphere-lithosphere –atmosphere.

The chief platform for any geomorphological studies is - applying suitable theme-based techniques of mapping to extract geo-information about any terrain. The information can relate to operation of geomorphic processes, the regions affected by such processes, the changes brought about in the landform features and the scope or potential for geo-hazards, is possible as these processes happen slowly over a considerable period of time and hence can be compared over a long interval by the discerning geomorphologist.

Changes in courses of rivers, changing coastlines, extension of mangrove coasts, increased siltation by rivers, and affect upon settlement patterns because of natural factors can be suitably mapped and the gradual changes can be recorded. Precise interpretation of relief now is not a tough task with the advent of remote sensing, GIS and GPS techniques and thus geomorphology now has a concrete footing in the field of earth studies as well as of the other planets which are being reached till now. The modern emphasis now being on accumulating geospatial data, it not only allows to locate and visualise the available assets of a region but their relationship with that of the surrounding. Thus, geospatial data can be used to monitor transport corridors, pipeline and utility monitoring, emergency planning, mining and earthworks and resource management.

Uses of mathematics, statistical techniques and fractal analysis are the main concern of the 21st century mapping using geospatial information techniques. For example, now INDIA's Population is 121 crore. We can prepare Demographic Analysis Structure by incorporating mathematical and geospatial analysis and mapping. Not only that, the need of food, Infrastructure and other facilities needed for our present day age-group of 10-15 years can also be yielded through Applied Mathematics geospatial information. Even after 15 years when this age-group will become youth, their requirements that can also be projected using mathematical geospatial techniques. Hence, it is very essential to use the Knowledge of geospatial space to full fill the demands of the Society. In fact we have to push the Pyramid from Very Poor to well to do, keeping in mind Health, Education, Energy and Food safety and security in 21st century.

Geomorphology has over the recent decades progressed tremendously. In today's world it has proved its indispensability in almost all spheres of modern life beginning from terrain evaluation and assessment for civil construction and urban planning to slope stability studies for tackling issues of landslides and avalanches. Nations around the world now are banking on geomorphologists to explain, advise and develop models for disaster management and mitigation for social welfare. Changes in the structure and shape of landforms are gradual and continuous in the case of exogenetic influences like processes of erosion and sometimes sudden with catastrophical results the case of endogenetic influences like volcanism, earthquakes, plate movements. The onus lies on geomorphologists to successfully ascertain the risk factors, the terrain zones that may affect anthropology due to geomorphic processes operating on the surface of the earth in that particular area. What better opportunities does geomorphology has today, with the advent of remote sensing, GIS and GPS techniques and tools which can be utilized for civilian purposes as well. With the advent of high resolution satellites, new practical applications in the areas of urban sprawl, infrastructure planning, assessment of desertification and depletion of forest cover, palaeo-channels, groundwater viability assessment, mineral prospecting, river control and restoration of river banks, coastal studies and transport through-fares for rapid dispersion of goods and masses are possible.

After all we have to accept the fact that nature is the most powerful entity and the success of civilization lies in how we cooperate and coexist with the nature in harmony. Any tendency on our part to go against the forces of nature and try to subjugate its forces for the selfish benefit does not go down well with her. Her dissent manifests itself in the form of desertification, as a result of depletion of vegetation cover, floods due to unchecked soil erosion and silting up of river channels, droughts and subsequent crop failures due to loss of rain forests and soil cover, reduction in the level of underground water table due to unchecked extraction and insufficient recharge because of scanty or inadequate rainfall. The desire to observe and explain the changes upon landform brought about by processes from ancient times has been the central idea of the subject. Evolution of landforms on the surface of the Earth is a continuous process and takes several decades or more to develop its individual identity. In the recent decades, more and more research and analysis in Geomorphology is being devoted to applied studies, for planning and development purposes as well as for sustained growth in a world where natural resources are constantly being exploited to supplement the burgeoning population.

Ecogeomorphology is the study of interactions between organisms and the development of landforms. Organisms affect geomorphic processes in a variety of ways *e.g.* trees can reduce landslides where their roots

penetrate to underlying rock, plants and their litter inhibit soil erosion, biochemicals produced by plants accelerate the chemical weathering of bedrock and regolith, and marine animals cause the bio-erosion of corals. Mapping of such ecological patches with their horizontal and vertical characteristics are the main concern of today using geospatial techniques.

Hydropedology integrates the pedon and landscape paradigms to link phenomena occurring at microscopic (e.g., pores and aggregates), mesoscopic (e.g., pedons and catenas), and macro scopic (e.g., watersheds, regional, and global) scales. There is a growing recognition that synergy could be generated by bridging traditional pedology with soil physics and hydrology to enhance integrated studies of soil–water relationships across spatial and temporal scales. Hydropedology is suggested as such a bridge to address: (i) knowledge gaps between pedology, soil physics, and hydrology; (ii) multi-scale bridging from microscopic to mesoscopic and macroscopic levels ; and (iii) data translations from soil survey data-bases into soil hydraulic information. It is hoped that hydropedology would contribute to our enhanced understanding of a variety of environmental, ecological, agricultural, and natural resource issues of societal importance through the hydrological models and watershed managements. These include water quality, soil quality, landscape processes, watershed management, nutrient cycling, contaminant fate, waste disposal, precision agriculture, climate change, and ecosystem functions. Moreover, the interdisciplinary emphasis of education in the 21st century will make hydropedology a timely addition to the training of the next generation of soil scientists, hydrologists and geomorphologists. (Hangsheng Lin, 2003).

Planetary Geomorphology studies the landforms on solid planetary surfaces and compares them to similar landform features on the surface of the Earth. The recognization of landforms and surfaces in images of planetary bodies have been greatly facilitated by centuries of studies of landforms on the surface of Earth. Understanding the processes that form these planetary landforms allows us to begin to understand the complex climatic and geologic history of their parent worlds. Planetary geomorphology is the latest addition to geomorphology. The discipline though new has already gained enthusiastic interest among geomorphologists with the easy accessibility to a wide variety of remote sensing data of planetary surfaces. The recent foray upon the Martian terrain is the best example. The release of NASA HiRISE data, a colour imaging data set with resolutions as high as 25 cm per pixels can be used to create meter resolution Digital Terrain Models (DTMs). Together with stereo capabilities of the ESA High Resolution Stereo Camera that can produce ~ 100 m / pixel DTMs over very large regions, we now have the tools to analyze quantitative geomorphological data at various scales (Wikipedia, 2009).

The proposed areas of study in this sub-discipline are-

(i) Remote sensing studies of the landforms of planetary solid bodies and the processes that shaped them,

(ii) In situ studies of planetary landforms from analysis of landing craft data,

(iii) Terrestrial field and laboratory studies of landforms and processes that have clear application to planetary bodies,

(iv) Geomorphological / geological mapping of surface of the solid planetary bodies,

(v) Techniques and advances in the fields such as remote sensing, GIS, and computing that are specifically aimed at improving the techniques used in planetary geomorphology &

(vi) Studies of geomorphological processes on the surface of the planetary bodies which can perhaps point to similar geomorphological processes that might take place on our planet.

In India, development of Geomorphology is actually a post-independence phenomenon. In the last few decades, it has emerged as a sub-field having interdisciplinary relations with geology, geography, climatology, hydrology, environment and other sciences. Though at World level, it has made some significant advances in its theoretical and applied aspects, yet in India, it is still in the juvenile stage with sectoral contributions.

Geomorphologists can play the most important role in the task of Geomorphological Survey particularly in the application of geomorphic understanding for solving the societal problems. In any kind of survey work, one of the pre-requisites is to ensure the complete coverage of the survey area. Delineation of survey units is the basic condition for the success of the survey work. The survey units may be at the level of meso and micro-levels. The Natural units like Geomorphic Units/Mountainous/ Hilly regions, Watersheds (Drainage Basins), Plains, forest areas, etc. may also be considered as the best satisfactory geomorphic units. So, for conducting Survey work, there must be a clear and precise system of survey units to avoid any chance of omission or duplication in data collection. In order to ensure hundred per cent coverage of the area as well as landforms and no less and no more, it is essential to identify each and every tract of land throughout the country in terms of specific natural divisions. Description about the geographical background of different geomorphic zones is also one of the important parts of the geomorphic survey. As the geographical background also plays a vital role in the spatial and temporal characteristics of the geomorphic zones. And this is possible only through preparation of maps and the application of cartographic techniques. Mapping is an integral part of any survey work. Without mapping, successful completion of survey is next to

impossible as there is maximum possibility of omission or duplication of data collection units. At present digital mapping and GIS is the basic criterion of survey process. The Remote Sensing Products are also considered as the best data source and mapping base. Not only the data collection but also the fresh interpretation of data is the prime task of the geographers. And in this field geographers in general and geomorphologists in particular hold the sole authority. Before the commencement of geomorphic survey, maps are to be prepared at various levels like meso and micro or as decided (the survey units). It will help to capture the data. The surveyors are provided with these maps for collection of data in the field. Once the data is captured these data are stored, analyzed, presented and ultimately disseminated to the data users. In addition to these, it also requires updating of maps for time series analysis as the frame of the geomorphic units changes with the passage of time.

All such exercises are neither easy nor possible with the help of traditional cartography. Hence, the necessity arises, and there is sufficient justification for the establishment of GIS (Geographical Information System) Laboratory as a supporting unit in landforms survey, where all the mapping, storage, retrieve, analysis of data, data interpretation, report writing and presentation of final results, future planning and decision making are possible in a cost and time effective manner. Maps ensure consistency and facilitate policy making in applied geomorphology. It supports data collection and can help monitoring survey work during geomorphic survey. Maps make it easier to present, analysis, and disseminate survey results in application of geomorphic understanding in planning and development. For this work, establishment of Digital Image Processing and GIS laboratory is a must because in the long run it is very cost and time effective.

The major benefits are-

1. Productivity gain and time saving
2. Cost saving
3. Generate creditability and authority of map products than traditional cartographic work
4. Better service
5. Increased accuracy
6. Income generation
7. Improved analysis
8. Improved policy making
9. Improved data sharing and
10. Improved outreach

On the other hand, achieving success in GIS application depends upon some critical success factors. There are a number of stumbling blocks that may cause a project to fail or to fall short of realizing its full potential.

The critical success components are:-

(i) A Key person to promote RS & GIS development in the organization,
(ii) High level management support,
(iii) Need based investment,
(iv) Strategic, operational and Managerial planning,
(v) GIS education and training,
(vi) Staff continuity,
(vii) Well established quality control process and Output generation and dissemination

In all these works, geomorphologists can be considered as Key persons as they are well equipped in both the theoretical knowledge of their subject and the practical use of RS & GIS. They are also well acquainted with the application of statistical techniques, geology, hydrology, anthropology and related issues which may be considered as important inputs for development planning and its implementation. Geomorphological mapping, thus, is the sole platform for further development of any form of planning and development today. To extract locational data, to record changes of urban or natural regions, to modify or carry out any form of development work involving construction of infrastructure, the role of applied geomorphology cannot be denied.

Cartography now is an important aid for India's missions in Providing Urban Amenities in Rural Areas (PURA) and the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), where cartographic data for road network, green areas, location of water bodies, existing roadways, slope of land (contours), existing sewer systems, natural drainage lines, transport nodes, alignment of settlement clusters is needed. Thus satellite images supplemented by ground surveys, remote sensing data, and aerial pictures need to be supplied to cartographers in order to prepare multi-layered thematic maps. For a developing nation like India with a fast expanding population, urban slums, encroachments, problems of vehicle parking, markets to supply needs of the new urban masses, infrastructural development, environmental management and upgradation ,planned settlements, sustainable development of resources and smooth road connectivity is the key to decision making and progress. It is mapping over a prolonged period of a particular region, using satellite data, the changes in landscapes and utility infrastructures can be recorded and monitored. This is imperative for disaster management and prediction both localised or at regional level. Earthquakes, landslides in mountainous terrain, areas ravaged by tropical storms (Aila-2009) and as a result the changing coastlines need to be regularly monitored and the data recorded to supplement a larger database for Earth sciences studies.

Cartography without geomorphological knowledge is unthinkable. The ground surveyor, photogrammetrist or cartographer in representing the earth's surface and

thus landforms in his maps, is engaged in mapping both planimetric details: rivers, coastlines, etc., and relief features. A knowledge of characteristics of the landforms involved and the effect of seasonal variations, secular changes, tidal range, etc. will enable the mapmaker to produce a map of better quality. This means he will acquire a better understanding of what he is actually doing, he maps more specifically as he is familiar with the characteristics of the features to be mapped and able to evaluate their importance and nature.

It will be evident that the use of interpretation of topographic maps, though definitely less revealing than aerial photo interpretation, is an essential part of geomorphological studies. Therefore, accurate and vivid representation of landforms on maps is of the utmost importance for the geomorphologists. Good contacts between mapmakers and geomorphologists are, therefore, mutually profitable (Verstappen, 1982). Thus the role of geomorphology in mapping and vice versa cannot be ignored .Areas of difficult terrain, slopes failures, gradual desertification of croplands are problems which have to be constantly monitored .Today the task is easier with geosynchronous satellites orbiting our globe. Constant updates are received and comparisons over a particular time span are possible as all parts of the terrain are simultaneously visible at a single glance.

"The wide range of terrain forms occurring in nature and depicted on topographic maps can be explained by the geomorphologists from a variety of endogenous and exogenous, causative factors and their different degree and period of activity. The differences in terrain thus produced, are so noticeable that conclusions can be drawn from a good topographical map concerning landform types, lithology, etc. Inversely, it is possible, once a proper idea of the nature of the landforms has been obtained by the geomorphologists, to assist the mapmaker in producing a better picture of the terrain configuration." (Carlsberg, 1958; McDonald, 1963; Mietzner, 1964; Pannekoek, 1946, 1962; Elvhage, 1980; Verstappen, 1982).

A distinct and significant correlation occurs between the nature of terrain and settlement and landuse patterns. This has to be analysed in detail and application of geomorphic knowledge is absolutely necessary. The settlement and landuse patterns are dynamic features over any terrain and gradually change with the gradual operation of geomorphic processes initiated by change in climatic regimes. Thus the flourishing river valley civilizations of *Mohenjodaro –Harappa* along the banks of the Saraswati and Indus i.e. the Ghaggar catchment in Rajasthan and the Saraswati-Drisadvati-Yamuna catchment in Haryana, the Mesopotamian civilization between the interfluves of the Tigris and the Euphrates during mid-Holocene are lessons to be learnt from the past. These civilizations gradually disappeared with deforestation, shift in landuse patterns which led to degradation in the quality of farmlands and shortage of croplands, tectonic movement causing change in river courses, marine transgression due to eustatic sea- level changes evidenced by Lothal (ancient busy port town in Gujarat, India) and their gradual drying up and limited capacity of semi-arid ecology to sustain large sedentary population (Agarwal, 1992).

The security and sustainability of natural resources for the masses requires the constant generation of natural self renewable products in order to maintain a greener planet and a welfare nation. Progress in the field of geomorphology has not only given us a better perspective to address these problems as elaborated just now but increased the scope for problem solving in association with geology, engineering geology, geodesy, archaeology, biological sciences, palaeochannel studies, soil studies, climatology, oceanography, seismic studies and occurrences of volcanic hotspots.

Cartography as evident now has a varied field and thematic maps have their basis in geomorphology .All geological, soil, hydrological, vegetation and landuse maps simply serve thematic information in the initial phases. For example, Hydrological maps, besides supplying information on surface and groundwater, geological formations which support the accumulation of water, also include data on the shape of the river basins, density of relief dissection, slope of the land and hence the irrigation requirements of the region can be ascertained. With the changing times it is required that constant updating to latest techniques is to be done. This is necessary as the problems challenging us are now manifesting themselves in newer forms also. The emphasis now is how to reduce casualties in times of natural calamities, how to prevent entire croplands from being turned unproductive, how to enhance better crop yields to feed the increasing population, rainwater harvesting in dry areas, preventing runoff and retaining soil moisture.

Cartography can be successful if the output not only saves costs but time as well.GIS laboratories are essential now both for land surveys and mapping. Establishment of Digital Image Processing laboratories not only generate credibility and authority to cartographic products but in the long run results in better policy making. The provision for establishment of Geomorphic Informatics Cell with Remote Sensing and Geographic Information System (GIS) Laboratory will help in creation of a Geomorphic Database and National Data can be transferred, described and presented in National Spatial Data Infrastructure (NSDI) format.

These may be in the form of:

i) The concept of Geomorphic Atlas of India beginning from Village Micro-level unit which can be user oriented based.

ii) Chronological Development of Geomorphic Zones (Mapping and Interpretation)

Keeping pace with the demands of modern policy makers and planners NATMO has geared itself to use the latest technologies available to bring about improved accuracy and authenticity in its cartographic outputs. With digitisation becoming widespread the incorporation of geospatial techniques are necessary. Accordingly, NATMO has planned its Path Forward into the Geospatial Space as well. With the advent of geo-spatial technologies, now a cartographer has the resources to use various geo-spatial data which are almost at his/her fingertips electronically. Thematic Mapping has a key role to play in organising geospatial data. Precise location and identification of geo-attributes of a terrain to facilitate their pragmatic utilization in support of utility installations which can be spread over thousands of square kilometres is possible through geospatial data systems. Normally ground observers have to physically travel to collect data and there is a limit to the amount of data that can be collected in a particular time. Geospatial techniques can inspect infrastructures more frequently, with higher density, precision and time.

With the help of modern state-of-the-art technologies in the field of map making, NATMO has also transitioned itself totally to grab the maximum use of various geo-spatial technologies in its activities. Now, geo-spatial techniques have become the life-line for preparation of micro, meso and macro-level maps in NATMO. Almost in every phase of its activity, geo-spatial data and techniques are the most essential tools to the scientists and researchers in NATMO. NATMO has already moved from paper map to digital map. Hence, NATMO has and will ever have a pivotal role in the path forward into the geo-spatial space of the country. Some important steps towards that are added hereunder;

a) NATMO is the largest and most efficient government organisation in the country which is using and still has ample scope to use geo-spatial space in micro, meso and macro-level mapping for effective planning and development of the country.

b) Database is the most important source for effective planning towards the development of a country. Framing of National Data Policy, establishment of NSDI are some initiatives taken-up by the Govt. in this regard. But still they are not sufficient to mitigate all the requirements in this arena. As NATMO has been using geo-spatial techniques and has expert knowledge of its use; in the near future, NATMO will become the richest and most reliable provider of geo-spatial data-base in the country.

c) Remote Sensing, GIS, and GPS techniques and their utilities rule the roost in this cyber-age. Our country is still not sufficient, though most capable in this sector, due to lack of proper monitoring only. NATMO is heading forward to become a vital source for catering geo-spatial data and other utilities which can be used for planning and development by the government bodies as well as the common people of the country. It can also impart training and support to different organisations, researchers, planners in effective use of geo-spatial techniques.

d) Issues related to Disaster-management, loss of fertile crop land due to land degradation and desertification, effective measures for environmental hazards and substantive steps for restricting pollution are the challenges to a developing nation in the present age. Use of geo-spatial technologies is the most effective and precise tool in this regard. Being a government organisation, NATMO can share its responsibility towards the above challenges by using its knowledge and resources in geo-spatial arena.

e) In recent times the spurt of interest in the planets of our solar system has opened up a new field of research. The surface morphology of the moon and the Mars are now being brought under scrutiny to determine their genesis. Thus planetary geomorphology is the new area for present day studies where geospatial analysis techniques can be utilized for resource analysis too. NATMO can definitely play a positive role here as a pioneer in our country for further analysis of such prospects using geospatial information of such locations.

NATMO has already started its journey to turn itself to be the most important source in the field of geo-spatial space of the country and is also executing tire-less research and activities to that effect. NATMO will surely achieve its goal and will disperse its duties towards the nation in the most effectual manner, in the near future.

In the words of Dr.APJ Abdul Kalam, “We need to explore how geospatial technology can help the bottom of the pyramid. Creating a sustainable development model for the 3 billion rural people involves linking data, information exchange and proper dissemination."

*Respected delegates**,** I have tried my best to portray the relationship among geomorphology, cartography and thematic mapping in this effort in the memory of Prof. S. P. Chatterjee; I have bye-passed some of the valuable aspects due to paucity of time. I did not think it wise to make a repetition of the valuable work done by the Indian geomorphologists and cartographers and referred in many places, but I must not forget to extend my sincere thanks to Prof. K. R. Dikshit, Professor N.K.P. Sinha, Professor Nageshwar Prasad and Professor R. K.Rai in association with whom I have taken training and learnt various facets of geomorphology and cartography.*

Thank you

Raja Todar Mal Lecture

MAP-TEXT INTERFACE

Dr Prithvish Nag
Vice-Chancellor, Mahatma Gandhi Kashi Vidhyapeeth,

''.....it may be safely concluded that only a fraction of the information in the real world eventually finds its way to the map reader from the map or representational model of the real world. The ways in which maps 'perform as a device in portraying spatial properties in competition with other devices, such as photographs, pictures, graphs, language and mathematics" are encompasses in what Bunge (1962) calls matacartography".

Board (1967)

Text has been an integral part of map-making since the beginning of this specialization. No line work, aerial patterns and symbols or their combination are not comprehensive to depict the earth surface. Hence, text has always been judiciously used in different forms and places in cartography. Texts are used in the form of headings or titles, describing scales and representative fractions (RF), reference box, legends, authority, copyright, source of information used and other supplementary details. Texts are also used within the neatlines for depicting place-names, river and road names, spot heights, contour values and the like. In some maps, texts in the form of alphabets, English or Greek, are also being used. Further, in atlas cartography, map-text interface has a wider role. Atlas is a collection of maps in some orderly fashion highlighting a particular theme or objective, such as the national atlases, marine atlases or school atlases. Here, the text is in the form of footnotes or explanatory notes, not necessarily within or outside the neat-line of a particular map. In several atlases, there are valuable descriptions of the maps either on the other side or on the facing side of a printed map. The example of the former case is the *Physiographic Series* at 1 : 1 million scale in the *National Atlas of India*; while, the example of the latter case is the *National School Atlas* – both produced by the National Atlas & Thematic Mapping Organisation or NATMO in short. Jennings (2011p. 114-5) tries to relate maps with text. He says ...

"..... fantasy novels are the kind of reading that comes closest to the way we look at maps. Reading text is a purely linear process. Look you are reading this sentence. Now you are reading this sentence..... But maps tell different kind of story. In maps, our eyes are free to wander, spatially; the way they do when we study new surroundings in life. We can sense whole swaths of geography at once, see relationships, linger over interesting details."

He finally remarks that that maps and texts make strange bedfellows sometimes. A map's goal, after all, is to suggest stability and completeness, while literature is all about suggestion, nuance, not showing everything (pp. 188-9). Monkhouse and Wilkinson (1952, pp. 41-6) in their book entitled "Maps and Diagrams" have given due importance to lettering. According to them, "the standard of appearance of the finished map depends to a large extent on the quality of the lettering; all too often fine line-work is marred by unpleasing lettering, or essential detail is obscured." They have highlighted the significance of alignment, size, style and spacing of letters as well.

With the advent of Geographic Information System or GIS and remote sensing, maps have taken the shape of data arranged in a software driven format. All the activities apparent on the earth surface by remote sensing have been reduced to grey level normally varying within a range of 1-255, if the data is 8 bit. The 'human' element in maps has been given lesser significance. Hence, in modern map-making, the role of text has been reduced to minimum. As a result, the correlation of map with the ground has loosened which is in contradiction with the whole concept of cartography. Even the place-names have become a layer or a file in GIS methodology – not an integrated part of the activity. Further, since the modern cartography is software driven, the art of map-making is led by the options available in the programme. The whole beauty of map designing which used to include different styles of neat-lines, north-direction, pictures, symbols and texts has been given less priority. Unfortunately, there are no longer country-specific, institution-specific or company-specific maps. They are all software-specific maps. Furthermore, with the introduction of graphical methods, 3D-mapping and laser-mapping, the role of texts has been reduced to bare necessity.

Text & Context

Historically, attempts have been made to depict the so-called real-world situation with the help of maps. But, there have been spatial gaps which also attract attention. Ken Jennings quotes Joseph Conrad and mentions (Jennings, 2011, p. 3) :

"Now when I was little chap I had a passion for maps. I would look for hours at South America, or Africa, or Australia, and lose myself in all glories of exploration. At that time there were many blank spaces

on the earth, and when I saw one that looked particularly inviting on a map (but they all look that) I would put my finger on it and say, "When I grow up I will go there."

Earlier, text and sketches were widely used to describe the spatial context. Use of symbols is a later development. Further, both the options were also applied for filling up the spatial gaps in information. It is said that :

So geographers in Afric maps,
With savage pictures fill their gaps,
And O´er unhabitable downs,
Place elephants instead of towns.
Mathers (1918)

There are several instances, since the beginning of map-making, where the spatial gaps have not only been filled up with picture and sketches but also texts describing what ever information then available. The two maps of 16th century, included in the Skeltons book entitled, *Explorers' Maps* (p. 13), of (a) part of Southern Continent, from Mercator's world chart, 1569, and (b) Tartary or the Kingdom of Great Khan by Ortelius, 1570 in several places descriptions have been placed within the map either to fill the gap or to describe the features of the places which could not be depicted by cartographic techniques. In the Willem Blaeu's famous world map, artistic design along with maps there are pictures and texts. In fact the space used for maps is less than then these items. In total, all things put together, the map looks interesting (Jennings, 2011, p. 81). In the same book, there are several examples of maps, mostly of the 16th century, where the text has widely been used. The most classic example is of the Map of Arctic region in Mercator's Atlas of 1595 where in this polar region sizeable text has been added (p. 101). Erwin Raisz in his book, *General Cartography*, has given several examples where maps have been prepared in different context and in different countries. It is interesting to note a variety of emphasis given for inclusion of texts in the maps. Texts have always been included, but the description about the maps along with the title of the maps is always of great interest. Further, Birch (1960, pp. 118-23) in his book, *Maps: Topographical and Statistical*, has dedicated one chapter on *Map Title and Scale*. It is of interest to note how other technical details, such as scale and series, become attached to the title of the maps through texts.

Such trend continued when the imperial powers came to India and started preparing maps of India with an intention to exploit resources and capture the territories. The textual details included such maps were based on descriptions made available by the traders, explorers, missionaries, navigators and the civil servants. As a result, regarding the frequently visited areas by the respective imperial powers, the details in the forms of place-names were over crowded apart from other types of locational distortions. The coastal areas, the colonies, routes to Agra and Delhi during the Mughal era were over crowded while the northern areas, interior territories were generalised (Fig 1). Nevertheless, such imperial powers have their own style of map-making and thereby variations in using text for the preparations of maps. The layout, cartographic style, fonts, use of picture, north direction, drawing of neatlines, limited symbols and the like were also different. In the maps of India prepared by the French cartographers, the text was very heavy within and outside the neatline (Fig. 2). Pictures have widely been used. Italians have also prepared maps covering India. Further, the maps prepared by the East India Company and later, under the Crown, by the Survey of India, have standard combination of map and text. Over the years, such combination has changed little. This standard practice has been more or less accepted in other South Asian countries. In the naval charts, texts have been used in the form of route, depths, distances and the like.

Apart from the professional attempts of preparing maps by the Survey of India, traditional method of map making was also in practice by Indian rulers. Land revenue maps by Raja Todarmal, during Mughal period, also has specific text contents. This system is reflected in today's revenue maps as well. Further, Jain, Chola and Maratha cartography were also well known (Arunachalam, 1997; Gogate & Arunachalam, 1997); Karani & Arunachalam, 1998). In terms of modern definitions, these maps could only be considered as sketches due to distortion. It appears that Jain cartography is an outcome of Jain paintings. Routes with symbols and descriptions were used. In fact we get the earliest references of the use of symbols in such cartography. In addition, there are traditional and religious maps of holy places, pilgrimage routes and conceptual maps where there are sufficient amount of text has been judiciously used. We do get references of conceptual world map as per Buddhists and Janis literature (Tripathi, 1969, pp. 208-15).

With the development of cartographic techniques, the use of diagrams and pictures were less preferred. This was due to the reason that such applications were to be repeated and space was not always available. Nevertheless, with the development of symbolisation, picture and diagrams are being used as symbols. On the other hand, the then new cartographic techniques such as choropleth, isopleth, shades, patterns, colours, trend surfaces and the like, reduced the applications of text on the maps (Raisz, 1948). These techniques became more sophisticated with the introduction of digital cartography. Map composition underwent a sea change. Nonetheless, the significance of place-names continued not only in the topographical cartography, but in other form of map-making. Board (1967) mentions that:

"It would be impossible to convey information by maps entirely by non-verbal symbols. Maps without lettering seem unfinished and disoriented (Imhof,

1951). Cartographic lettering often follows conventions so that the reader, once he is familiar with them, is assisted to use the map"

Further, place-names are of paramount importance in the study of the origins of the distribution and of the spread, as well as of the character, of early settlements. Great care, however, must be exercised in the use of place-names. The random plotting of any place-names which happen to figure on ordinary topographical maps is to be deprecated, because many place-names plotted may not be genuine place-names (Monkhouse & Wilkinson, 1952, p. 282). However, place-names have become mixed up with politics, more particularly with respect to the form used. The advent of air photos and recently remote sensing data do provide time-specific spatial information. But, they are considered as "pseudo-maps" because they differ from maps chiefly in respect of names and invisible features (Board, 1967, p. 707).

Text as Marginal Information

In several books, there are elaborate chapters on different aspects related to map-making. These chapters include intricate details about projections, scale, symbols, sources of data and even on non-quantative data, but the importance of text has been ignored (James, 1959, pp. 489-520). Apart from the importance of place-names, text has been an integral part of the maps in the form of marginal information, *i.e.* text written outside the neatline. In topographical maps such information is extremely important because these can be related to spatial, scientific and administrative aspects, apart from the mapped surface features. In case of thematic mapping, interpretation, classification, research and presentation are also involved which may require textual details in terms of statements, reference box, key and tables. In both the cases, following marginal textual information is added:

1. Series name
2. Scale and RF
3. Sheet name and number
4. For Use By
5. Longitude and latitude values
6. Graphical scale
7. Series number, edition
8. Credit legend
9. Contour intervals
10. Grid notes
11. Imprint of the authority
12. Sheet name
13. Geographic index number
14. Reliability index
15. Projection and datum
16. North direction
17. Administrative index

The above details are generally in the form of text. However, each map series have its own methods and styles of designing such marginal information. The users do become familiar with such details. Hence, it is not always desirable to make rapid changes. Apart from the above technical details, there are interesting textual details which make the maps most important, historically, politically and academically. Some examples are mentioned below :

1. Phillimore, R.H. (1950), *Historical records of the Survey of India*, Vol. II, Plate 11. opposite p. 106 : MYSORE :

Map of the Rajah of Mysore together with Canara & Punganoor etc belonging to the E:E-I Company from survey of Mysore to which are added Malabar (as far as Calicut) & the Barramahl from the Surveys of these Districts.

Reduced from Mackenzie's map of 1808, scale 12 miles to an inch, compiled from survey of Mysore and Kanara 1800 to 1807 (111 n 8).

Place names underlined indicate Mackenzie's trigonometrical stations which were quite independent of Lambton's survey and were not connected to Madras till 1808. Lambton's triangles over this area are given in plate 16."

2. Nag, P. (2010), *Atlas of the City of Calcutta and Its Environs*, National Atlas & Thematic Mapping Organisation, Special Atlas Series 1, Kolkata, pp. 30-1 : River Hoogly :

Portion of Topographical Survey of the River Hoogly from Bandel to Garden Reach exhibiting the principal buildings, ghauts, temples & ca : on both banks, and comprising of Danish settlements of Serampoor, Cantonments and parks of Barrackpoor, together with the settlements of Chinsurah, Chundunnuggur & environs of Hoogly, with Great Road from Calcutta to Hoogly via Palta Ghaut. Executed in the year 1841.

Is dedicated by permission to The Right Honourable George Earl Auckland GGB, Governor General of India, By his most obedient humble servant Charles Joseph, Calcutta 1st July 1841.

The Barrackpoor Road: Base-line measured by Col. G. Everest, Sue: Gen: of India. 33959"965 ft 6.4318 miles. Note: The portion of the places and course of the river are laid down with mathematical precision they agree with the principal stations of the great trigonometrical survey.

From above narrations, it is evident that the marginal text not only provides the technical details, such as mathematical precision with respect to Great Trigonometrical Stations (GTS), but also the administrative, political and survey set up at the time of preparation of the map. We have seen that such details become very significant for boundary negotiations.

Text along with Maps

Apart from the text with and outside the neatline, textual information is also appreciated as explanatory notes, description, interpretation and in other forms. In text books, communication maps (railway maps, metro maps), coffee table books, advertisements, text and maps have close binding. But, in atlases, such relationships are stronger. For example, in the *National Atlas of India* (1st edition), explanatory note along with each maps/plates is highly appreciated (NATMO, 1982). In other thematic atlases, such as the *National School Atlas* or *Agricultural Atlas of India* or *Atlas of the Freedom Movement of India*, thematic maps have an important part of a greater textual exercise.

There has been all round appreciation of the addition of text along with maps. We have experienced that the sale of cartographic product increases tremendously with textual description. In thematic maps this is important because (a) cartographic technique is explained and justified, (b) proper perspective of presentation, and (c) correct interpretation of facts. In such mapping the understanding of the map-maker, capability of map user and technology used for mapping are involved which may require description. Hence, a write-up would be very supportive along with the map. From the above description, it is apparent that in some publications maps are added along with the text, such as books on geography or history. On the other hand, text is being used to support interpretation and understanding of maps, such as thematic atlases. In both the cases, map and text are closely associated.

The enormous reduction of scale entails a great loss of detail which is reflected in many ways. For example, the dimensions of the paper covered by a map set a natural limit to the number of names which can be printed upon it. An atlas map of the whole Africa can bear no more than can be shown upon a topographical map of like size but representing only a few square miles of territory (Brich, 1949, p. 21).

Text vs Diagrams and Pictures etc.

Cartographic symbols, colours, tints, hill-shading, pictures and diagrams have been widely in order to reduce the text component. Hence, cartography, or the technique of map-making, has become more complicated. Moreover, the maps users have to be trained so that the desired message is communicated. This is not always easy. Map literacy will depend on the context, map composition and intelligence of the user. But, even after such sophistication, the text component cannot be eliminated. In fact, users prefer to have text with or within a map. Cartographers have laid different emphasis to the application of such methods. Board mentions that the information about the real world is coded in symbolic form and quotes Robinson so as to say that 'the entire map is a symbol..... and it is not quite correct to designate only certain component as symbols' (Board 1967, pp. 682-3; Robinson 1960, p.136).

Conclusion

The combination of map and text is a solution. It is one expression of the earth surface or a part of it and is best explained by such combination. Can maps speak ? Can maps express ? Kozakis mentions in his article "World Topographical Map Coverage" (p. 553) :

Prime Minister Churchill, wise and clear through his words were, asked us to look at a map while he was speaking, for the map assisted him in telling what he could not put wholly or satisfactorily into words. Maps are one of the oldest and best forms of expression known to man.

On the other hand, have we reached a level where the application of text reached the minimum level ? This question has to be answered keeping in view of the capabilities of the software. The software has map-making more specialised, but the products have become more acceptable as map composition and map visualisation can be finalised beforehand. The text can be put in right placed with desired orientation, size and colours. Perhaps, in the digital environment, it has become pertinent to balance the text and other associated techniques in more sophisticated way. On the other hand, how the spatial data in GIS format can be used in the best way for map composition will remain a matter of application in future as well. The related software will keep on modifying but the demand for simple, easily communicable and expressive maps will always remain. In such a trend, the role of text in map-making will remain to be an important factor in the decades to come.

References:

Arunachalam, B. (1997), Cartography of Chola administrative hierarchy, *Indian Cartographer*, pp. 3-8. Board, C. (1967), Maps as models, in Richard J. Chorley & Peter Haggett (eds), *Physical and Information Models in Geography*, Methuen, London, pp. 671-727.

Brich, T.W. (1949), *Maps : Topographical and Statistical*, Clarendon Press, Oxford.

Gogate, Prasad P. & B. Arunachalam (1997), Two eighteenth century Maratha maps of administration, *Indian Cartographer*, pp. 30-4.

Imhof, E. (1951), *Terrain et Carte*, Zurich, p. 261.

James, Preston E. & Hibberd V.B. Kline, Jr. (1959), *A Geography of Man*, Ginn & Company, Boston, New York, London (Appendix A : Maps, pp. 489-520).

Jennings, Ken (2011), *Maphead*, Scribner, New York London, Toronto, Sydney, New Delhi. Karani, Rohini & B. Arunachalam (1998), Jain maps of pilgrimage, *Indian Cartographer*, Vol. 18, pp. 26-9.

Kaplan, Robert D. (2012), *The Revenge of Geography*, Randon House, New York.

Kazmi, Hasan Askari (1982), *The Geographical Concepts of Al-Biruni*, Chandra Prakash and Sons, Hapur.

Kozakis, John T. (1959), World topographic map coverage, in the *Proceedings of IGU Regional Conference in Japan 1957*, The Organising Committee of IGU Regional Conference in Japan, The Science Council of Japan, Tokyo, pp. 553-7.

Lehmann, Edgar (1965), Cartography from an international point of view, in M.R. Chaudhuri (ed.), *Essays in Geography*, The Geographical Society of India, Calcutta, pp. 93-8.

Mathers, E.P. (1918), *Zambesia*, Kins & Railton, London, p. 17.

Monkhouse, F.J. & H.R. Wilkinson (1952), *Maps and Diagrams : Their Compilation and Construction*, Methuen & Co., London and E.P. Dutton & Co., New York.

Nag, P. (ed) (1984), *Census Mapping Survey*, IGU Commission on Population Mapping, Concept Publishing Company, New Delhi.

Nag, P. & Smita Sengupta (2007), *Geographical Information System: Concepts and Business Opportunities*, Concept, New Delhi.

Oberlander, Theodore M. (1968) A critical appraisal of the inclined contour technique of surface representation, *Annals of the Association of American Geographers*, Vol. 58, No. 4, pp. 802-13.

Robinson, Arthur H. (1954), Geographical cartography, in Preston E. James & Clarence F. Jones (eds), *American Geography : Inventory & Prospects*, Association of American Geographers, Syracuse University Press, pp. 553-77.

Robinson, Arthur H. (1960), *Elements of Cartography*, 2nd Ed., New York.

Raisz, Erwin (1948), *General Cartography*, McGraw-Hill Book Company, New York, Toronto, London.

Ramamurthy, K. (1982), *Map Interpretation (Indian Landscapes through Survey of India Topographic Maps)*, Madras.

Sketton, R.A. (1958), *Explorers´ Map*, Routledge and Kegan Paul, London.

Tripathi, Maya Prasad (1969), *Development of Geographical Knowledge in Ancient India*, Bharatiya Prakashan, Varanasi.

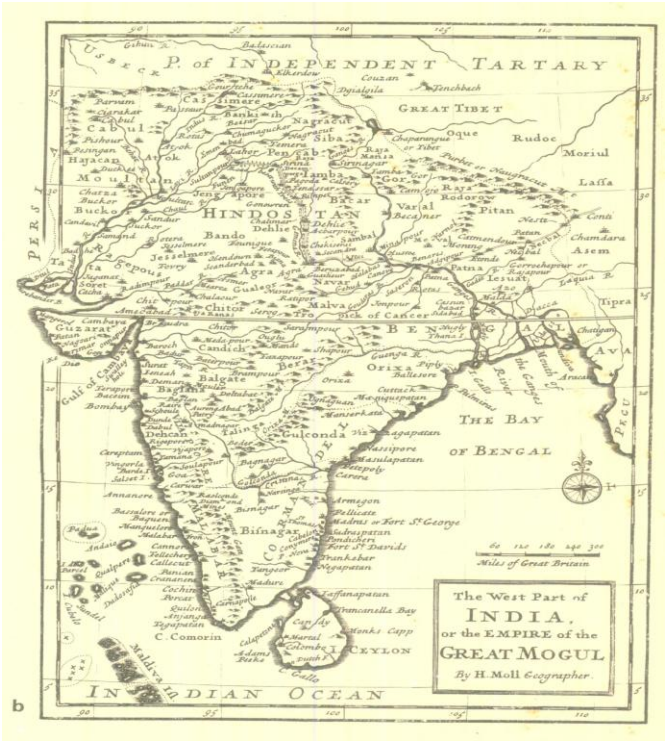


Fig. 1

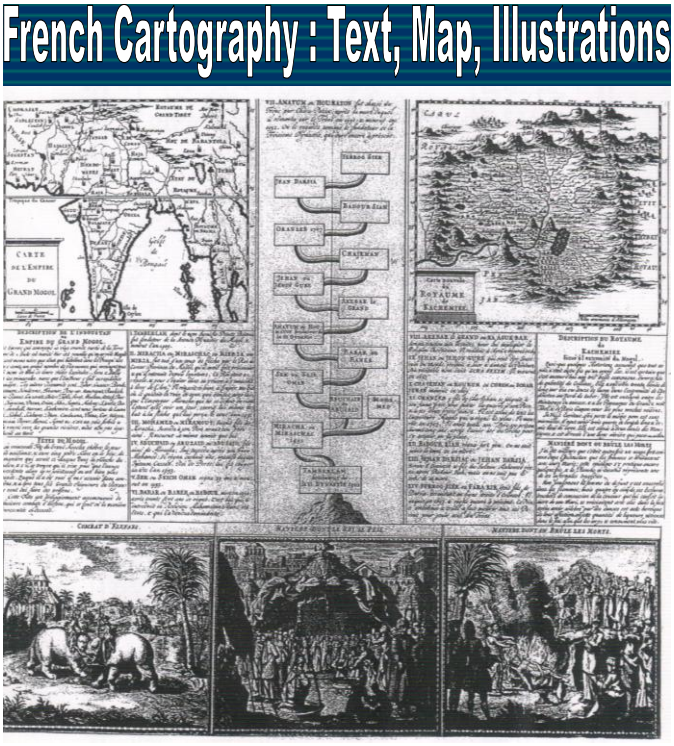


Fig. 2



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

FOCAL THEME

"CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT"

SUB THEMES

1. Technological trends in Cartography
2. Integrated mapping and space technology
3. Mapping for sustained development
4. Geomatics in disaster management
5. Thematic map surveying and GIS
6. Cartography in environmental planning
7. Coastal and marine mapping
8. RS and GIS for water resource mapping
9. Hydrography for resource management
10. Cartography for urban and regional mapping
11. Natural resource management at sea and on land
12. Advancements in marine cartography
13. Land mapping and resource management
14. Cartography for human resource management



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

TECHNICAL PAPERS



XXXII

INCA INTERNATIONAL CONGRESS

CARTOGRAPHY FOR SUSTAINABLE EARTH RESOURCE MANAGEMENT

Cartographic Trends and Prospects in the 21st Century

Professor (Retd.) JL Jain
Sagar
E-mail: jain_jawa@yahoo.com; 094251-93558

Abstract

Cartography as a discipline and profession has been transiting through radical changes and now critical challenges to its survival. In the later decades of the 20th C. it was struggling to cope up with the overwhelming technological revolutions bearing on mapping as well as map use. In the fading years of the Century these sub-parallel technologies culminated in the GIS revolution, which looks poised to supersede and push out Cartography into oblivion. In the popular image many people loosely use Cartography and GIS interchangeably, as if they the synonymous. Though Cartographer will remain overshadowed by GIS technologist for some time – a decade or two – but they will resurge to the fore as the people start using Web-based geo-information routinely for various practical purposes. In the longer-range, however, the comprehensive GIS S/W's will support a good deal of essential cartographic finish and perfection to the GIS maps also. This as well as the emerging common new market of scooping and customizing readily available geo-information from Govt. source and from almost free WEB geoportals will serve to bring back Cartographic and GIS professions into mutual harmony. Also, a new community doing some exercise with web maps etc. so as to make them readily usable for their purposes, is likely to emerge as 'Neocartographers'.

This paper examines these popular notions and pins-down the subtle, but crucial and intensive, differences between the two amid overt, extensive and gross similarities between them; and posits that Cartography as a discipline and profession is going to survive the GIS debut and will co-exist with GIS. The paper also tries to project long-range impact of blurring of mapmaker and map user, ubiquitous accessibility of geo-information through free geoportals on World Wide Web, affordability of computer hardware and software for GIS & Image Processing, etc. on the Cartographic discipline and profession in foreseeable future.

Introduction

Technological revolutions in Cartography and their impacts have been a sub-theme or even the over-all theme of many a Cartographic conference. While the deliberations at such forums shed ample light on the new technological revolutions 'per se' and their impressive advantages, they do little to show/explore how Cartographic profession and practice can adapt to them so as to preserve their survival and identity. It stands much warranted therefore to take an earnest insight into the background and etiology of daunting existential challenges to the age-old discipline of Cartography in the face of new vibrant technologies, prognosis of this critical, competitive situation, and to ponder over in what mode it can cope-up with the Geospatial syndrome.

Historical Backdrop

After a lull of about two decades since the World War II, there was again a spurt of several revolutionary technological developments, almost parallely, bearing on the mapping sciences and map use for diverse applications. Out of them computer-based spatial and pertinent attribute data analysis-synthesis has come very handy for umpteen practical applications, which came to be popularly called the GIS. It has since snowballed into an umbrella technology subsuming all pertinent technologies as subservient to it- Space Remote Sensing, satellite based navigation and positioning called GPS, Mobile Mapping, and others. GIS has truly consummated this technology syndrome, which is referred to as Geospatial Science & Technology in its entirety. Thus space-based digital remote sensing came of age in 1970's and 80's; Computer graphics and DBMS fruited into GIS in 80's, GPS and mobile mapping became operational in the 90's; and the whole ensemble coalesced into one Geospatial Science & Technology around the turn of the millennium.

Maturing of satellite remote sensing with 3-D visualization and high-resolution imaging, direct marking of positions/features on maps on GPS-enabled mobile computers, and advanced computer graphics/visualization have made it practical to map and monitor any areas of the World in near-real-time and almost within the convenience of one's office. Pivoted around GIS, this ensemble of sub-parallel technologies appears to perform very many mapping tasks in a basic/gross sense, i.e. converting spatial or cartographic database into a graphic/symbolic representation within a predefined coordinate system, called map. As an outright functional utility, it looks like rendering the age-old, tedious cartographic practice well nigh redundant.

Special Advantages of GIS

Riding the workhorse called computers equipped with special software powers, the GIS can turn other thematic data also into corresponding map layers that may be overlaid on the base map in any combination. Most critically, these map layers can be crossed/analyzed in a number of ways and manners depending on the purpose at hand and the functionalities of GIS S/W, leading to practical spatial planning decisions. Further added with remote sensed digital data and processing S/W, the GIS maps is often enriched with image base, map information updated, and even 3-D vision realized – enabling a virtual, annotated image view and even continuously kinematic bird-eye view from any position and angle.GPS with electronic surveying, and mobile mapping enable us to directly mark new positions on the map or image map. All these functionalities and capabilities render Geospatial technology a far superior and convenient methodology vis-à-vis the conventional mapping or map revision as well as working with maps.

Misconceived Synonymy of Cartography and GIS, and its Etiology

The Geospatial technology has also largely vitiated the distance and difference between mapmakers and map users – enabling users to acquit quite a few of the tasks of mapmaker. This became a real practical utility with availability of map and image data from the mostly free geo-portals on World Wide Web.

Though geospatial technology, particularly GIS, does many elementary or basic mapping tasks, it is not a mapping tool kit. It is instead very capable and advanced map and image application gadgetry, which can also handle many ancillary data necessary/available for specific tasks, so that one can visualize the entire panorama along with even non-tangible thematic information, as well as analyze this entire data ensemble towards spatial planning. In so far as GIS is not essentially a mapping tool-kit, GIS or Geospatial Science cannot substitute or subsume Cartography. If Cartographic maps often stand as versatile reference documents packed with maximum pertinent information, and communicative of spatial view and relationship, the GIS maps are practical tools/solutions for a given purpose of essentially spatial nature. Thus GIS is a universal supporting tool or technology; but its main function is management of databases that can be mapped and matched, and their analyses mostly aimed at spatial decision-making (SDSS), (Jain JL, 2009). If Cartography is a map-making profession, GIS is essentially the map using tool-kit for practical purposes. Nevertheless, GIS map use function, in turn, itself involves a lot of analytical mapping aimed finally at a spatial decision support.

Thus, while there appears to be rather extensive overlap between the peripheral functions of GIS and of Cartography, the two disciplines are markedly distinct in their core functions. Precisely, the similarities between the two are more apparent and extensive, whereas the differences, though subtle, are more real, and intensive. This apparent, conspicuous commonality between Geospatial sciences and Cartography has swept the popular image of GIS and turned it oblivious of covert and indelible differences between them(Jain JL, 2009).To clarify the above point further, while geospatial science caters to various peripheral functions of Cartography, it does not cater to its basic or core functions like map designing, hill-shading, map editing, manuscript map proofing, and ensuring their highest visual appeal and communicativeness, i.e. an immaculately dressed and finished map product, sometimes designed within a larger, overall design frame like that of an atlas or a national map series.

GIS can at the most be seen as the recent, most practical development on the common interface of Cartography, DBMS, image processing and image mapping, GPS and mobile mapping – all riding the common workhorse called computer. And, standing as fulcrum, GIS has evinced inordinate vigor to snowball and entails all sister disciplines in its extensive ambit and utilize them in their specific roles for its own umbrella role. So much so that one finds as if GIS is Cartography, even the whole Geospatial Science.

Prognosis of the Tangled Relationship of Cartography and Geospatial Science

Intermingling of Cartography and the various components of Geospatial sciences, particularly the GIS, has largely vitiated the distance and difference between mapmakers and map users – enabling users to acquit quite a few of the tasks of mapmaker. This became a real practical utility with availability of map and image data on the World Wide Web. The advent of new, revolutionary technologies in the mapping and map use fields though look posed to replace the traditional discipline; this is not going to happen any soon, only because the hard-core cartographic functions are not the GIS's cup of tea.

There is, however, a rider to this bold conclusion. By simply turning database into maps, or churning new planning or actionable maps out of crossing/analyzing several pertinent map layers, GIS is focused on functional and pragmatic maps for practical purposes in real time – essentially as an SDSS tool-kit - rather than a mapping system 'per se'. If this functional map paradigm takes precedence over the elaborate, diligently hachured/hill-shaded, immaculately dressed and meticulously proofed maps like those of major atlases, Cartography is going to be confronted with a

precarious and portentous future – to be marginalized in its core functions, and to be subsumed in or superseded by GIS in many of its gross or rudimentary functions (or, to be 'Geospatialized').

Future scenario of Cartographic Profession and Practice

Reference has just been made to survival resilience of Cartography in face of the GIS whirlwind and to the likely paradigm shift from the highly finished, impeccable and informative maps (to serve as a reference document)to the transient, functional map for practical purposes. Under the impact of these rather conflicting trends Cartography will likely survive the GIS début, even if the Cartographic profession and practice becomes rather limited in the process - the market for highly finished printed maps, such as major world atlases in the print form, is certainly going to be much attenuated in near future. It will nevertheless retain its core identity, even while it perforce relinquishes some of its peripheral roles to the vibrant GIS.

In the digital ambience a newly emerging market for cartographers outside Govt. offices and major mapping houses, will be in accessing map and image data from general sources like free geo-portals, other Govt. and corporate sources, and customizing/value-adding that geo-information for specific clients. Furnishing map and image information on WEB geo-portals will also provide some sustenance to the cartographic and geospatial community. The future cartographer will thus be a computer-suave navigator of geospatial information highways himself who can deftly scoop and edit this information from public and corporate sources and further augment it with thematic information and customize it for a more specific and ready use. The subtle but crucial nexus between base geo-information from general sources and the finished, value-added information ready for specific usage will be the future business of cartographers (Jain JL, 2005).

Regulatory System for Geospatial Business & Profession

Also, this professional activity will expedite an already emerging need and scope for a legal control regime for regulating diverse legal aspects of this business, such as copy-right ownership of geo-data and ancillary attribute or thematic data, compatibility of data assembled from diverse sources, quality of data or products based thereon, ownership of copy right, and proper royalty to be levied on the value-adding agencies, etc.

Already, legal institutions are working at framing such a system. In India the National Spatial Data Infrastructure (NSDI) – the long mooted apex regulatory and facilitating body in India on pertinent information and its networking – will largely provide this regulatory and management apparatus. Since the geo-information is now often culled out from global sources, these issues and Geospatial Policy & Law, currently on anvil, may have even international dimensions. Such a regulatory framework will strike the right balance between the public demand for liberalized access to geo-information and the compulsions to strictly control this information from inimical, subversive elements. This regulatory body will serve the internal security concerns of the country against inimical misuse of such information. Pertinent extant conventions and departmental guidelines, often adopted piece-meal and on ad-hoc basis, will then be covered under a properly framed Geospatial Policy & Law (Jain JL, 2012).

Regression to Harmony

However this newly expanding market will soon be shared by free lance GIS or geospatial professionals also; and in that practice the two overlapping professions will look just the same, because they will be focused on the common marginal area of either. This business will thus be an additional side activity for free-lance professionals, which will soon mature in full-scale organized practice through corporate business houses. Other newer business areas like tourism, trekking or hiking maps and ancillary geo-information will also be soon shared by the geospatial practitioners. Furnishing quality geo-visualization on hot spots to the newspaper and magazine houses will be another expanding area for cartographers.

For sometime certain major GIS S/W houses are focusing their R&D on all-compassing and integrated S/W packages that can cater not only to the standard GIS and Image Processing functionalities, but also to those of combining map vectors on images, generation of DEM and ortho-images, image-draped perspective models and flythrough, digital mosaicking and other photogrammetric operations, and finally to presenting a well-finished map or image-map. In fact, some vendors are already claiming integrated functionalities of many of the above-noted elements in their major S/W's. When reasonably operationalized, this development will pave way for the integration of Remote Sensing, GIS, Photogrammetry, even Mobile Mapping, and Cartography into one grandiose subject complex.

Resurgence of Perspective Elements in Cartographic Representation

In the early stages of cartographic (rather pictographic) representation, many an important landmark was portrayed in the perspective manner (naturally at the cost of surrounding map information). This would give a readily appreciable view of such

features. The newer activities on maps noted in foregoing will be greatly enriched if a perspective panorama from a vantage point is also geo-tagged with some important map features/locales or place names, so that many more elements of the landscape are more readily appreciated. Thus a new branch – Perspective Cartography - will emerge on the scenario, which was essentially non-perspective i.e. orthogonal.

Today technology provides for incorporating perspectives of select landmarks by just clicking at the location of those landmarks in the map. Thus it provides a snapshot close-up perspective of desired features without permanently obscuring surrounding map information. Thus the perspective 3-D views on images draped over DEM's in the kinemative mode via fly-through coupled with clickable ground-views of landmarks is making for more ready and popular cartographic visualization. Just nominally annotated, such image maps will furnish a good media of geographical or topographic appraisal.

From Harmony to Exaltation into Neo-Cartography

So too, progressing from digital maps to multi-media maps, WEB-maps, and service-oriented-maps, may be even animated maps, Cartography is going to become much more than just about maps – it will be geo-information exalted or adorned with these newer forms, features and functionalities. Only, then becoming a cartographer will entail a lot more things than just mapping or map-making. And surely, such developments will be incorporated in the comprehensive GIS or Geoinformatical S/W's. Some people tend to call this 'Neo-Cartography'. If so, I futuristically guess, the Cartographic progression will be digressing from its overly science-&-technological path and regress back to entails some elements of Art and Aesthetics - with a fair scope for personal imaginativeness and creativity.

Conclusion

The future of Cartography will largely be tagged with the future prognosis of the larger Geospatial development; and this will mostly be driven by the trend of integrated geospatial S/W's, and emerging common business of sourcing geo-information and value adding it for end use. Whereas the first trend will make GIS out-puts cartographically more versatile and respectable, the second trend will put them on common platform of shared concern. This only implies that the future Cartographer and/or Geospatial Scientist will have to acquit and appreciate a larger and higher level share of geo-information editing and handling with modern tools than they currently do. This will actually be accomplished through acquitting well with all segments of pertinent comprehensive geospatial S/W's. Incorporating multimedia elements with map will add new dimensions to Cartographic practice and profession – a pointer to what is emerging as Neo-cartography.

Nevertheless, the high-end atlases, topographic map series, WEB maps and image maps, even thematic mapping, will have some scope, however attenuated though, for a higher-level Cartographic perfection. And to that extent Cartography will survive in the original form also.

WEB-Mapping: A Passing Flare or Abiding Trend -

The first decade of this Century is well nigh the age of WEB applications, and WEB mapping will dominate the Cartographic field. Appearing around the turn of the Century, WEB mapping has since been maturing steadily. This culminates in the map mash-ups such as the live Earthquake Mash up by geo-tagging US feeds of earthquakes onto to Google Maps. Here the Earthquake Mash up has neither stream of data, except for the code to combine them (Sujata Ghosh, et. al., 2012). Initial bickering and doubts as to the quality and fidelity of volunteered or crowd-sourced mapping will eventually subside as the ways and procedures of standardization and quality/fidelity control mechanism of the system come to be realized and appreciated, and tools of this mapping and the process of its incorporation in the mainstream mapping are well in place.

Even then, it may be recalled, there has come about a paradigm shift to pragmatism in the content and quality of maps, which are now more a routine artifact for practical purposes, which can be corrected/updated easily, replacing perfectionist zeal for the finish and get-up of map essentially as a reference document (as it was not amenable to change or updating easily). Even a stand-alone type map and the map as part of larger frame (which can be mosaicked perfectly) have different standards of practice.

Volunteered and inter-active mapping – on platforms like '*Open Street Map'* – will not only further inter-mingle the erstwhile distinct roles of mapmakers and map users but will also make map use more ubiquitous, which will have a more distinct impact in countries like India where map use beyond few sensitive Govt. Departments and educational purposes was, overtly or covertly, much too controlled. As the WEB Cartography becomes distinctly participatory and interactive, it will make much of Cartography a common activity rather than a specialized, professional practice. Initial skeptism and resistance on the quality and acceptability of the volunteered, user-contributed mapping particularly among puritan, conservative circles is also quite understandable, which, however, is more in the nature of initial distaste and pooh response.

Conservative, perfectionist cartographers need not over-react and be over apprehensive as to the quality and finish of the crowd-sourced WEB-mapping. Stewards of the geoportals do screen this crowd-volunteered mapping and redesign it before incorporating the same in the mainstream mapping. Even so, the 'crowd' is not so utterly layman; at the present experimental stage they are often some enthusiasts from some pertinent technical institutions trying the interactive capabilities of the edit tools provided with geoportal data, or, may be, some open-source tools. Thus, this is only an experimental state, which appears to be potentially very promising.

Again, this crowd-sourced mapping is an additional mapping to the existing map on the geoportals, which needs not be compounded with primary mapping of any kind, which is the exclusive mandate of pertinent premier Govt. agencies. Only geoportal owners garner some additional geo-information through this crowd-sourced interactive WEB-mapping. Thus, in the final analysis, this interactive Web-mapping, and additional forms of geo-information with interactive capability, and their radically new application areas are going to be dominant future trends and traits of Cartography. Understandably, the conservative cartographers' shrug and pooh at the prospects of every Tom, Dick and Harry doing some bizarre mapping in an interactive WEB geoportal, such as the *'Open Street Map'* will die out before long.

Finally, I must tell you, friends, this exercise may have some elements of my personal hunches, as it is at least partly based on my cumulative personal impressions and contentions cultivated often through self-schooling and my interactions with professional and academic people around. I shall, as I must, therefore welcome any critical or constructive comments from the dais or the floor; and I receive them in an earnest learning spirit.

References

1. Ghosh Sujata, Prasad Raju P.V.S.P/, Saibaba J., and Vardhan Geeta, 'Web-Mapping and Cartography for Sustainable Resource Management', XXXII INCA International Congress, Dehra Dun, 2012.

2. Jain J.L. (2005), 'Presidential Address' to the 25th INCA International Congress, Sagar.

3. Jain J.L. (2009), 'Hugging or Grappling! Eliminative v.s. Complimentary Relationship between Cartography and GI-Science' Presented at the XXIX INCA International Congress, Kolkata.

4. Jain, J.L. (2012), 'Evolving Indian Geospatial Scenario: A Backdrop To Geospatial Policy And Regulatory Framework', paper presented at the 'International Conference on Space Law and Contemporary Issues: A Focus on Asia-Pacific Region', June 24, 2012, NALSAR University of Law, Hyderabad.

Database Driven Cartography

Matthew Holland
CARIS
T: +1.506.458.8533
F: +1.506.459.3849
Email: matthew.holland@caris.com
Web: www.caris.com

Abstract

Traditionally software solutions for digital cartography have been desktop applications, which utilize file based data structures. Although desktop solutions offer many benefits, particularly in comparison to manual cartographic techniques, the use of independent files often results in duplication of data and effort. This is especially true for agencies with large portfolios containing many products with the same, or overlapping, spatial extents. Conversely, a database solution allows agencies to integrate spatial information as a common source and derive multiple cartographic products, including various types and at different scales, from the common source. This integrated environment also allows changes to be more efficiently applied to multiple products. It has been realized by a growing number of agencies that database driven cartography offers many substantial benefits, including improved productivity.

Database solutions also allow agencies to maximize the use of their spatial information by easily expanding their portfolio to include new product types, and by enabling the data for use by various stakeholders to address a wide range of GIS application. In the context of the marine environment, this includes safe navigation, but also all other marine activities such as resource management, defence, environmental protection and coastal zone management.

This paper will explore a database driven approach to cartography and associated benefits, including the maximized use of marine spatial data.

Introduction

In the late 1980s and 1990s many hydrographic authorities around the world moved towards digital chart production and implemented computer aided solutions to compliment and/or replace their manual cartographic processes. The transition to desktop mapping solutions continues, more than 20 years later, with some nations implementing their very first digital cartographic solutions in 2012.

Today there are many cartographic products to support the marine and coastal zones. These include both paper and electronic products based on the International Hydrographic Organization (IHO) standards for safe navigation to support commercial shipping, tourism, etc. Other examples include digital products to provide supplemental information for maritime defence operations, marine environmental protection and sea ice coverage.

Marine spatial data used in the compilation of cartographic products, and the products themselves, are a powerful asset which can be used to effectively manage the marine environment and related resources. Hydrographic and non-hydrographic organizations, such as geological institutes and marine science and technology agencies, are holders of massive amounts of spatial information. As such, maritime agencies are being increasingly pressured to provide access to their data to facilitate economic development, resource and coastal zone management and other uses.

With a growing demand for marine cartographic products and services it is important that agencies are able to effectively integrate, visualize, access and re-distribute the spatial information and derived products. To achieve this goal many agencies have transitioned to database systems and implemented a database driven cartographic process to optimize productivity, maximize the use of their marine spatial data and improve upon the previously implemented digital systems.

Database Solution

Marine agencies are faced with increasing volumes of digital data and mandate to provide their clients and stakeholders with an increased number of product types and data services. By meeting this demand, agencies can provide stakeholders with access to cartographic products to support many overlapping activities in the marine and coastal environment. This includes sustainable economic development through safe passage for offshore vessels and identification of natural resources, habitat mapping to facilitate environmental protection, and other activities.

At present many organizations in the maritime community have mandate to reduce duplication of data, improve data accessibility and security, and increase productivity. To achieve these goals agencies are transitioning from traditional desktop applications, which utilize file based data structures, to database solutions.

Marine Geographic Information System (GIS) solutions that use a Relational Database Management System (RDBMS) and interoperable standards allow agencies to integrate most GIS data formats, address the mandates identified above, and maximize efficiencies in the provision of their cartographic products and services.

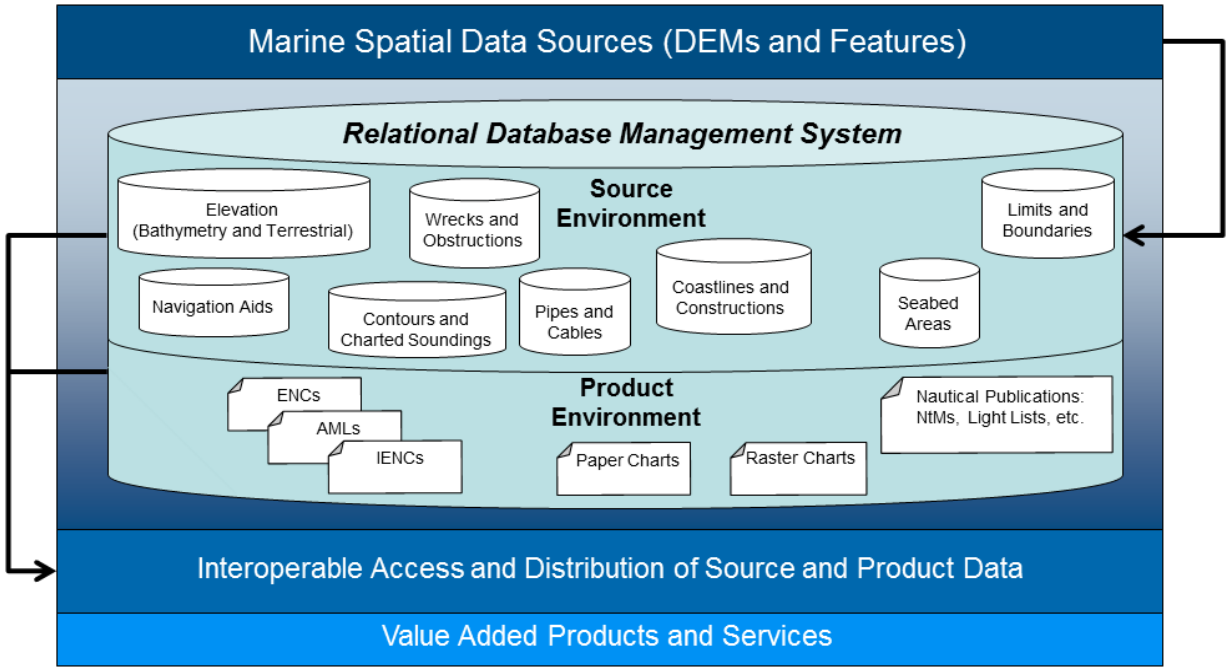


Fig. 1: Relational Database Management System for Marine Spatial Data

The RDBMS uses an object oriented data model for complex spatial information, including Digital Elevation Models (DEMs) and cartographic Features, and is adopting IHO S-100 (i.e. The Universal Hydrographic Data Model) as it comes into use by the international community. IHO S-100 has been developed to conform, as much as possible, to the International Organization for Standardization (ISO) 19100 series of geographic information standards developed by ISO Technical Committee 211 (TC 211). [1]

The adoption of S-100 will include support for new product specifications, such as S-101 for Electronic Navigational Charts (ENCs), as they are finalized by the IHO. This transition to S-100 and related product specifications will facilitate increased use of hydrographic-related digital data by the wider geospatial industry.

As examined in further detail below, by incorporating all spatial data sources into a RDBMS, efficiencies can be realized in the production of various paper and electronic products and the exchange of spatial information with various stakeholders.

DEMs: The RDBMS allows agencies to store, manage and analyze substantial volumes of elevation data, which includes both bathymetry and terrestrial elevation data sets. The elevation data holdings of any single organization may be compiled from a wide range of sensors and sources. In the example of the Energy Division of Geoscience Australia (GA), who are responsible for the management of bathymetry data from Australian Territorial waters, their data holdings are made up of over 325 surveys. The surveys have been conducted by a total of 43 vessels using various sonar systems, and form the largest collection of single and multibeam data in Australian territorial waters. [2]

The RDBMS supports the storage of both high volume 3-D point clouds and gridded DEMs. The technology framework and formats developed by CARIS allow for billions of points and tens of billions of grid nodes to be stored in a single point cloud and DEM respectively. This provides users with an extremely scalable solution for the efficient access and rapid visualization of high density elevation datasets. This is further illustrated in the below Figures which display a 3-D point cloud containing approximately 85 million points and a DEM at two metre grid resolution covering approximately 162 kilometres of coastline.

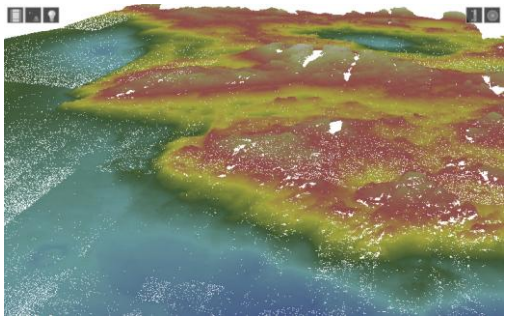


Fig. 2a: Point Cloud (approx. 85 million points)

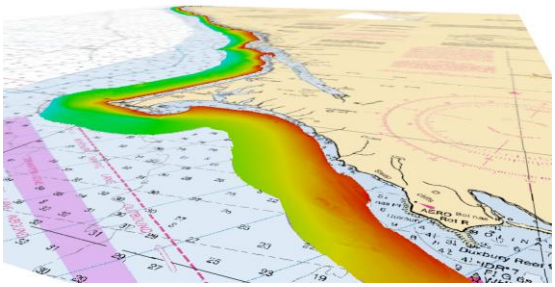


Fig. 2b: 2m DEM (approx. 162km)

Metadata: Elevation datasets are stored in the RDBMS along with associated metadata information, which supports the search and discovery of the database content. The metadata profile for the elevation data uses ISO 19115 / 19115-2 / 19139 metadata standards for geographic information. The 19115-2 metadata extension allows for standardized information about imagery and gridded data, such as the measuring equipment, to be described. [3]

To ensure that both standardized and organization specific metadata is retained and available for subsequent discovery, the RDBMS metadata profile can be further customized to support non-standardized metadata records. The metadata is also used in operations such as stipulating the criteria to combine / mosaic multiple overlapping datasets into a seamless representation for a geographic area. This could, for example, be for the extents of a cartographic product or an agency's entire elevation data holdings to support subsequent cartographic production and analysis.

Challenges and Solutions for DEMs: Traditionally regular DEMs, with single grid spacing, have been created to model datasets with a consistent spatial resolution. In cases where the resolution varies, or is irregular, a Triangulated Irregular Network (TIN) may be created. However, both of these modeling techniques have associated limitations.

In the case of the regular DEM, a single resolution may not be sufficient to adequately represent the geographic area. And although a TIN model can be used to overcome the varying resolution challenge, TINs are more difficult to handle and visualize (i.e. large memory footprint).

To effectively deal with varying sensor data densities and to minimize storage requirements, maritime agencies have identified the need for DEMs to support multiple resolutions. To address this industry requirement CARIS has developed the Variable Resolution Grid (VRG) which allows the resolution of a single grid layer to vary over the geographic extent. Through the definition of multiple resolution areas in a single grid, [4] the VRG provides users with a solution to overcome the varying resolution challenge and continue to store very high volumes of data.

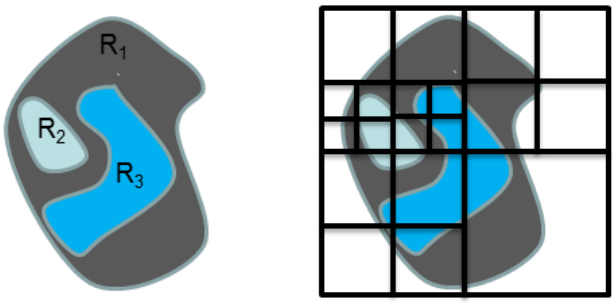


Fig. 3a: VRG Illustration

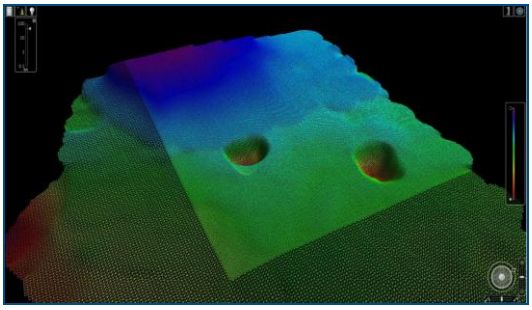


Fig. 3b: VRG Prototype in 3-D View

The VRG will support cartographic operations such as contouring and further analysis (e.g. slope and aspect computations). It is being developed in a phased approach with Phase 1 completed and in testing and Phase 2 in progress.

Features

Frequently a cartographic feature will be represented on multiple products and as a result, agencies encounter duplication of effort when updating multiple products independently. This is especially true for

agencies that have portfolios containing many product types, with varying scales, and with the same or overlapping spatial extents. However, an RDBMS that allows for one feature to be stored only one time, but have multiple persistent cartographic "representations" on multiple product types and at multiple scales, enables agencies to handle spatial data in a more efficient manner.

The data model allows for source data, compiled from a multitude of raster and vector GIS formats, and derived products to be stored in one integrated database solution. This approach supports the creation of multiple product types from the common source. Importantly, there is a common link between the source database and product database to ensure that the products are not independent from the source. This allows for changes to the source information to be tracked and efficiently applied as updates to the products in an automated manner.

Common Source

As an extensive range of data formats existing in the GIS community, it is important for the RDBMS to allow agencies to integrate and manage complex spatial information from a wide range of possible sources. The spatial data may also be received from cartographic products at various scales. If a new feature is created in the source database the scale, or usage, that the data is received in will become the base usage. The new feature representation will then be stored at that scale. However, as illustrated in the figure below, representations of the feature can then be added to other usages and, if required, further generalized (e.g. for a coastline represented at a smaller scale).

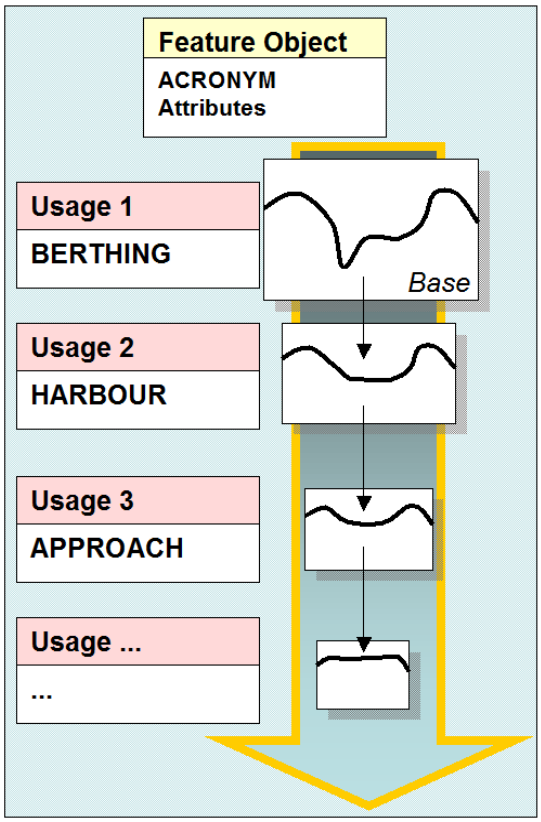


Fig. 4: Single Feature with Multiple Cartographic Representations

The data model also allows features to be stored independent from a specific presentation. This approach enables a single agency to minimize duplication of data while supporting many marine applications. Examples of the spatial information included in the common source can include, but would not be limited to navigational aids, wrecks, obstructions, underwater rocks, submarine cables or restricted areas. [5] All of these spatial data types support marine activities such as safety of navigation and, importantly, economic development, security, defence, scientific research and environmental protection. [6]

In addition to the above, agencies also have the ability to undertake law of the sea related work through the calculation and maintenance of the territorial sea and other maritime zones, such as a nation's Exclusive Economic Zone (EEZ). The geodetic calculations also have applications in other sectors, such as petroleum exploration, through the determination of concession maps.

Use of desktop solutions for such GIS analysis can pose a number of challenges, such as corruption issues associated with the use of many independent files being continuously accessed by multiple users, and lack of an audit trail to provide history of changes made to the data. [7] Use of the RDBMS with integrated limits and boundaries tools however, allow agencies to overcome these challenges.

Many Products for Many Purposes

Products such as paper charts and ENCs of course provide information for safe navigation. However, the products and marine spatial information provide decision support for many aspects of the marine and coastal zones (e.g. security, flood modeling, etc.). As such, the RDBMS also enables agencies to produce products, such as Marine Information Overlays (MIOs), which provide navigation-related information, but are non-mandatory and in addition to that required for safe navigation with an Electronic Chart Display Information System (ECDIS). [8] In addition, by supporting several data formats as the carrier for the various products, agencies can support the needs of a greater number of stakeholders and users.

Product Type	Description / Comment
Paper Charts	Nautical paper charts based on IHO INT1 and INT2 presentation as well as organization specific products (e.g. created by harbour / port and inland river authorities)
ENCs	S-57 ENCs in accordance with IHO specifications for use with ECDIS / Electronic Chart Systems (ECSs).
IENCs	S-57 Inland ENCs (IENCs) in accordance with international standards for the safe and efficient navigation of inland waterways.
AMLs	S-57 Additional Military Layer (AML) vector products designed to support maritime defence operations, [9] including mine counter measures, submarine operations and other security activities.
RNCs	S-61 Raster Nautical Charts (RNCs) in accordance with IHO specifications to further assist mariners.
Nautical Publications	Nautical publications including Notices to Mariners (NtMs) for critical navigation updates and list publications, including List of Lights, List of Wrecks and others.
bMIO	S-57 bathymetric MIOs (bMIOs) containing high density contours (i.e. decimetre interval) and other features to supplement ENC / IENC bathymetry information. For example, for use by harbour pilots to visualize the state of a rapidly changing seafloor. [10]

Table 1: Examples of Database Driven Cartographic Products

Database driven cartography allows agencies to minimize the duplication of data and effort, and realize efficiencies in the production of multiple products. As an example, in 2010 the Canadian Hydrographic Service (CHS) reported that use of the RDMS and the same source data has allowed them to remove 90 per cent of the duplication of effort in the production of paper, ENC and RNC products. [11]

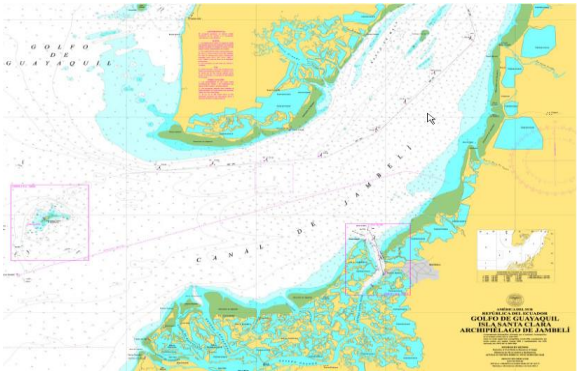


Fig. 5a: Paper Chart from RDBMS [12]



Fig. 5b: ENC from RDBMS [13]

The above makes reference to existing products that are based on existing standards. However, as new product specifications are finalized under S-100, which is based on the ISO/TC 2011 data standards, these will also be supported by the RDBMS to facilitate the expanded use of marine spatial information by a larger number of data users.

An example of this transition to the new products under S-100 is support for the IHO S-102 Bathymetric Surface Product. [14] As an alternative to traditional soundings and contour products to represent bathymetry, the S-102 product specification has been defined with the CHS and US Naval Oceanographic Office (NAVO) leading the effort. [15] S-102 Bathymetric Surface Products will provide a seafloor model that can be integrated into an ECDIS / ECS and overlaid with the electronic chart data to provide value-added information. The product specification will also facilitate the exchange of high resolution bathymetric data for coastal zone managers, geologists, environmentalists and others. The RDBMS has been used by CHS and NAVO in early S-102 production to prepare the datasets and export them to the selected carrier format. Options for the carrier format currently include the Bathymetric Attributed Grid (BAG) and 32-bit floating point GeoTIFF.

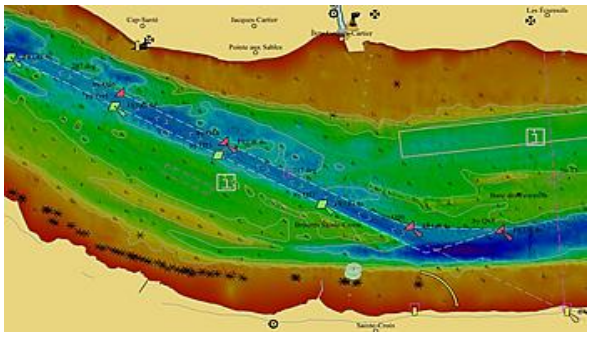


Fig. 6: Filtered ENC and S-102 in background [15]

Marine Data Discovery

Marine agencies are increasingly being pressured to provide easy access to their spatial data holdings. A primary example of this trend includes the Infrastructure for Spatial Information in Europe (INSPIRE) directive, which aims to create a European Union (EU) Spatial Data Infrastructure (SDI). At the same time, the marine community also has a growing interest to integrate external data. To achieve these objectives a standardized approach is needed.

Though the use of web-enabling technology and standardized web services defined by the Open Geospatial Consortium Inc.® (OGC), marine agencies can gain access and provide access to spatial data holdings. In particular, web mapping solutions using OGC standards, such as WMS and WMTS, WFS and WCS, facilitate web map browsing, query and download of RDBMS DEMs and Features by various stakeholders.

In addition, it is also important for interested parties to be able to effectively search and discovery the marine GIS data. This is achieved through the use of the OGC Catalogue Services for the Web (CSW), which allows information about the data holdings (metadata) to be collected and made available to web-based searches. Stakeholders can then investigate the search results and decide if they wish to access / download the spatial information.

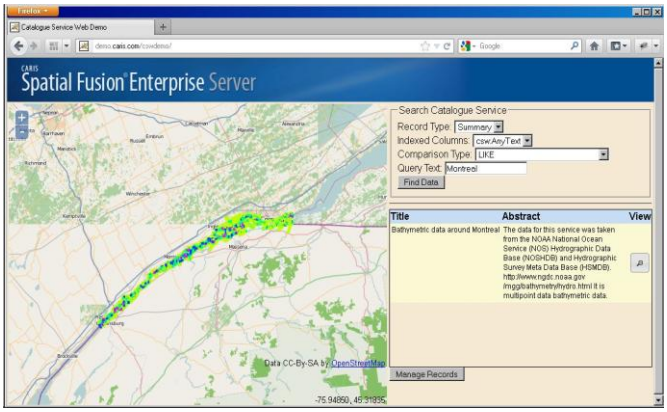


Fig. 7: Web Search and Results for Bathymetric Data using OGC Services

Through the RDBMS and web-enabling technology supporting OGC services, agencies can implement the technical infrastructure required to support interoperability. This includes the principals of a Marine Spatial Data Infrastructure (MSDI), which is the marine component of an SDI. This will lead to increased access to marine geographic information and maximized use of the data within the organization, with related organizations and other stakeholders.

Summary

Since the late 1980s and 1990s many agencies within the maritime community have implemented digital mapping and GIS systems. Although these solutions provide associated benefits, users may still encounter challenges when handling a large number of independent files, and independently updating multiple products. However, an RDBMS specially designed for the marine environment allows agencies to effectively integrate, visualize, access and re-distribute the spatial information and products.

Using a database driven approach for cartography users can effectively manage high density DEMs and compile a common source of vector Features to support rapid production of multiple paper and electronic products. Access and use of the spatial information can also be further extended through web-enabling technology that supports standardized web services. By implementing these marine GIS solutions agencies can achieve their goals to reduce duplication of data, increase productivity, and ensure interoperability to support MSDI principles and sustainable Earth resource management.

References

1. IHO S-100 – Universal Hydrographic Data Model, Edition 1.0.0 – January 2010

2. Fellinger, Kruimel, Spinoccia; Implementation of a Bathymetry Database for Geoscience Australia; Proceedings of the Shallow Survey 2012 Conference

3. ISO 19115-2:2009, Geographic information -- Metadata -- Part 2: Extensions for imagery and gridded data; http://www.iso.org/iso/catalogue_detail.htm?csnumber=39229

4. Mark Masry; Variable Resolution Grids: Implementation and Applications; Proceedings of the Shallow Survey 2012 Conference

5. Caroline Texier, Service Hydrographique et Océanographique de la Marine France; Implementation of a geospatial infrastructure for hydrographic data at the French hydrographic Office (SHOM); Proceedings of the CARIS 2010 User Conference

6. International Hydrographic Organization; Definition of Hydrography; www.iho.int/srv1/index.php?option=com_content&view=article&id=299&Itemid=289

7. Simon Matthews, UKHO Law of the Sea; Hydrographic Production Database and Law of the Sea: Digital Data with No Limits; Proceedings of the CARIS 2012 User Conference

8. Dr. Lee Alexander and Michel Huet; Marine Information Overlays (MIOs), Relationship to Current/Future IHO Standards

9. AML Handbook, Additional Military Layers, Information superiority in the maritime environment; Produced by the United Kingdom Hydrographic Office on behalf of NATO; Edition 3 January 2012

10. Marc Roesbeke, Flemish Hydrography; Using the Bathy DataBASE to produce high-density bathymetric electronic charts and paper survey plans at the Flemish Hydrography; Proceedings of the CARIS 2010 User Conference

11. Lynn Patterson, Canadian Hydrographic Service; A Unified Production Suite, Vector and Raster; Proceedings of the CARIS 2010 User Conference

12. Patricia Villa, Instituto Oceanográfico de la Armada del Ecuador (INOCAR); CARIS Calendar 2009

13. Eduardo Machuca, Directorate of Hydrography and navigation, Peruvian Navy; CARIS Calendar 2010

14. IHO Publication S-102, Bathymetric Surface Product Specification, Edition 1.0.0 – April 2012

15. Marc Journault and Louis Maltais, Canadian Hydrographic Service and Ed Kuwalek, IIC Technologies Canada; The New IHO S-102 Standard; Hydro International, May 2012, Volume 16, number 3

Strip Adjustment of Airborne LiDAR data

Anil Kumar G., Sadasiva Rao B., Gopala Krishna PVSSN.
Aerial Services & Digital Mapping Area, National Remote Sensing Centre, ISRO.
Email: g_anilkumar@nrsc.gov.in

Abstract

Obtaining precise height information using traditional methods requires more manpower, time and cost. Light Detection And Ranging (LiDAR) is a Remote sensing technique, by which it is possible to get precise elevation information with sub meter accuracy in very less time, with less manpower and cost. Airborne Laser System (ALS) is a sensor which works based on the principle of LiDAR. ALS consists of mainly 3 independent components i.e. Laser ranging instrument with scanner mirror, Global Positioning System (GPS) and Inertial Measurement Unit (IMU). The final accuracy of the height information achieved from this system depends on the accuracy of these 3 independent systems and derivation of systematic errors. Boresight calibration is carried out to establish a relation between these 3 independent systems. This boresight calibration addresses the various kinds of errors namely misalignment angles, lever arms between sensors, scan mirror angle biases & range bias. Final LiDAR accuracy depends on the Kinematic GPS (KGPS) data solution apart from above mentioned systematic errors. The time dependent KGPS data accuracy and the small residual misalignment errors after the boresight calibration cause the biases between different strips of data which are flown with overlaps. To minimize these biases due to systematic errors, strip mismatch and datum shifts, it is required to carry out strip adjustment of LiDAR data using few ground control points. This paper provides the insight of LiDAR sensor boresight calibration, strip adjustment of LiDAR data and its effectiveness on final data accuracy.

Introduction

Airborne LiDAR (Light Detection And Ranging) is a complex multisensory system consisting of three main components: laser, GPS, and IMU units. The basic principle is to measure distances from the sensor to the ground by converting the travel time information of the laser pulses sent to the earth. A scanning mechanism, usually a scanning mirror, is used to collect the data in a strip-wise fashion (A. F. Habib et al., 2008).

In applications, where a rectangular block or corridor is flown in a parallel line pattern, minimal overlap between neighboring strips is typically required to maintain contiguous coverage of the ground. The accuracy achieved for the final product depends on the KGPS data solution accuracy, IMU drift, and accurate estimation of misalignments between GPS/INS system and laser scanner measurement head apart from the scanner and range errors. The misalignment angles are calculated using a procedural calibration of the integrated sensor.

The quality of the derived point cloud from a LiDAR system depends on the systematic and random errors in the system measurements and parameters (Baltsavias 1999, Glennie 2007). One of the reason for the presence of the errors in the data even after boresight calibration of the system is due to the estimation of the position of the points are based on the interpretation of GPS & IMU data (as the sampling interval of the GPS is 0.5 sec and IMU is 0.005 sec). Depending on their source, these errors can be distinguished into local errors and strip wise errors. Strip wise errors have influence on all three ground point coordinates (George Vosselman et. al. 2001).

The main goal of strip adjustment is to minimize the impact of strip mismatch errors in the LiDAR system parameters by improving the compatibility among neighboring strips. Many strip adjustment techniques works based on sensor parameter calibration, therefore to better support these processes, cross strips are also frequently flown. This strip adjustment is similar to the bundle block adjustment in the photogrammetry. This paper provides the insight of LiDAR sensor boresight calibration and strip adjustment of LiDAR data and the parameters required for strip adjustment of the LiDAR data, its effectiveness on final LiDAR data accuracy.

Study Area

Table 1: Study area description

Location of the study area	Narsingapur district, Madhya Pradesh	
Area of extents	$23^0$10'N, $78^0$20'E	$23^0$10'N, $79^0$30'E
	$22^0$40'N, $78^0$20'E	$22^0$40'N, $79^0$30'E
Area in Sq. Km.	930 Sq. Km.	
Land Cover	Covered by 70% Agricultural, 20% water bodies, 5% settlements and 5% others	
Topography	80% of land is flat with slope < 5 deg and 15% land gullied riverine land and 5% land is with hills with slopes > 20 deg	

Table 2: Data description

Sensor Used	ALS 50
Date of Acquisition	18th to 24th February 2012
Point spacing	2m x 2m
Flying Height	~ 2000 m (AGL)
No. of flight lines	40 regular flight lines with 5 additional tie lines

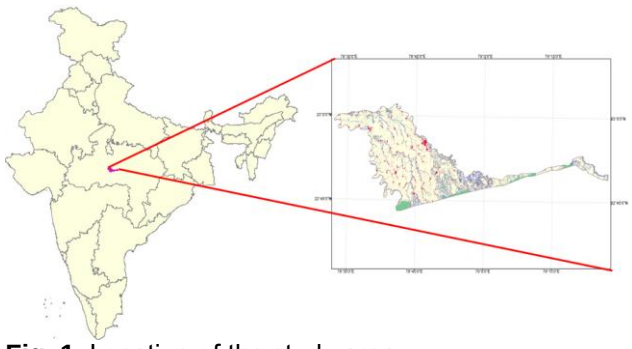


Fig. 1: Location of the study area

Methodology

The major error sources in the LiDAR data are due to systematic and local errors. Systematic errors are due to inaccuracies in measurement of laser range, scan mirror angles, sensor misalignment angles and lever arms. Local errors are due to estimation of GPS position, IMU orientation angles. The systematic errors in LiDAR data can be removed by estimating the sensor calibration parameters and local errors can be removed by carrying out strip adjustment. To obtain the data seamlessly the following sequential processes are carried out in any LiDAR data preprocessing.

i. KGPS & IMU data processing
ii. Geo-referencing of LiDAR data
iii. Boresight calibration of the LiDAR sensor at calibration site
iv. Strip Adjustment of LiDAR data for project study area

a. Measurement of tie patches and ground control points
b. Carrying out discrepancies stripwise
c. Applying correction for each strip
d. Finding KGPS trajectories fluctuations
e. Applying fluctuation corrections for each strip Verification of data
f. Using profile technique
g. Geometric accuracy checking with respect to check points

Boresight calibration is carried out to estimate the misalignment angles, leverarms between IMU and laser sensor. This is realized by finding systematic errors present in the positional and height errors in laser data due to roll pitch and yaw. To estimate the errors flightlines are to be acquired in four different directions perpendicularly with the following pattern shown in Fig. 2 at project flying altitude over the calibration site. There are many ways to carry out the bore sight calibration. In this study profiling technique is used for Boresight calibration. To carry out the calibration using profile technique the calibration site should have flat ground (to estimate roll and dz estimation) with sloped roofed buildings (to estimate pitch and heading).

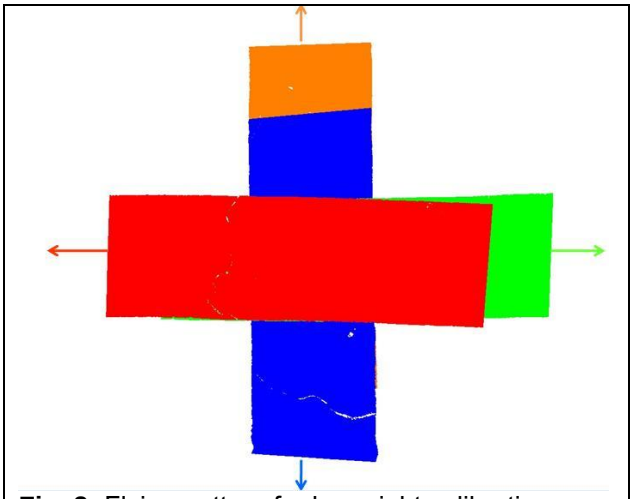


Fig. 2: Flying pattern for boresight calibration

After removing the systematic errors present in the data using boresight calibration, strip to strip mismatches are verified. If the mismatch errors are not in the permissible limits, strip adjustment is to be carried out. The mismatch between strips is shown in Fig. 3 after Boresight calibration.

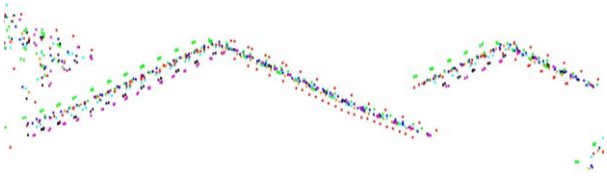


Fig. 3: Strip to strip mismatch before strip Adjustments

This strip adjustment can be done either automatically or manually. To carrying out this there are several softwares and algorithms are available. The software is Terramatch is used in this study. To carry out the strip adjustment data has to be acquired with overlaps between strips and tie lines similar to photogrammetric block adjustment. To carry out strip adjustment tie patches, lines and control points are required in overlap regions.

Since the LiDAR data is in the form of point clouds, it is not easy to find out the strip tying features like in

photogrammetry like sharp points and corner points and intersection of the roads, etc. So, in LiDAR data the homogeneous point locations, homogeneous patches and tie patches (such as sloped roofs, similar patches) have to be identified as shown in Fig. 4. For identifying the homogeneous point locations and tie patches the software will consider the TIN structure and intensity information presented in the LiDAR data. This can be done manually or automatically. When automatic method fails tie patches are to be identified manually in overlap regions for better estimation of strip discrepancies in all directions.

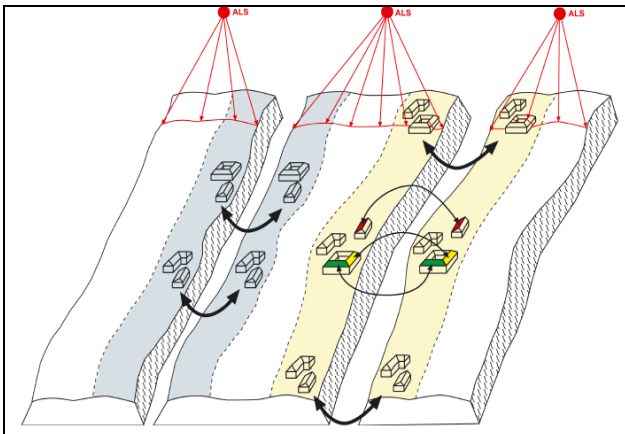


Fig. 4: Sample homogeneous patches and tie point locations (Norbert Pfeifer 2008)

After identifying the tie patches, tie points and control points strip to strip discrepancies are estimated in vertical and horizontal direction. These discrepancies can be computed for individual flight lines or for whole project area at a time. In this study discrepancies are estimated for individual flight lines separately to have better adjustment. These discrepancies between the strips are estimated for 6 parameters, easting shift, northing shift, Z shift, heading shift, roll shift and pitch shift. These corrections are applied stripwise along with KGPS trajectories fluctuations derived in z direction. Control points can also be used to reduce the datum shift errors are present in the data if any. The distribution of control points, tie lines used over the study area are shown in Fig. 5.

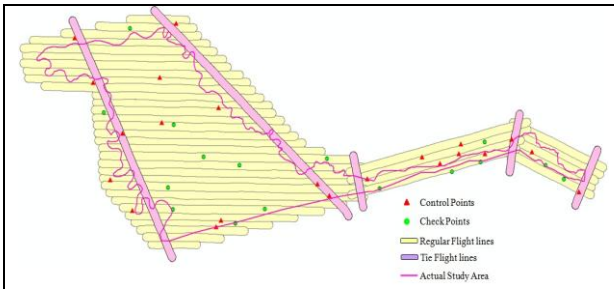


Fig. 5: Distribution of GCP's & Check points used in the study area

Results

To validate this methodology in this paper, data with parallel and tie strips are used. This study area consists of 40 strips flown in east-west direction and 5 strips flown in a north-south direction. The distribution of this study area is shown in Fig. 5. The statistics of mismatch errors between strips are shown in table 3. The statistics of derived parameters of roll pitch and heading shifts, dz corrections are shown in Table 4 and 5 respectively after strip adjustment. The final accuracy of the data was verified with respect to check points (distribution is shown in Fig. 5) are given in Table 6. The Strip to strip mismatch after strip Adjustments are shown in Fig. 6.

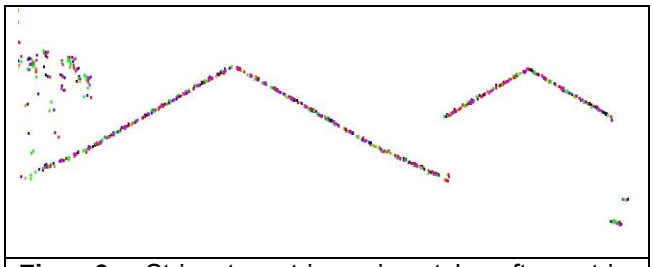


Fig. 6: Strip to strip mismatch after strip Adjustments

Table 3: Measure match results before strip adjustment

MinIMUm	-0.212
MaxIMUm	0.252
Range	0.465
Mean	-0.101
Std Deviation	0.119

Table 4: Roll, Pitch, Heading corrections applied on the flightlines after strip adjustment

	Roll shift	Pitch shift	Heading Shift
MinIMUm	-0.0132	-0.0164	-0.0274
MaxIMUm	0.0114	0.0080	0.0427
Range	0.0246	0.0244	0.0701
Mean	-0.0004	-0.0003	0.0013
Std Deviation	0.0045	0.0040	0.0107

Table 5: Dz corrections applied on the data after strip adjustment

MinIMUm	-0.197
MaxIMUm	0.275
Range	0.472
Mean	0.050
Std Deviation	0.112

Table 6: Control report of the data with respect to check points

Average Dz	0.083
MinIMUm Dz	-0.119
MaxIMUm Dz	0.138
Std Deviation	0.091

Conclusion

The study shows that, even though boresight calibration is done, strip to strip errors are persisting in the data due to the local errors. Using strip adjustment method local errors present in the data can be minimized. So combination of these two methods ensures the seamless dataset.

References

1. F. Habib, A. P. Kersting, Z. Ruifang, M. Al-durgham, C. Kim, D. C. Lee, "LiDAR Strip Adjustment Using Conjugate Linear Features In Overlapping Strips" International Archives of Photogrammetry and Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B1. 2008 pp. 385-390.
2. Baltsavias, E., 1999. "Airborne Laser Scanning: Existing Systems And Firms And Other Resources", ISPRS Journal of Photogrammetry and Remote Sensing, 54 (2-3), pp. 164-198.
3. George Vosselman and Hans-Gerd Maas, "Adjustment And Filtering Of Raw Laser Altimetry Data", OEEPE Workshop on Airborne Laser scanning and Interferometric SAR for Detailed Digital Elevation Models 2001.
4. Glennie, C.L., 2007. "Rigorous 3D Error Analysis Of Kinematic Scanning LiDAR Systems", Journal of Applied Geodesy, 1: 147-157.
5. Norbert Pfeifer, presentation on "Strip Adjustment and DSM Computation" at International School on LiDAR Technology 2008 at IIT Kanpur, India

Developments in Cartography - A boon or bane?

Dr. V.V.L.N. SARMA
Civil Hydrographic Officer
National Hydrographic Office, 107A, Rajpur Road,
DEHRADUN-248 001, Uttarakhand.
E-mail: vvlns@yahoo.co.uk

Abstract

Traditionally, cartography has been playing a vital role in the decision making process of mankind. Like many other subjects, cartography has also been transformed by the technological innovations and rapid changes in terms of its representation, use, popularity and commercialisation too.

From the centuries old maps constructed with brushes and parchment to the present day computer-aided plots, the saga of cartography continued with many such capabilities which are proved to be inseparable from human life. However, in modern times, the real cartography has been seriously infested with its normal use to anything that appears like a map. From its perspective ways of manual representation to the use of automated cartographic techniques, this subject has witnessed several changes that have, needless to say, increased its use to a large extent, but not definitely in the name of cartography and replaced in many ways by the term 'GIS'. Even this change has also affected the educational departments/institutes that offer the courses on cartography have been converting as centres of RS, GIS or Geoinformatics.

On the other hand, latest trend indicates the use of the term 'cartography' by non-mapmakers and new types of cartography have been emerging such as emotional, expression, web, knowledge cartography thereby widening its scope and opening new opportunities for the present generation. Although these trends are encouraging, the gloomy element is ignoring the cartographic principles, rules, conventions and quality aspects of a map. Consequently, these maps may be mistaken and accepted as good ones and best of the times by the coming generations. The objective of this paper is to highlight the developments in cartography and their pros and cons with respect to the very existence of this fascinating subject.

Introduction

The discipline cartography combines science, aesthetics, and technical ability to create a well-balanced and legible representation of the real-world (Zentai, 2009). In a modern approach, mapping is understood as the ability to create a knowledge frame of an environment in space (Konecny and Ormeling, 2005)**.** This discipline from its centuries old history has been witnessing many developments that have now transformed it to more or less a household name. However, this popularity is not in the name of cartography but as a map of any kind in any form. From its static nature in the form of rock and drawings of ancient times to the present day information technology driven real-time mapping techniques, the art and science of cartography has many progressive changes in the form of inventions and advancements. Some of them include: Magnetic Compass (13^{th} Century), Sailing charts (*Portolan) bearing compass roses (1300 A.D.), Printing (15^{th}* Century), Map projections (17^{th} – 18^{th} Centuries), The era of global explorations and national mapping programmes in Europe (17^{th} -19^{th} centuries). All these had great impacts on conscious development of Cartography. Though people have been using the maps to the best of their purposes, most of them were unaware of the relative importance of skills and expertise involved in representing the real world details. Most of the times, the term 'Cartography' or 'Cartographer' was not importantly known to the map users although they were the best benefitted.

Cartography Vs GIS

Silayo *(2002)* distinguished the cartography as the theory and practice of mapmaking and map use, notably in the context of graphic communication, whereas Geographic Information System (GIS) is the Computer-based system for data input, management (storage and retrieval), manipulation and analysis, and displaying of spatial data. He further adds that the distinction between analogue cartography and digital cartography is *contextual.* Cartography is concerned with *representation*. GIS is a product of the development of computer-assisted cartography, which generated geo-referenced spatial digital databases.

In the past, most of the maps were perspective in appearance compared to the maps produced using modern automatic techniques. Cartography, in modern times, has been infested with its normal use to anything that appears like a map. Modern maps with the application of ready made tools of GIS need a

special understanding/reading ability to visualise the real world information. The popularity and use of GIS has started gradually replacing the 'cartography' with the advent of information technology. More and more sophisticated data analysis tools present in the GIS packages have made the art of map making as anybody's job without the need of cartographic expertise. Many of the GIS professionals nowadays claim to be the best map makers even without studying the basics of cartography in their life time. Very less professionals are aware of cartographic practices, rules and conventions. For example, many modern maps have not been indicated with the north arrow, which is most useful for the map reader to orient the map to its real-ground location. Such maps are indicative of being made by the GIS experts without having the cartographic knowledge. Though these professionals are very good operators of several GIS softwares, they must also study the subject of cartography and its practice in map making process. With this knowledge only one can produce a best map that can easily be interpreted and understood by the end user(s) without any extra effort. Further, the increasing use of GIS and availability of affordable software packages have resulted in fading the glory of the cartography. The author endorses and retains most of the views expressed by Silayo (2002) in this paper.

Cartographic maps – bad examples

Many maps of different themes and types have been produced globally for the needs and demands of the users. In the process, several good and bad quality maps were produced. If the bad ones are concerned, as the author feels that they are on the higher side, several violations of cartographic conventions and practices can be noticed. The reasons might be because of lacking basic cartographic skills or proper guidance or limitations in making those maps such as time and resources in terms of map making tools. However, once the map is made available in the public domain, all these factors take a back seat as user is not unduly aware of any such inherent difficulties, perhaps in all probability, misunderstand the available ones as the best of the times.

There are numerous bad quality maps available at *http://cartastrophe.wordpress.com*. For example, Fig. 1 is a map of Europe (part of a world map) that uses colors excessively and without obvious purpose. Main deficiencies in this map include too many names, poor colour combination, etc. Names must be in proportion to the scale of the map and colour contrast should have been improved for better appreciation of the map user(s). Look at another map (Fig. 2) as highlighted by Silayo (2002). In this map, map maker's objective was to show the cattle distribution. However, the following inconsistencies such as weird scale of the map, shading used for cattle is too coarse, text is not easily readable, water areas have dominated over other themes etc., can be seen here.



Fig. 1

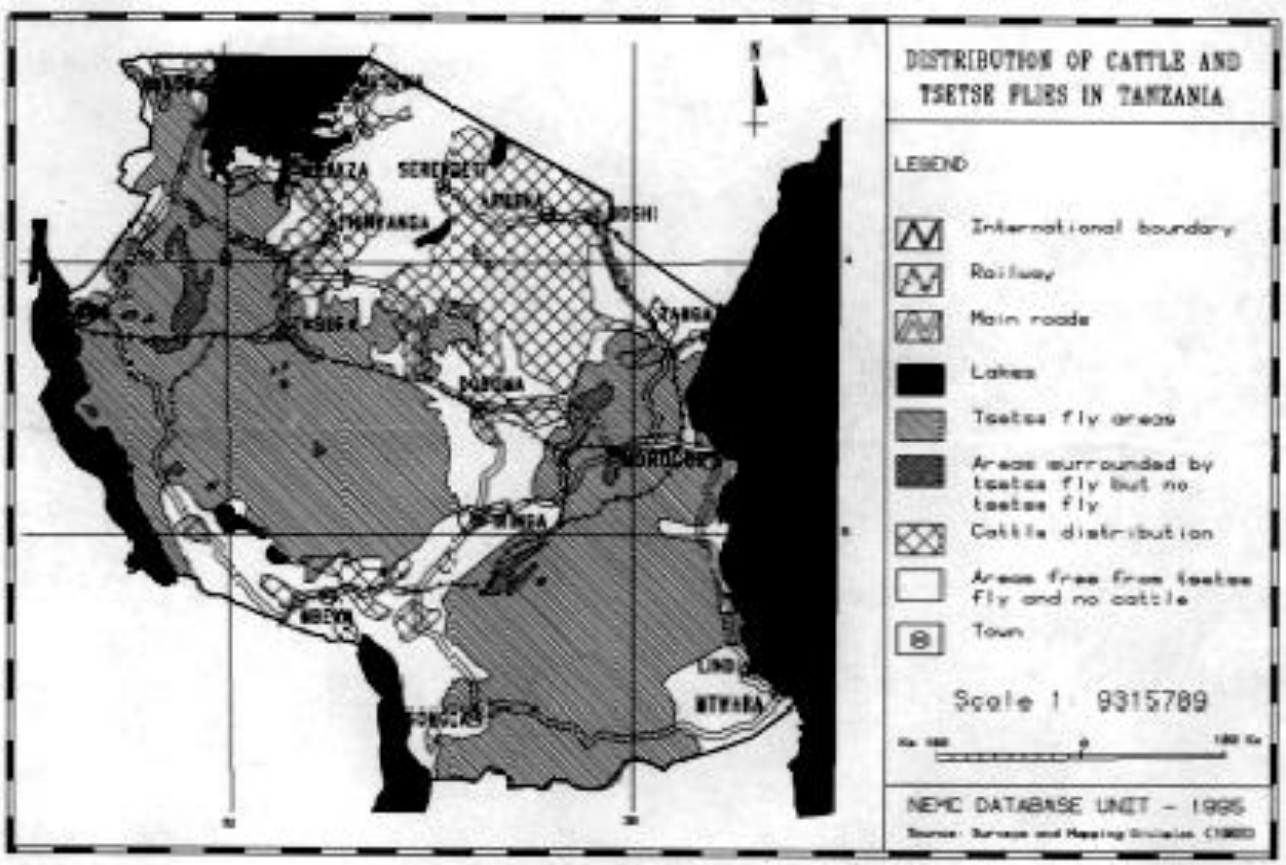

DISTRIBUTION OF CATTLE AND TSETSE FLIES IN TANZANIA
LEGEND
International boundary
Railway
Main roads
Lakes
Tsetse fly areas
Areas surrounded by tsetse fly but no tsetse fly
Cattle distribution
Areas free from tsetse fly and no cattle
Town
Scale 1 : 9315789
NEMC DATABASE UNIT - 1995

Fig. 2

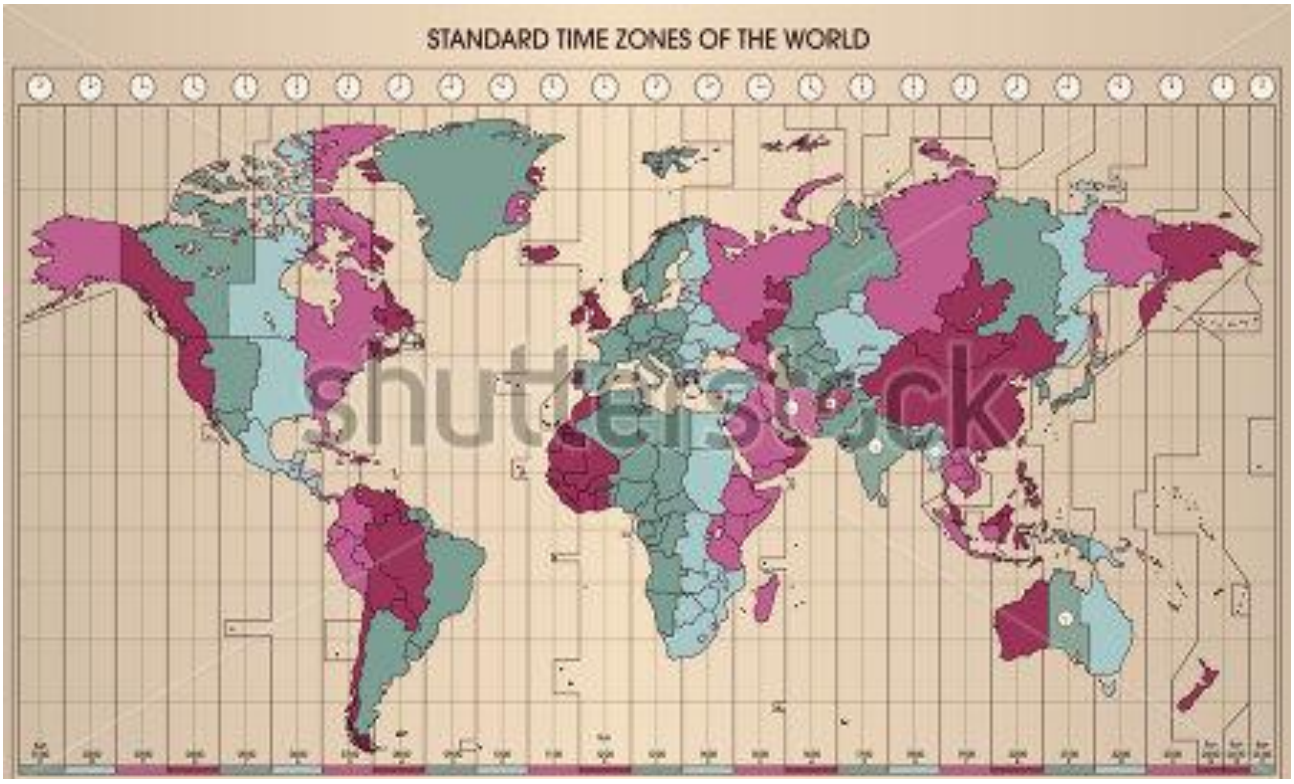

STANDARD TIME ZONES OF THE WORLD

Fig. 3

In Fig. 3 above, one can observe the poor colouring chosen for standard time zones. Thick colours as available in the GIS package might have been used rather than applying good cartographic skills to represent the zones. In order to address the deficiencies highlighted in the above examples, map maker must have the cartographic skills and professional thoroughness so that map user uses the map without any formal knowledge of cartography and map reading ability. As pointed out by Silayo (2002), map maker must keep in mind the purpose of the map, the intended use, conditions in which the map will be used, the scale of the map, its content, design, colour and entire graphic presentation. GIS operators especially those without proper cartographic knowledge need to consider and remember these points while producing a best quality map with effective use.

Latest developments

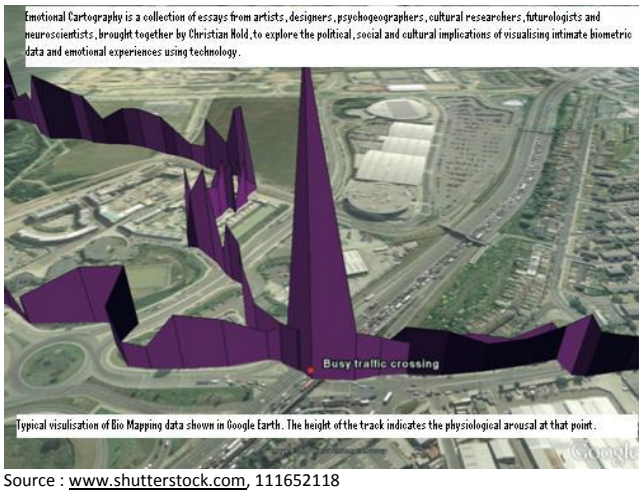
The increasing popularity of computer embedded devices is creating new forms of communication and interaction between people and things. Ubiquitous computing is continuously adding and retrieving information to and from an augmented space (Loidl et al, 2011). Here, to allow for a seamless transitioning between the virtual and the physical space, Geographic information media are a baseline for any application in this field (Blaschke & Strobl 2010). However, in some fields, without the location information, the art of cartography has been used, to some extent, to highlight a particular theme. The role of cartography in such cases has been changed to an interface for any kind of communication in rating, describing and commenting about a specific theme viz. expression, knowledge, emotion etc. The latest trend indicates the use of the term 'cartography' by many non-map makers. As a result, some new types of cartography are emerging such as expression, emotional, web and knowledge cartography, to mention a few.

Expression Cartography

This term was particularly used by Wirth *et.al* (2011) to emphasise on gene expression analysis. In this study, Self Organised Maps (SOMs) were prepared characterising the whole genome expression profiles of 67 healthy human tissues selected from ten tissue categories (adipose, endocrine, homeostasis, digestion, exocrine, epithelium, sexual reproduction, muscle, immune system and nervous tissues). In order to see the genome expression profiles, they used the term 'expression cartography'. Though the individual researches are not essentially belongs to the field of cartography, as it appears from the maps they produced (available at *www.biomedcentral.com*), but are medical and bioinformatics experts. It gives a sense of pride when a rare group of experts of this kind using the term cartography in their study.

Emotional Cartography

In this type of cartography, the word cartography is used to show and map the emotional intensity of a person under different situations and places. To practically explore this subject, Christian Nold invented and built the Bio Mapping device, which is a portable and wearable tool recording data from two technologies: a simple biometric sensor measuring Galvanic Skin Response and a Global Positioning System (GPS). The bio-sensor, which is based on a lie-detector, measures changes in the sweat level of the wearers' fingers. The assumption is that these changes are an indication of 'emotional' intensity. The GPS part of the device also allows us to record the geographical location of the wearer anywhere in the world and pinpoint where that person is when these 'emotional' changes occur. This data can then be visualised in geographical mapping software such as Google Earth. The result is that the wearer's journey becomes viewable as a visual track on a map, whose height indicates the level of physiological arousal at that particular moment. The Bio Mapping tool is therefore a unique device linking together the personal and intimate with the outer space of satellites orbiting around the Earth. The device appears to offer the colossal possibility of being able to record a person's emotional state anywhere in the world, in the form of an 'Emotional Map' as shown in Fig. 4. *(www.emotional carography.net).*



Source : www.shutterstock.com, 111652118

Fig. 4

Web cartography

The web is the new medium of maps, changing cartographic representation from paper and desktop GIS to distributed, user-centered, mobile, and real-time geospatial information services. Web cartography is a

new frontier in cartographic research transforming the design principles of map-making and the scope of map use (Tsou, 2011).

Some types of web maps (Harrie, 2011),) include Analytic web maps, Animated web maps, Collaborative web maps, Customisable web maps, Distributed web maps, Dynamically related web maps – hyper maps, Interactive web maps, Online atlases, Personalized web maps, Real-time web maps, Static web maps, and Temporal web maps.

Knowledge Cartography

The Knowledge Cartography, primarily proposed by W. Waloszek, has been applied in a prototype knowledge management system called KASEA (*Knowledge Signatures Analyzer*). The Knowledge Cartography takes its name after a map of concepts. A map of concepts is basically a description of interrelationships between concepts in a terminology. The map is created in the course of knowledge base creation. A map of concepts can be graphically represented in a form similar to a Venn diagram (Krzysztof *et al,* 2006). Using this technique we can assign any concept in the terminology a *signature* - an array of binary digits representing a region covered by the concept in the map. In this way we can describe any combination of complement, union and intersection of described concepts by simply mapping these operations to Boolean negation, disjunction and conjunction.

Knowledge cartography is a management model for the research ecosystem offers the ability to create a collective network of users, resources, and keywords. Working on these data it's possible to create an *Atlas of knowledge spaces* made of maps at various levels of scale, ranging from personal research maps to department level maps of knowledge, or even collective maps of research areas emerging at university level. Of course, a naive visualization of *all* the entities stored within the database would be both impossible and useless because of excessive information density. As with traditional cartography, the task of representation doesn't simply lie in the creation of a *replica* of reality, but appears as a cultural process for the narration of the territory. According to cartographic rhetoric, reality must be selected, projected and symbolized in order to create maps with specific objectives (Quaggiotto, 2007). Sierhuis and Shum **(***2007) describe* the socio-technical embedding of a knowledge cartography approach (Conversational Modelling) within a prototype e-science work system. This was evaluated over two-week field trials, simulating collaborative Mars-Earth geological exploration. They believe that this work is the first demonstration of a knowledge mapping tool embedded within a human/software multiagent work system, with humans and agents reading and writing structures amenable to agent understanding and autonomous agent execution, and human understanding, annotation and argumentation. Secondly, in terms of the applied problem, they have demonstrated how human and agent plans, data, multimedia documents, metadata, discussions, interpretations and arguments can be mapped in an integrated manner, and successfully deployed in field trials which simulated aspects of mission workload pressure

Cartography – losing its ground?

A detailed study was carried out by Zentai (2009) on the use of the term 'Cartography' in research papers (English version abstracts only) published in the proceedings of the ICC since 1989 to 2007 (6 conferences). This study has revealed the dominance of words namely 'data' and 'information' and no use of cartography related words in the top 10 frequency occurrence ranks, thus giving indications of replacement of cartography by words data, information, spatial and digital.

Zentai (2009) also highlighted that the educational departments, centres, institutes that were traditionally established for imparting the cartographic knowledge in colleges and universities have been changing their old names to keep their relevance to the technological advancements in the field of GIS. Further, in higher education, the names of different institutes and departments have skipped the traditional term 'cartography' and begun to include more modern terms like Geomatics, Geoinformatics, GI science. Many centres of cartography have either become the centres of Remote Sensing, GIS or Geoinformatics. Some universities have started offering UG and PG courses in GIS and Geoinformatics thereby attracting the new generation students to study these courses. In fact, the cartography has been reduced from its lead role in the past to a subsidiary role nowadays (Silayo, 2002). But this trend is not in the best interest of the cartography.

Conclusion

Main point to highlight in this paper is to understand various issues that the traditional cartography is facing due to the advent of GIS software and information technology. Many map users often confuses cartography with the modern GIS and even some of them are not aware the term 'cartography' too. From its lead role in the past to the subsidiary role of the present, it appears that cartography is on the verge of disappearance in its popularity. However, the cartographic approach is built in the human brain of the cartographer and will not be built-in totally in software, at least not in our life (Zentai, 2009). In order to bring back the glory of this subject, educational institutes, mapping organizations, professional cartographers and geographers must inculcate the facts and use of

cartography and its application in maps by giving wide publicity in class rooms and at various forums. “Every profession has acceptable justifications for being protective and insular. But all together, they have a mission for sustainable human development, which can be realized only through collective efforts (Silayo, 2002)”.

References

1. Harrie, Lars (2011), Web cartography for INSPIRE, INSPIRE Conference, Lund University, Edinburgh, 30 June 2011

2. Konecny Milan, and Ormeling Ferjan (2005), The Role of Cartography in the GSDI World, From Pharaohs to Geoinformatics , FIG Working Week 2005 and GSDI-8, Cairo, Egypt April 16-21, 2005.

3. Krzysztof Goczyła, Teresa Grabowska, Wojciech Waloszek, and Michał Zawadzki (2006). The Knowledge Cartography – A new approach to reasoning over Description Logics ontologies.*http://www.km.pg.gda.pl/kmg/publications/papers/Cartography.pdf*

4. Nold, Christian. Editor, *Emotional Cartography – Technologies of the Self*

5. Quaggiotto Marco (2007). Knowledge Atlas: a cartographic approach to the social structures of knowledge. *www.*knowledgecartography.org.

6. Silayo, E.H (2002). Cartography in a GIS environment. www.isprs.org/proceedings/ *XXXIV /6-W6/ papers/silayo_cor.pdf*

7. Sierhuis Maarten and Shum Simon Buckingham (*2007).* Human-Agent Knowledge Cartography for e-Science: NASA Field Trials at the Mars Desert Research Station. *Draft chapter for Knowledge Cartography: Software Tools and Mapping Techniques. Eds. Okada, A., Buckingham Shum, S. and Sherborne, T. (Springer 2007)*

8. Tsou Ming-Hsiang (2011) Revisiting Web Cartography in the United States: the Rise of User-Centered Design. *Cartography and Geographic Information Science, Vol. 38, No. 3, 2011, pp. 250-257*

9. Wirth Henry, Markus Löffler, Martin von Bergen and Hans Binder (2011). Expression cartography of human tissues using self organizing maps, BMC Bioinformatics 2011, 12:306 *http://www.biomedcentral.com/1471-2105/12/306.*

10. Zentai László (2009) Change of the meaning of the term ‘Cartographer’ in the last decades, available at *http://lazarus.elte.hu/cet/academic/academic_papers.htm*

Adaptive Image Contrast Enhancement Technique on CARTOSAT - 1 Stereo pair for DEM quality improvement

Y K Srivastava[*], Arati Paul, VM Chowdary, A Jeyaram, Surajit Panda[#]
Regional Remote Sensing Centre - East, NRSC, ISRO, Kolkata
 # Jharkhand Space Application Center (JSAC), Ranchi
**Email: srivastava_yk@yahoo.com*

Abstract

Advancement in the acquisition of satellite images in stereo mode has added new dimension in generating DEM (Digital Elevation Model) and ortho-rectified images that helps in improved mapping. One of the most important factors that affect DEM quality is the image contrast of the stereo pair. Simple Histogram Equalization (HE) or Linear Stretch methods are effective, which improves the interpretability or perception of information for visual interpretation, or automated image processing. However, these methods are generally incapable of providing satisfactory enhancement on stereo pair as they act globally rather than locally causing over or under enhancement on certain regions in the image. Hence, there is a need to take care of local contrast enhancement within the image, where image characteristics differ considerably from one region to another due to complex terrain and varied reflectance of Electro Magnetic Radiation (EMR) from different features. In the present study, Adaptive Image Contrast Enhancement method, which is found to be very effective in the low contrast stereo pairs was envisaged for improvement of DEM derived using CARTOSAT-I stereo pair. Particularly, this method enhances image evenly by applying enhancement locally. It has been found that the DEM generated from an enhanced stereo pair produces overall better quality DEM as compared to the stereo pair without enhancement.

Introduction

DEMs (Digital Elevation Model) are used in many cartographic and GIS applications (*Krishna Murthy et al., 2008).* Indian Space Research Organization (ISRO) realized the importance of DEMs and launched CARTOSAT-1 satellite into circular (altitude is 618 km) near-polar sun-synchronous orbit on May 5, 2005. CARTOSAT-1 is equipped with two panchromatic cameras capable of simultaneous acquisition of images of 2.5 meters spatial resolution. One camera is looking at +26 degrees forward while another looks at –5 degrees backward to acquire stereoscopic imagery with base to height ratio of 0.62. The time difference between acquisitions of stereo pair images is approximately 52 seconds. Cameras are across-track-steerable to enhance the system productivity (*Navalgund, 2005, NRSA, 2005*). CARTOSAT-1 stereo pairs are extensively used for generation of high resolution DEMs and ortho-rectification of CARTOSAT -1 (mono) image. There are several factors that influence the quality and accuracy of the DEMs like; sensor tilt, error in GCPs, radiometry and image contrast etc. Image contrast of the stereo pairs could be manipulated through available image processing software to improve DEMs quality up to certain extent.

This study was carried out to compare DEMs quality that have been generated using CARTOSAT -1 stereo pairs having low contrast and after enhancement of image. Linear and non-linear image enhancement techniques are effective to some extent but they are incapable of providing satisfactory enhancement on the whole image as they work globally rather than locally, which causes over or under enhancement in certain regions of the image. Image characteristics differ considerably from one region to another in the same image depending upon the complexity of the terrain and reflectance of EMR (Electro Magnetic Radiation) from the different features (*Sreedhar et al., 2012*). Histogram equalization is the most popular algorithm for contrast enhancement due to its effectiveness and simplicity. It can be classified into two branches according to the transformation function used: global or local. Global histogram equalization is simple and fast, but its contrast-enhancement power is relatively low. Local histogram equalization, on the other hand, can enhance overall contrast more effectively, but the complexity of computation required is very high due to its fully overlapped sub-blocks (*Kim et al., 2001*). In the past several image enhancement techniques viz., CLAHE (Contrast Limited Adaptive Histogram Equalization) (*Sepasian et al., 2008*); Local Standard Deviation (LSD) (*Somorjeet Singh et al., 2012)* Adaptive Contrast Enhancement (ACE) techniques *(Dah-Chung Changh et al., 1998, Narendra et al., 1981)* were successfully demonstrated and used in many studies to enhance digital images. CLAHE (Contrast Limited Adaptive Histogram Equalization) is a modified histogram equalization procedure that optimizes contrast enhancement based on the local image data. The basic idea behind the scheme is to divide the image into a grid of rectangular contextual regions, and to apply standard histogram equalization in each. The optimal number of contextual regions and the size commonly used is 8x8 pixels. In addition, a bi-

linear interpolation scheme is used to avoid discontinuity issues at the region boundaries. CLAHE image enhancement technique with region size 10 X 10 (pixels) has been used in this study for the enhancement of stereo pairs that are having comparatively low contrast. Other image enhancement techniques like Histogram Equalization (HE), Linear Stretch, Minimum - Maximum and Standard Deviation (SD) have been tried and compared with CLAHE technique, it is found that CLAHE technique produces better result. Thus, the present study was taken up with a specific objective of improving the quality of DEM from CARTOSAT-1 stereo pair that was digitally enhanced with CLAHE image enhancement technique. Subsequently, CLAHE based DEMs were compared with DEMs that are generated without image enhancement.

Satellite Data Used

Two Stereo pairs of CARTOSAT-1 covering high mountainous terrain of Sikkim State and moderate undulating terrain of Jharkhand State were considered for the present study. The details of satellite data along with their date of acquisition are given in the Table 1.

Methodology

Stereo pairs that are taken for this study have comparatively low contrast. CLAHE image enhancement technique is used for the enhancement of stereo pairs. The main advantages of the CLAHE transformation are its modest computational requirements, ease of use and excellent results on most of the images. This process allows only the maximum number of pixels in each of the bins associated with the local histograms. The pixels are equally redistributed over the whole histogram to keep the total histogram count identical (*Chek Koon Teo, 2003)*. Region size of 10 x 10 (pixels) has been adopted in the present study.

The algorithm of CLAHE is given as follows:

CLAHE 'Uniform' $DN_{new} = [DN_{max} - DN_{min}]*P(f)+ DN_{min}$ -------- (1)

Where, DN_{new} is new pixel value, DN_{max} is maximum brightness value of the pixel, DN_{min} is minimum brightness value of the pixel and P(f) is the cumulative distribution function within the specified region size. MATLAB software is used for the enhancement of stereo pairs using CLAHE technique. The detailed methodology adopted for the present study was presented in the flow chart as Fig. 1. Overall, the methodology was implemented in two stages, in which the first stage involves the enhancement of stereo pairs and the second stage involves generation of DEMs using stereo pairs with and without image enhancement.

In the present study, LPS (Leica Photogrammetry Suite) project manager version-2011 is used for the DEM generation. Initially block file was created and subsequently, interior and exterior orientation was performed on the stereo pairs using RPC model parameters available with stereo data set. Auto points were added to the stereo pair using inbuilt module of LPS. Auto tie points with search size of 30, correlation size 07 and 0.85 correlation coefficient were intended in the present study. Auto tie points around 164 and 168 were generated in the 582-271 and 565-285 stereo pairs respectively. Well distributed 9 manual points were also added and aerial triangulation was performed using zero order polynomial refinement function having RMSE to the minimum possible limit i.e. less than or equal to 0.5. Further, triangulation process was repeated using zero order polynomial refinement function by adding 6 GCPs (Ground Control Points) with acceptable RMSE error (<=0.5). Once necessary error corrections were applied on erroneous points, final aerial triangulation was performed using 1st order polynomial refinement function with RMSE of less than 0.2. Subsequently, regular DEMs were generated equivalent to 10m ground resolution. Similar procedure was adopted for generation of DEM using stereo pair without image enhancement.

Results and Discussion

CLAHE based enhanced images appear to have 'better clarity' as compared to the images enhanced using Standard Deviation (SD) and Histogram Equalization (HE) algorithms (Figures 2a-d). Particularly, it was observed that CLAHE technique was found to be very effective in low contrast images. Distribution of Tie Points is more prominent and uniform in case of CLAHE based enhanced stereo pairs as compared to the other having no image enhancement (Figures 3a-d). High variation in the Z values was observed in the DEMs generated without enhancement (Tables 2-3). LTF (Leica Terrain Format) files were generated using with or without CLAHE enhancement technique. From the figures 5a-b, it is seen that the contour lines of LTF were following the topography of terrain more accurately.

It was also observed that the significant difference was found among various statistical parameters such as Standard Deviation (SD), RMSE and Linear Error (LE 90) in case of DEMs generated with or without enhancement of stereo images (Table 2-3). Thus, the quality of DEMs was significantly improved when stereo images were enhanced with CLAHE image enhancement technique. The adaptive image enhancement technique is very useful as compared to global enhancement technique particularly stereo pairs having low contrast.

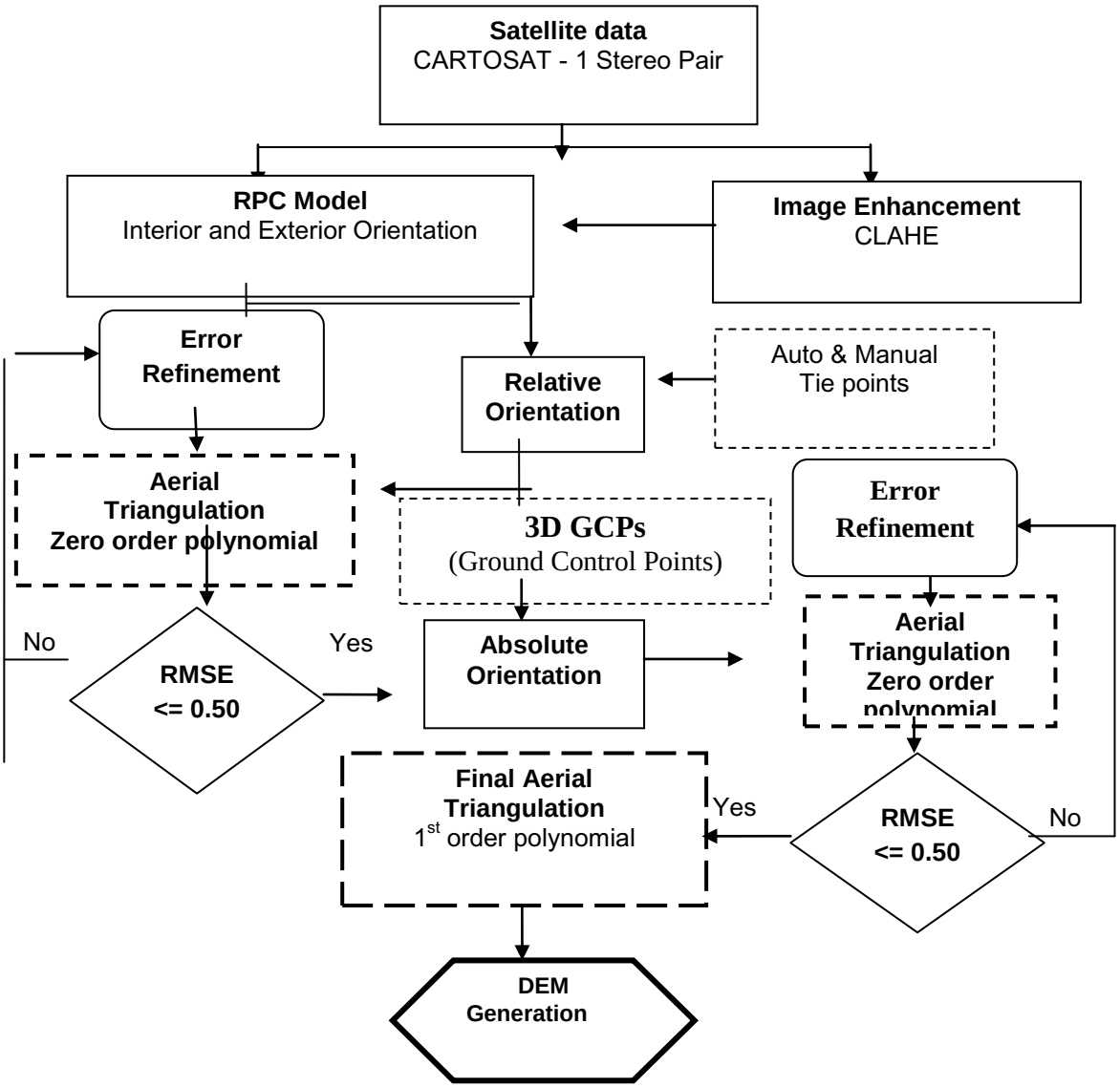


Fig. 1: Methodology for generation of DEM

Table 1: Details of CARTOSAT 1 stereo pair used with present study

Sl No.	Path	Row	Date of Pass	Area of Interest	Roll	Pitch	Yaw
1	582	271	20/03/2010	Sikkim	-3.51989	-0.02682	3.23559
2	565	285	11/06/2010	Jharkhand	-0.00079	-0.02836	3.39549

Table 2: Z value Observations from DEMs generated using 582-271 stereo pair

Sl No.	Ground Control Points			Observed Z values		Difference in Z values	
	Longitude	Latitude	Z Value	Without Enhancement	After CLAHE Enhancement	GCP Z value & Without Enhancement	GCP Z value & after adaptive Enhancement
1.	88 05 44.2345	27 32 02.7965	5112.00	5114.518	5100.252	-2.518	11.748
2.	88 07 36.0343	27 28 07.8986	3680.00	3658.202	3661.560	21.798	18.440
3.	88 05 31.8439	27 23 39.8196	3814.00	3809.561	3824.820	4.439	-10.820
4.	88 05 52.4949	27 26 31.1634	4155.00	4149.937	4150.186	5.063	4.814
5.	88 03 13.3949	27 22 02.4522	3222.00	3237.458	3230.941	-15.458	-8.941
6.	88 01 20.6090	27 31 17.4670	4565.00	4549.512	4553.832	15.488	11.168
7.	88 02 39.4652	27 27 31.4037	3952.00	3997.998	3981.813	-45.998	-29.813
8.	88 01 34.0155	27 27 33.2284	3519.00	3488.497	3533.945	30.503	-14.945
9.	88 00 34.7016	27 23 39.6612	3657.00	3572.424	3663.660	84.576	-6.660
10.	88 00 08.1127	27 26 16.5892	3330.00	3341.856	3327.332	-11.856	2.668
					Total	**86.037**	**-22.341**
					Mean	**8.6037**	**-2.2341**
					Standard Deviation (SD)	**34.3274**	**14.6692**
					RMSE (Root Mean Square Error**)**	**33.6831**	**14.0947**
					Linear Error (LE90)	**55.4088**	**23.1857**

Table 3: Z value Observations from DEMS generated using 565-285 stereo pair

Sl No.	Ground Control Points			Observed Z values		Difference in Z values	
	Longitude	Latitude	Z Value	Without Enhancement	After CLAHE Enhancement	GCP Z value & Without Enhancement	GCP Z value & after adaptive Enhancement
1.	84 07 27.6165	24 23 48.5523	260.00	253.250	264.211	6.750	-4.211
2.	84 00 24.5882	24 24 12.2293	219.00	215.637	216.122	3.363	2.878
3.	83 55 14.5827	24 25 46.9373	156.00	138.415	159.240	17.585	-3.240
4.	83 53 40.9352	24 19 25.1458	116.00	117.836	118.460	-1.836	-2.460
5.	83 054 3.5397	24 13 27.0312	140.00	137.336	139.960	2.664	0.040
6.	84 01 32.4019	24 12 30.7983	199.00	182.360	204.570	16.640	-5.570
7.	84 05 41.0521	24 14 20.3044	250.00	243.116	252.080	6.884	-2.080
8.	84 06 32.7197	24 18 22.9936	268.00	265.192	267.485	2.808	0.515
9.	84 02 11.1526	24 18 46.6706	230.00	217.881	229.540	12.119	0.460
10.	83 57 59.2731	24 15 22.4566	192.00	192.604	191.975	-0.064	0.025
					Total	**66.913**	**-13.643**
					Mean	**6.6913**	**-1.3643**
					Standard Deviations (SD)	**6.7319**	**2.5772**
					RMSE (Root Mean Square Error)	**9.2499**	**2.7999**
					Linear Error (LE90)	**15.2161**	**4.6058**

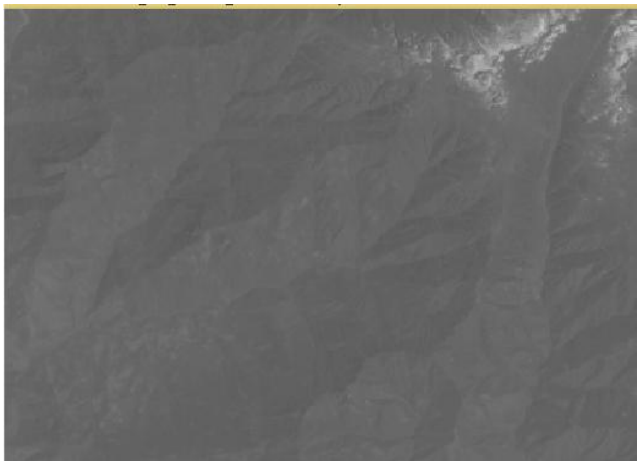


Fig. 2(a): Original image

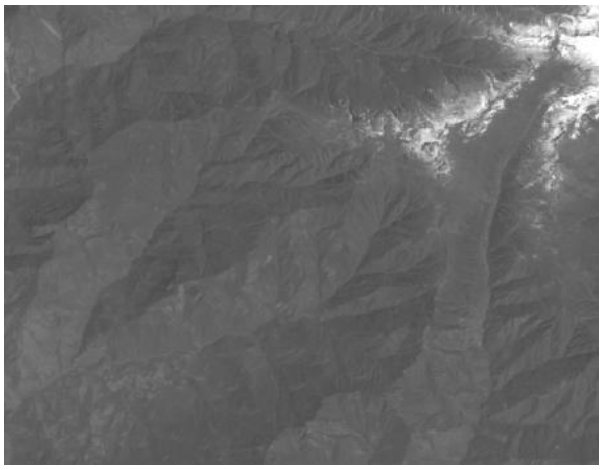


Fig. 2(b): Standard Deviation Enhanced



Fig. 2(c): HE Enhanced



Fig. 2(d): CLAHE Enhanced

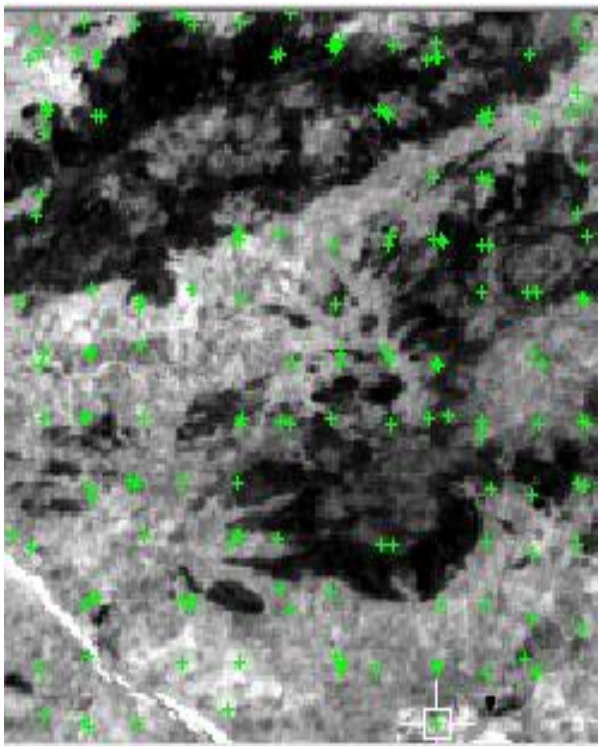


Fig. 3(a): Auto tie points distribution without enhancement (BAND A of 565-285)

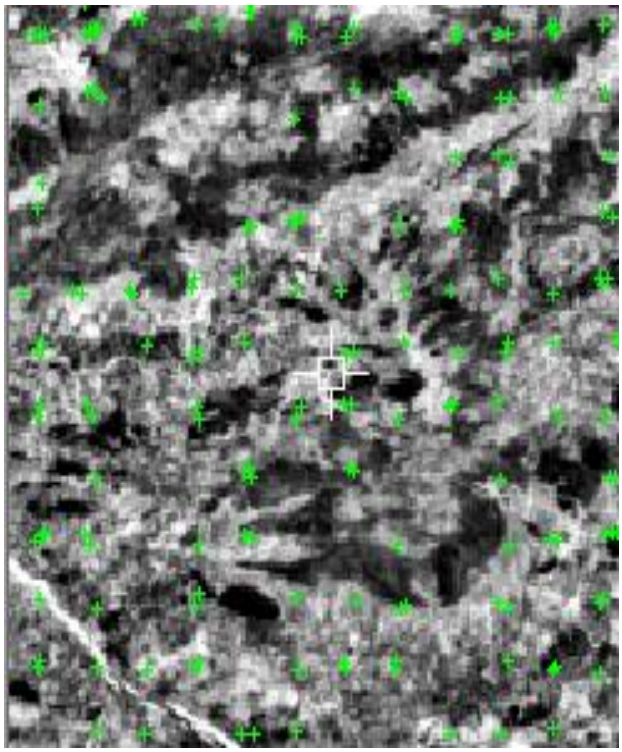


Fig. 3 (b): Auto tie point's distribution with CLAHE enhancement (BAND A of 565-285)

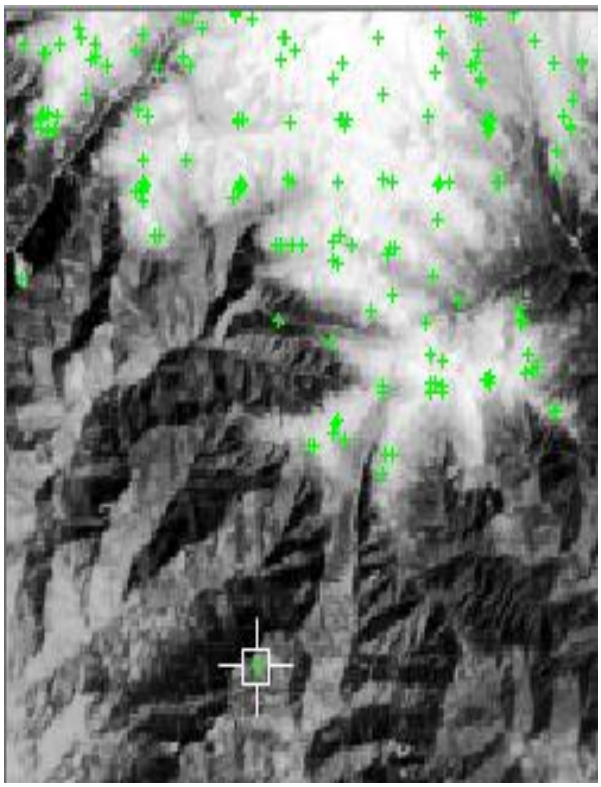


Fig. 3(c): Auto tie points distribution without enhancement (BAND A of 582-271)

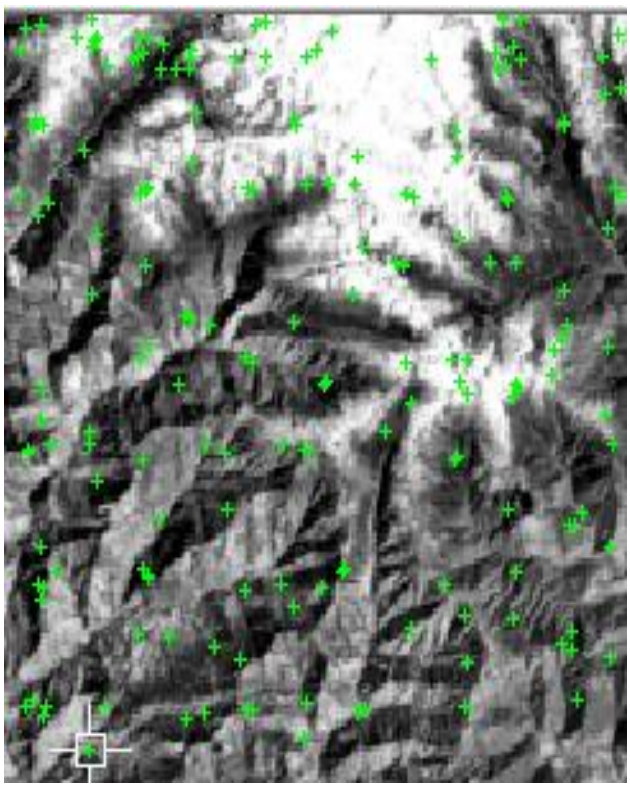


Fig. 3 (d): Auto tie point's distribution with CLAHE enhancement (BAND A of 582-271)

DEMs generated using stereo pair with or without enhancement are shown as Fig. 4(a) & 4 (b).

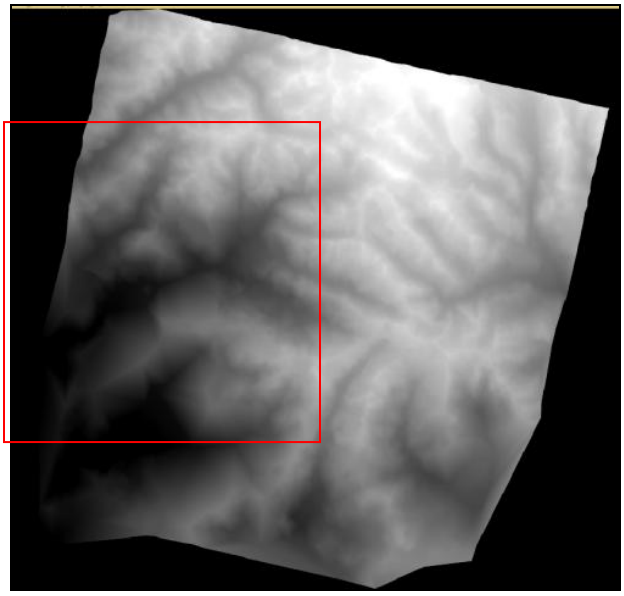


Fig. 4 (a): Digital Elevation Model (DEM) derived from without image enhancement (582-271)

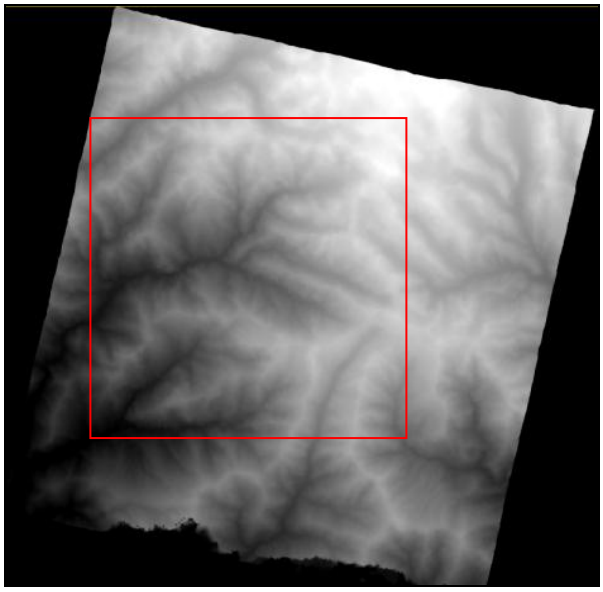


Fig. 4 (b) Digital Elevation Model from with CLAHE image enhancement (582-271)

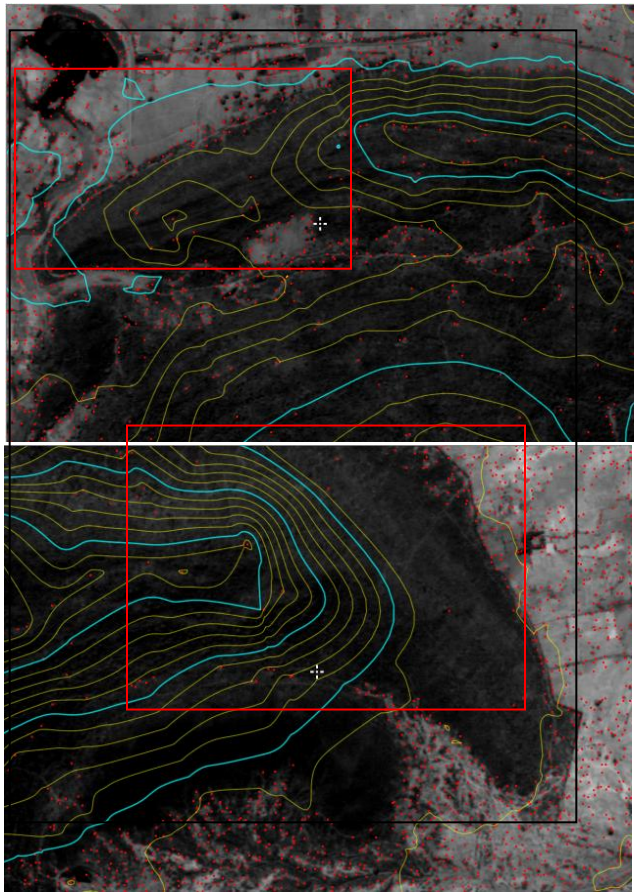


Fig. 5(a): LTF Contour lines generated from without image enhancement (565-285)

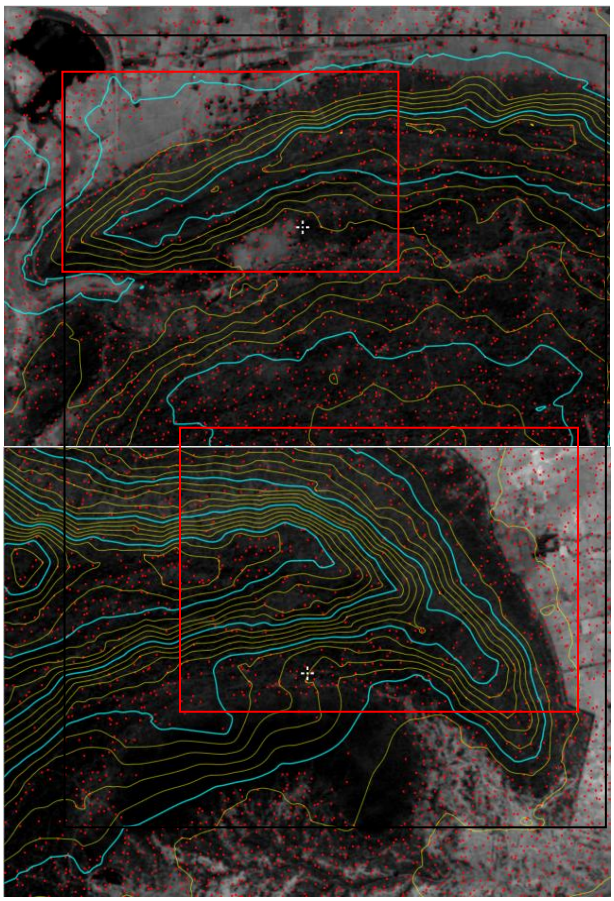


Fig. 5 (b): LTF Contour lines generated with CLAHE image enhancement (565-285)

References

1. Krishna Murthy Y. V. N., Srinivasa Rao S., Prakasa Rao D.S. , Jayaraman V. (2008). Analysis of DEM generated using CARTOSAT -1 stereo data over Mausanneles Alpiles - CARTOSAT 1 Scientific appraisal programme (CSAP TS – 5). ISPRS proceedings, XXXVII, commission 1 SS II, Page(s) 1343-1348.
2. Navalgund R.R. (2005). CARTOSAT-1: The Latest from the Indian Remote Sensing Satellite Series. ISPRS Highlights; Vol. 10, No. 3.
3. NRSA (National Remote Sensing Agency). (2005). Brochure on Cartosat-1: A Global IRS Mission for Large Scale Mapping and Terrain Modelling Applications. Hyderabad.
4. Sreedhar K., and Panlal B. (2012). Enhancement of images using morphological transformations. International Journal of Computer Science & Information Technology. (IJCSIT) Vol 4, No 1.
5. Sepasian, M, Balachandran, W and Mares, C. (2008). Image Enhancement for Fingerprint Minutiae-Based Algorithms Using CLAHE, Standard Deviation Analysis and Sliding Neighbourhood. Proceedings of the World Congress on Engineering and Computer Science 2008,WCECS 2008, October 22 - 24, San Francisco, USA.
6. Somorjeet Singh S., Mamata Devi H., Tangkeshwar Singh Th., Tejmani Sinam. (2012). Local Contrast Enhancement using Local Standard Deviation, International Journal of Computer Applications. (0975 – 888) Volume 47– No.15.
7. Dah-Chung Chang and Wen-Rong Wu. (1998). Image Contrast Enhancement Based on a Histogram Transformation of Local Standard Deviation, IEEE Transaction on medical imaging. VOL. 17, No. 4.
8. Narendra P.M., Fitch, R. C. (1981). Real-time adaptive contrast enhancement. IEEE Trans. Pattern Anal. Machine Intell., Vol. PAMI-3, pp.655–661.
9. Chek Koon Teo. (2003). Digital enhancement of night vision and thermal images. PG Thesis, Naval Postgraduate School, Monterey, California.

Intensity Augmented ICP for Registration of Laser Scanner Point Clouds

Bharat Lohani* and Sandeep Sashidharan
*Department of Civil Engineering, IIT Kanpur
Email: blohani@iitk.ac.in.

Abstract

While using Laser Scanner for map-making or developing 3D models of objects, it is important to scan the site or the object of interest from multiple viewpoints. These different scans are then integrated to generate a complete point cloud which is then used for developing the map or 3D model of the site. ICP (Iterative Closest Point) is a standard algorithm for registration of point clouds. However, in the absence of marked 3D features which are geometrically distinct in the points clouds, that are being combined, this method tend to fail sometime. This paper exploits the radiometric data that are always obtained along with the coordinates of point cloud and devises a novel approach for scan registration. Before using radiometric data in registration process these are normalized. The algorithm presented in this paper works in two stages- with Intensity Augmented ICP (IAICP) for coarse registration stage and conventional geometric ICP at the fine registration stage. The proposed approach is successfully applied to a test data resulting in an accurate estimation of the transformation parameters. A comparison of the conventional and intensity augmented registration approaches is also presented. The results indicate the supremacy of IAICP over the ICP, as the latter is found to fail in geometrically confusing cases while intensity augmented ICP works in these cases.

Introduction

The process of map making has changed in a significant manner since the availability of laser scanners. As laser scanners are capable of capturing billions of data points in a single hour, in comparison to about 60-80 data points in case of Total Station, the speed of data capture has increased multifold. Besides, the data captured are very comprehensive and make it possible to map or model fine details, which would otherwise go unnoticed in case of Total Station survey. There are several advantages of using laser scanner for mapping or 3D modeling and in view of these this is replacing Total Station based mapping to some extent in some applications.

While working with laser scanner it is required to capture multiple scans of the area to be mapped or the object to be modeled. The multiple scans have their own local coordinate systems. To view complete area of interest together all such scans are combined in a single point cloud. This single point cloud is then used for mapping or modeling the objects.

The conventional methods of integrating multiple scans are by first selecting few control points in the overlap area of the master and slave scans. With the rigid body transform using these control points the slave scan is brought on to the coordinate system of the master point cloud. This method is, however, affected by the observational errors in selecting the control points and also need the manual intervention as control points are selected by an observer. In order to avoid these limitations a common method for scan point cloud registration is ICP (Iterative Closest Point) algorithm [1]. The original method was based on establishing point to point correspondences by Euclidean distance evaluation. The ICP variant proposed by [2] analyzes the local surface approximations of the datasets. A method to incorporate the k-d tree data structure into point matching algorithm in order to speed up point correspondence computational times is described in [3]. The classical ICP is susceptible to non-overlapping regions since it does not consider the overall geometry but local geometries and may lead to incorrect results by converging to local minima [4]. As the ICP algorithm basically uses the geometric property of the scanned objects it tends to fail in situations where the objects do not possess marked geometric features, or where the geometric match still is possible even if the object is rotated e.g. wide land, a wall, a door etc. Most of the variants of ICP that were developed tend to focus on increasing the speed but not to solve this problem.

In view of the above the goal of this paper is to investigate the use of intensity information along with the geometric information of point clouds for their registration. This approach is based on the fact that despite the objects (overlap area between two scans) being bereft of any or sufficient number of distinctive

geometric features there always is a possibility that there exist distinctive radiometric features which can be used for matching scans. The paper will show development of this new approach, called, intensity augmented ICP (IAICP), and present some results to show its utility.

Methodology

The proposed methodology has three basic steps. (1) Normalization of the LiDAR intensity data (2) Coarse registration of the LiDAR point clouds using intensity augmented method (3) Fine registration using geometric ICP algorithm. The flow chart of the proposed algorithm is given in Fig. 1.

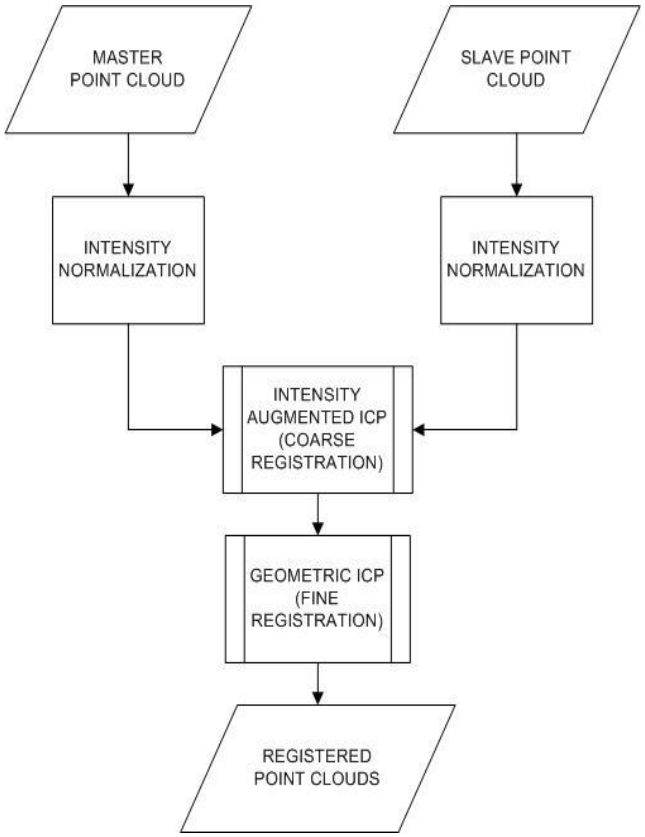


Fig. 1. Flow chart of the proposed algorithm.

A. Resources employed

ILRIS 3D terrestrial laser scanner from Optech. Inc. Canada was used in this study for collecting laser scans of the test objects. This scanner collects data in a 40 by 40 degree window, while this window can be rotated with the help of a PanTilt device to cover entire 360 degree in horizontal and 180 degree in vertical. The initial data generated by ILRIS3D were processed using the accompanying parser software to yield coordinates (x, y, z) and the intensity value for each point captured. The intensity directly provided by the instrument is called raw intensity. The 8 bit intensity data is derived from the raw intensity after applying some corrections and truncating these values to 8 bit format for improving the visual quality of the point cloud and is unavailable to the end user. In this paper terminology 'raw intensity' refers to the 16 bit intensity data provided by the TLS.

All algorithms developed and employed in this paper were realized through a code written in MATLAB. The mathematical background and code is beyond the scope of this paper and are not being presented.

B. Normalization of LiDAR intensity

The steps for normalization of LiDAR intensity are shown in Fig. 2. Outlier elimination step removes the isolated data points, i.e., those with less than 10 nearest neighbors. A simple k-nearest neighbor ball

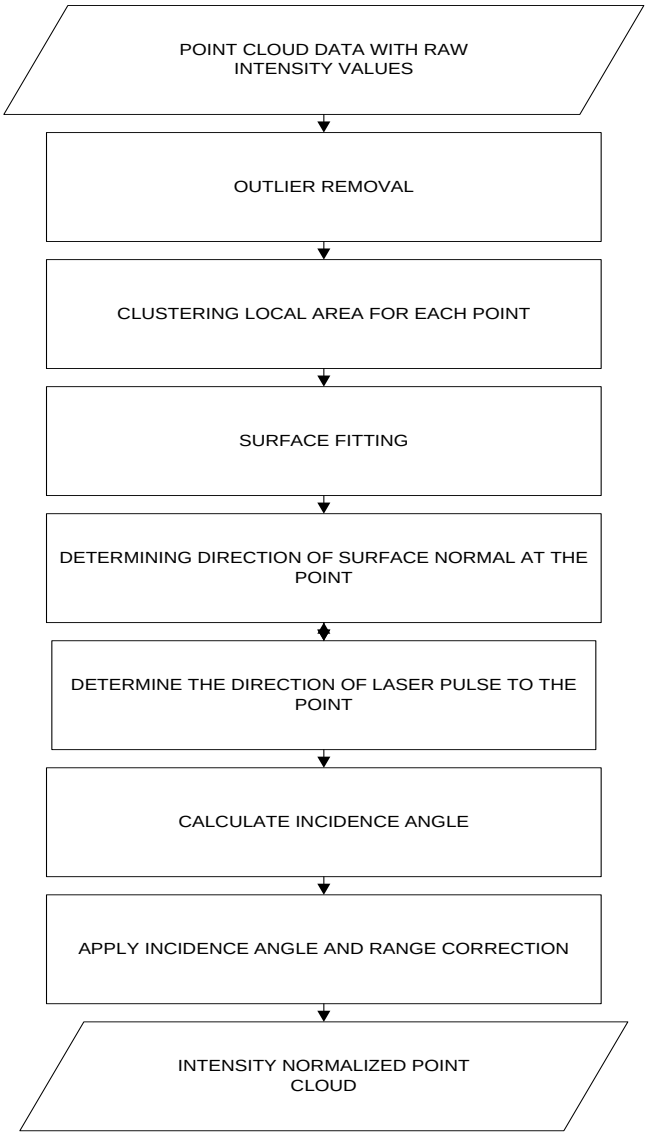


Fig. 2. Flow chart for Intensity Normalization Algorithm.

search is employed for clustering the data. Each data point is selected at a time and its neighboring data points lying at a radius are selected. The radial distance for nearest neighbor ball search depends on scan density. To apply the incident angle correction at each data point, the direction of the incident ray vector and the normal at each data point needs to be calculated. For individual clusters formed at each data point, a second order polynomial surface is fit and the direction of the normal at that data point is determined. The incident angle is calculated by taking the inverse cosine of the ratio of dot products of direction of normal and direction of laser pulse at a particular point, where the latter is known in terms of coordinate of the point where normal is being computed. The normalized intensity is then computed using:

$$I_{norm} = I_{raw}\left(\frac{R_{act}}{R_{ref}}\right)^2\left(\frac{1}{\cos(i)}\right) \quad (1)$$

Where, I_{raw} and I_{norm} are raw and normalized intensities, R_{act} and R_{ref} are actual and reference ranges and i is the incident angle.

C. Coarse registration by intensity augmented ICP

The description of ICP algorithm is beyond the scope of this paper and can be seen in the cited references. The intensity augmented ICP implemented in this paper differs from the classical ICP as in addition to coordinates the intensity information is also included in the correspondence matching search space. Before including the intensity information, the intensity normalization process explained above is performed. This enables the determination of correspondences in a more abstract way by using (x, y, z, Intensity) vectors rather than using pure geometric information using (x, y, z).

Hence the algorithm searches both intensity and spatial spaces at the same time for correspondences. For a point cloud from a terrestrial laser scanner the spatial coordinates and the intensity values cannot be directly utilized without scaling. For scaling intensity data, the z-score statistical standardization technique is used. The basic algorithm flow chart is shown in Fig. 3.

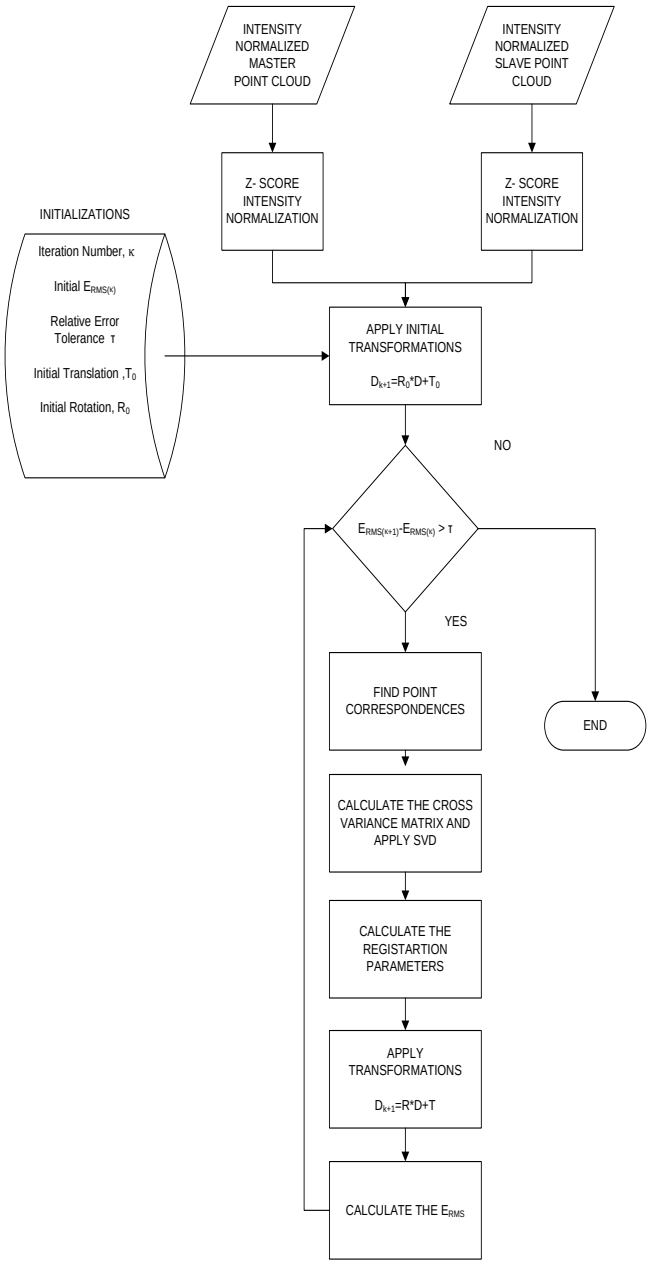


Fig. 3. Course registration process-Phase I

D. Fine registration using geometric ICP

The IAICP is followed by the geometric ICP in order to guarantee proper registration. Here the more accurate point to plane minimization technique is used. The point to plane variant of ICP improves performance by taking advantage of the surface normal information. The point to plane algorithm minimizes the error along the surface normal.

This minimization scheme involves two processes, viz. calculating the surface normals for the Master point cloud and then minimizing the angle between the normals of Slave and Master cloud. The approximate

surface normals are computed using Principal component analysis. For computing the surface normals, four nearest neighbors are selected for each point, the Eigen vector corresponding to the smallest Eigen value represents the surface normal at that point. The flowchart for fine registration is shown in Fig. 4. The output of ICP iteration is 3D transformation parameters for registration. Plane minimization is computationally complex and time consuming, but as the coarse registration has already been achieved, the convergence is faster.

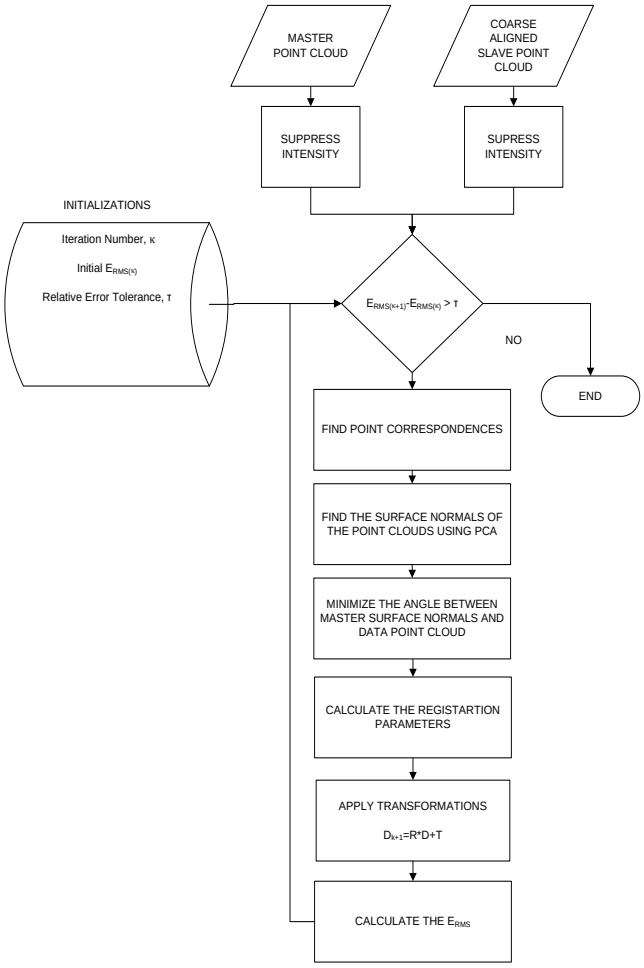


Fig. 4. Fine registration – Phase-II

Results and discussion

The results are aimed at proving the hypotheses that (i) intensity normalization method proposed is effective and (ii) intensity augmented ICP is an effective solution where classical ICP fails due to geometric confusion.

E. Intensity normalization results

Point clouds of same materials captured from different scan locations are used for analysis. Six sets of data were subjected to normalization technique explained above though result for only one is being presented here for want of space. The raw 16 bit intensity values

Table 1: Intensity Normalization Result

Material	Scan	Raw Mean	Raw SD	Norm. Mean	Norm. SD
Concrete Wall	1	418	192	104	48
	2	1385	505	147	53

obtained after parsing the scan data were used for normalization.

The intensity normalization results are tabulated in Table I. The normalization is performed for a reference range of 100 m while the average object range varied from 35 m to 50 m. The histograms of the raw and normalized data are represented in Fig. 5.

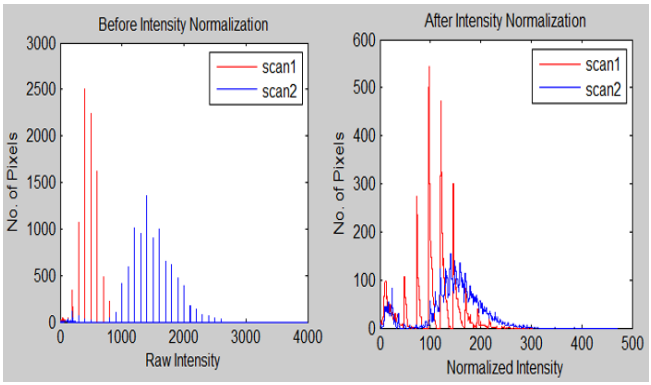


Fig. 5: Geometric ICP Vs. IAICP

The raw intensity values, after incidence angle and range correction, change to become comparable values for mean and standard deviation, as shown in the Table I. From the histogram also it can be inferred that after intensity normalization, intensities for the same material appear to have similar mean and standard deviation values and thus it can be effectively incorporated as one of the parameters for finding point to point correspondences in the ICP algorithm. In order to understand the efficacy of normalization process quantitatively, a statistical distance between the raw and normalized intensity distributions is calculated using the ratio of difference of the means and sums of the standard deviations for their distributions. This distance is 1.39 for raw data while 0.43 for normalized data, thus showing that the scans come nearer to each other after normalization.

F. IAICP Vs. ICP results

Four sites were chosen for studying this but for the want of space the results from only one site, which is a door with some notices pasted, are shown here. The

registration was performed in 30 iterations and the RMS error value was computed. The RMSE value is the root of mean of square of the differences in the coordinates of master point and slave point after applying rotation and translation as suggested by registration process to the latter for all data points. This is computed at each iteration of the registration. Fig. 6 shows the result of only Geometric ICP and Intensity Augmented ICP, while Fig. 7 shows the convergence graph for this data. The RMSE for

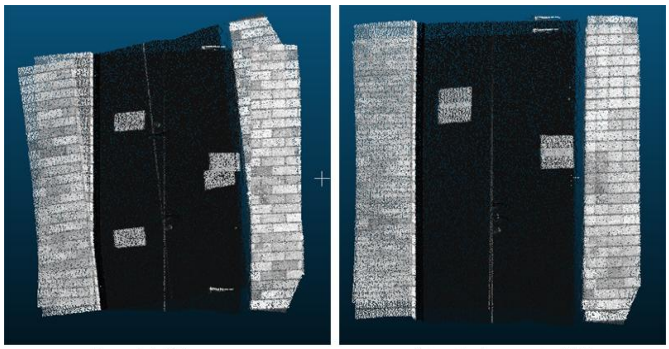


Fig. 6. Geometric ICP Vs. IAICP

Geometric ICP was 3.26 cm while for IAICP it was 2.61 cm. Moreover, despite comparable RMSE it is important to note that in the case of Geometric ICP the slave scan was inverted thereby providing absolutely incorrect registration. This is due to the Geometric ICP converging at local minima. In case of IAICP the registration is correct, which is basically due to the use of intensity information in the coarse registration process. The convergence graph shows that IAICP converges faster.

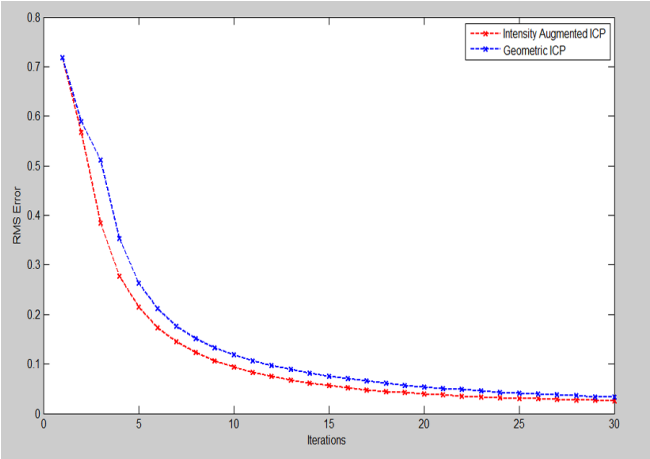


Fig. 7: Convergence graph – ICP Vs. IAICP

Conclusion

The automatic registration process in commercial software is generally not found correct as it leads to local minima. The procedure adopted in practice is to collect a good number of control points and use these through similarity transform to provide initial condition to ICP. In the present paper an Intensity Augmented ICP has been proposed, where first a coarse registration has been realized by using intensity along with geometric information through ICP. This process has potential to replace the manual selection of control points before proceeding to fine registration. In the present paper the fine registration has been achieved by Point to Plane ICP. While performing IAICP the intensity of both scans should be normalized, as proposed by the present approach.

The paper has shown with a data set that the intensity normalization approach suggested is effective and brings the intensities of multiple scans to same level, thereby facilitating their comparison. The paper further shows, with scan data of a site, that how simple ICP can fail in geometrically confusing circumstances, while IAICP has the potential to converge to the global minima, as the fourth dimension added in ICP process provides additional information to locate distinctive features in both scans. The proposed approach can be tested on more data and used in commercial software.

References

1. Besl, P. J., and McKay, N. D. , “A method for registration of 3D shapes”, *IEEE Transactions of Pattern Analysis and Machine Intelligence*, Vol.14, 239-255, February,1992.

2. Chen, Y., and Medoni, G., “Object modeling by registration of multiple range images”, *Image and vision Computing*, Vol.10(3), 145-155, 1992.

3. Masuda, T., Sakaue, K., and Yokoya, N., “Registration and integration of multiple range images for 3D model construction”, *13th International Conference on Pattern Recognition*, Vol.10(3), 879-883, August, 1996.

4. Hebel, M., and Stilla, U., “Automatic Registration of laser point clouds of urban areas*”, International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVI(3/W49A)*, 13-18, 2007.

Mapping Groundwater Sources in NCT Delhi Using GIS for Sustainable Water Resource Management

Dharini Dube
Dept of GIS & RS, Centre for Development of Advanced Computing (CDAC), Noida.
Email: dharini.dube@gmail.com

Abstract

Groundwater is an invaluable and one of the most important sources of water, which is usually available in abundance. The growing demand of potable ground water has led to rapid depletion in ground water levels. The groundwater scenario at the National Capital Territory (NCT) of Delhi is an issue of concern as the quality and quantity of groundwater is suffering drastically due to excessive pressure of growing population. With 16.7 million residents as per census 2011, Delhi has become the second most populous metropolis of India. In such a scenario Delhi Jal Board (DJB) is the sole government agency responsible for meeting water demands of the city. It has the capacity of supplying 650 million gallons water per day (MGD). If we account for 20% transit losses, DJB supplies around 520 MGD water. Groundwater is contributing 100 MGD water to the water supply system of DJB. It is being extracted through a network of tube wells and ranney wells in Yamuna Flood Plain and number of tube wells located in south and south-west districts of Delhi. Moreover, another 250 MGD of ground water is being exploited by individual private tube wells to meet the demand-supply gap in water supply. This unplanned exploitation has led to degradation and depletion of groundwater in many areas of Delhi. Surveys conducted by Central Ground Water Board (CGWB) have revealed that about 56% of groundwater samples are not fit for drinking.

This calls for an immediate action to be taken. Proper planning of groundwater resources is the need of the hour. In this paper an attempt has been made to map "the groundwater resources in NCT of Delhi within a GIS environment". Geographical Information System (GIS) with its capability of integration and analysis of spatial, aspatial, multi-layered information obtained in a wide variety of formats both from remote sensing and other conventional sources has been used effectively to address problems of groundwater resources for sustainable water resource management.

Introduction

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. It is also a scarce resource. India has more than 17 percent of the world's population, but has only 4% of world's renewable water resources with 2.6% of world's land area. There is a great diversity and uneven distribution of water resources in time.

Low consciousness about the scarcity of water and its 0life sustaining and economic value results in its mismanagement, wastage, and inefficient use, as also pollution and reduction of flows below minimum ecological needs. In addition, there are inequities in distribution and lack of a unified perspective in planning, management and use of water resources. This calls for integrated and judicious use of available water resources.

Background of Problem

The present scenario of water resources and their management in Delhi has given rise to several concerns, important amongst them are;

- Large parts of Delhi have already become water stressed. Rapid growth in demand for water due to population growth, urbanization and changing lifestyle pose serious challenges to water security.
- Access to safe water for drinking and other domestic needs still continues to be a problem in many areas. Skewed availability of water between different regions and different people in the same region and also the intermittent and unreliable water supply system has the potential of causing social unrest.
- Groundwater, though part of hydrological cycle and a community resource, is still perceived as an individual property and is exploited inequitably and without any consideration to its sustainability leading to its over-exploitation in several areas.
- Growing pollution of Water Resources due to a number of reasons is causing health and environmental hazards.
- Depletion of Groundwater and surface water sources in many areas. The groundwater is declining in majority of the areas of Delhi on account of overexploitation of the resources.
- The lack of adequate trained personnel for scientific planning, utilizing modern techniques and analytical capabilities incorporating information technology constrains good water management.

Objective & Scope of Study

The key **Objectives** of the present Study is:

- To identify and demarcate the problem areas of NCT, Delhi with respect to Groundwater Resource Management using Remote Sensing and GIS Technologies.
- Preparation of integrated ground water resources map derived from hydro geomorphology and depth to water level maps.
- To prepare maps illustrating demographic structure of NCT, Delhi.
- To establish a relationship between demographic structure and Groundwater condition.

Methodology

- **The pre-field** study includes Development of theoretical framework, formulation of hypothesis, justification of problem, review of literature etc.,
- **On-field** study includes gathering of information from Central Groundwater Board (CGB), Delhi Jal Board (DJB) and other government and private bodies, books, World Wide Web and the Newspaper articles.
- **Post-field** study deals with the analysis and interpretation of collected information with the help of representative maps and diagrams using various Statistical, Cartographic and GIS Techniques.

Technologies Used

Auto CAD Map and Map Info, the powerful desktop GIS tool have been used to visualize, update, analyze geographical Information, and create quality presentations that brings the power of interactive mapping.

Water Supply in Delhi

- With **16.7 million** residents as of census 2011, Delhi has become the **second most populous metropolis of India.**
- **Delhi Jal Board** (DJB) is the sole government agency responsible for meeting water demands of the city.
- It has the capacity of supplying **650 million gallons** water per day (MGD)
- If we account for **20%** transit losses, DJB supplies around **520 MGD** water.

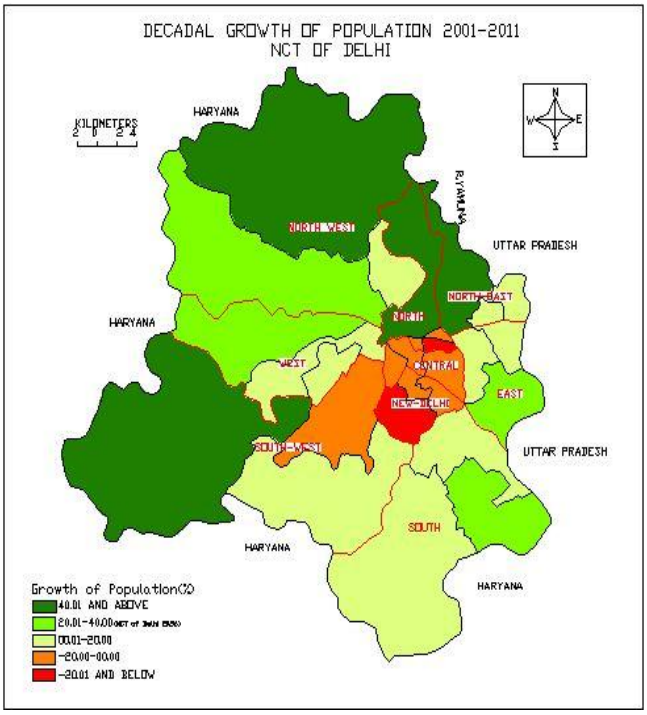
Groundwater Scenario in Delhi

- The Groundwater scenario at The National Capital Territory (NCT) of Delhi is an issue of concern as the quality and quantity of groundwater storage is suffering drastically due to excessive pressure of growing population.
- Groundwater is contributing 100 MGD water to the water supply system of DJB.
- It is being extracted through a network of tube wells and ranney wells in Yamuna Flood Plain and number of tube wells located in south and south-west districts of Delhi.
- Another 250 MGD of ground water is being exploited by individual private tube wells to meet the demand-supply gap in water supply.
- This unplanned exploitation has led to degradation and depletion of groundwater in many areas of Delhi.
- Surveys conducted by Central Ground Water Board (CGWB) have revealed that about 56% of groundwater samples are not fit for drinking.

Population Pressure...

Demographic Trend

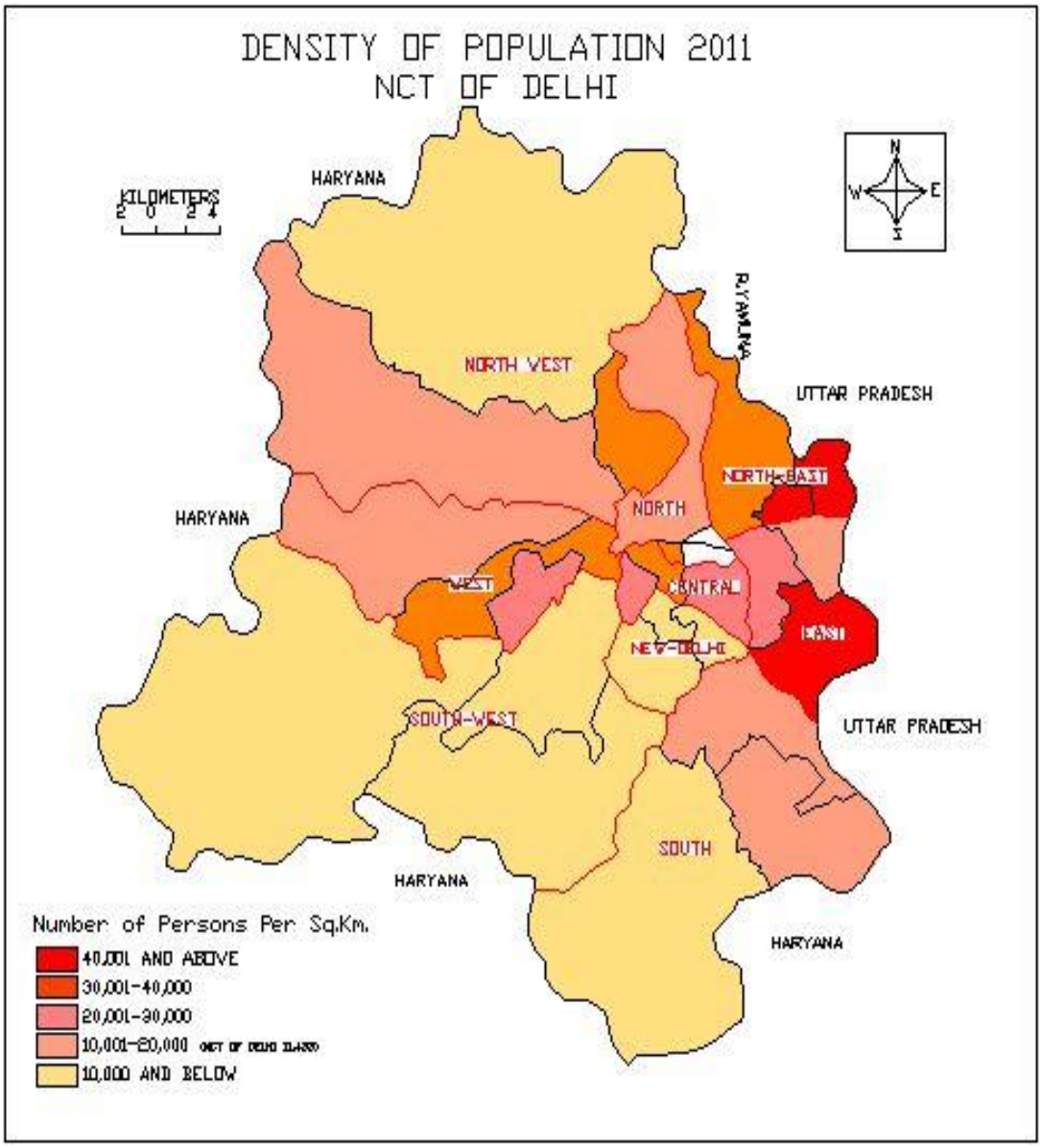
Delhi has been one of the fastest growing cities in the country, clocking over 47% decadal growth from 1991-2001 and 20.96% from 2001-2011, more than double the national rate. Delhi has 9 districts and 27 sub-divisions. Population Census 2011 was conducted in Delhi in each of 9 districts and 27 Sub-divisions. Ranking of districts by population growth, from 2001 to 2011 is given in following map (Map-1):



Map-1: Decadal Growth of Population 2001-2011.

Population Density

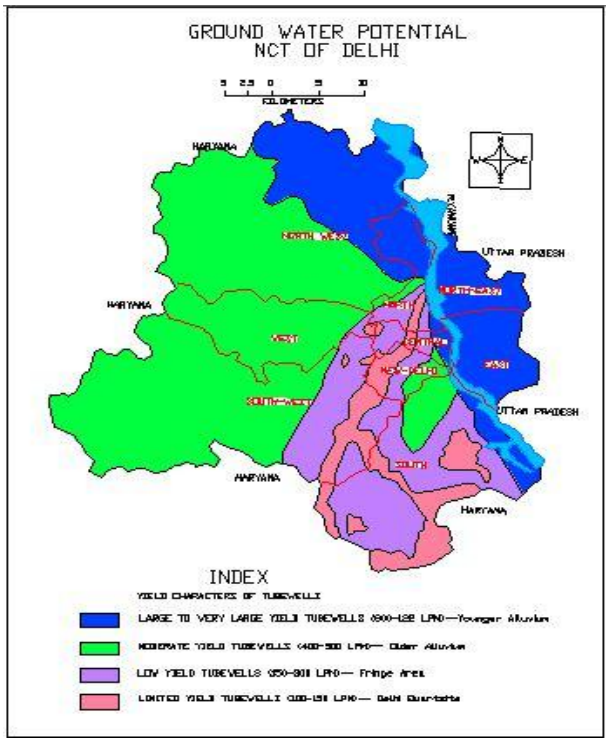
- According to Census 2011, the density of population, in Delhi, averages 11297 persons per sq. km. as against 6,352 persons in 2001.
- Density of population at All-India level has been worked out at 382 persons per sq. km. in 2011.
- The density of population in Delhi is the highest among all states / UT's in the country as shown in Map-2.



Map-2: Density of Population 2011.

Groundwater Analysis

- The groundwater table in Delhi has depleted to 20 –30 metres in various areas across the city. Compared to a level of 30 – 40 feet at the time of Independence, the water table has dropped to 350 feet at certain places (Map-3).
- It is said to be falling at 10 feet per year on an average. Groundwater levels have depleted by 2 – 6 m in Alipur and Kanjhwla blocks, 10 m in the Najafgarh block, and about 20 m in Mehrauli block.
- The quality of underground water is also deteriorating and in several places it has been found to be unfit for human consumption.



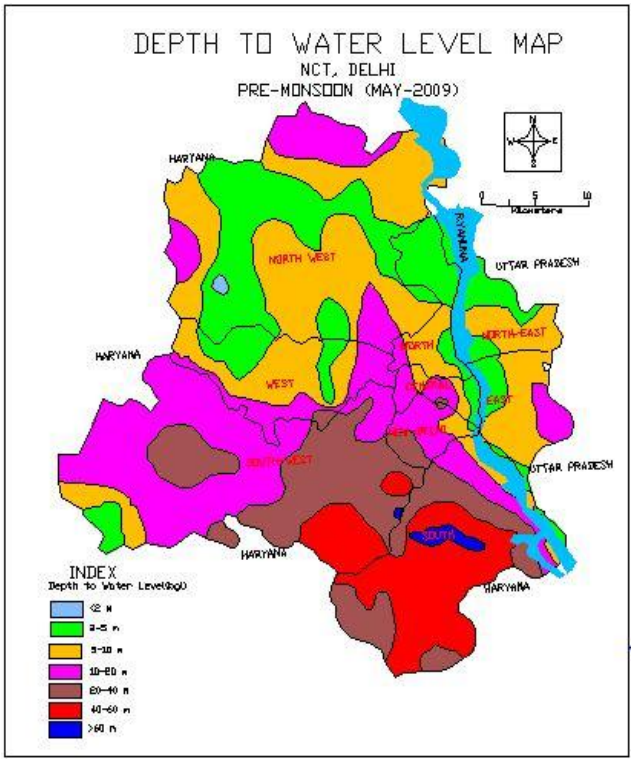
Map-3: Ground Water Potential of NCT Delhi.

Depth to water level, NCT Delhi

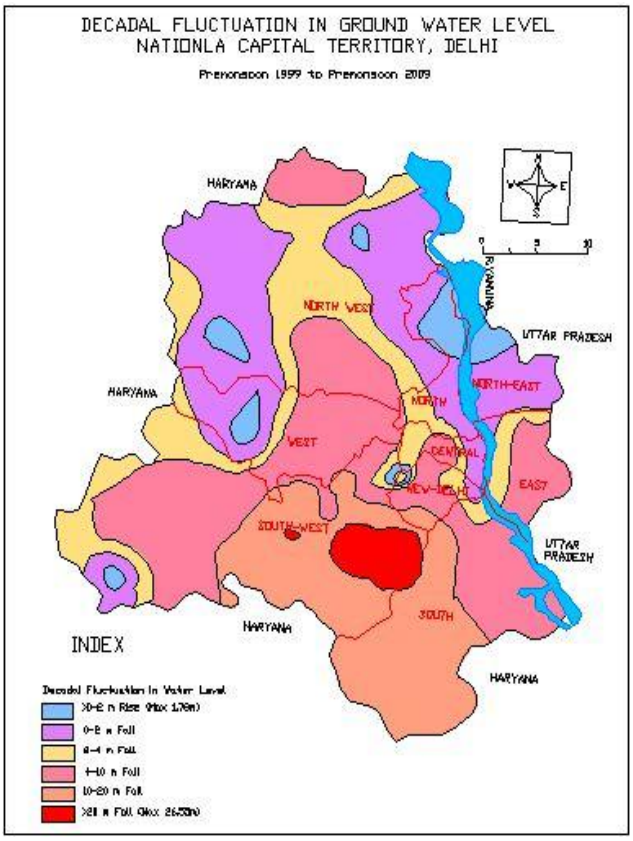
The Depth to water level recorded in NCT Delhi as on date ranges from 1.20 to 67.73 mbgl. The deeper water levels are mostly found in south and south west districts of NCT Delhi, while the shallower water levels are found in central, northern and eastern part of Delhi (Map-4) .The CGWB data shows that nearly 50% wells of south district shows depth to water level more than 40 meters below ground level (mbgl) and nearly 35% wells show depth to water level in the range of 20 to 40 meters below ground level. In New Delhi and South-West district 56% and 46% wells respectively shows depth to water level in the range of 10 to 20 mbgl. In Central, East and North west districts 50%, 77% and 31% monitoring stations respectively have depth to water level in the range of 5-10mbgl. While in East, North, North East, North West, and West district 22%, 85%, 100%, 34% and 44% monitoring stations respectively have depth to water level in the range of 2 to 5 mbgl. The Yamuna flood plain in NCT Delhi also has depth to water level in the range of 2-5 mbgl.

Decadal fluctuation in groundwater level, NCT Delhi

The decadal pre-monsoon water level data shows that nearly 95% monitoring stations shows decline in water level in the range of 0.08 to more than 20 meters as compared with 10 year mean of May water level. The maximum fall have taken place in district of South and South-West (i.e. 11.01 to 26.55m) as shown in Map-5.



Map-4: Depth to Water Level map of Delhi (Pre-monsoon 2009).



Map-5: Decadal Fluctuation of Ground Water Level of NCT Delhi.

Conclusion

Consequences of Indiscriminate Extraction of Groundwater: "It just takes *2,600 hand pumps running for ten hours* to suck Delhi dry of all its groundwater. Delhi's 3,000 unauthorized colonies, which do not receive municipal supply, sink deep bore wells. In the Sainik Farms area, for instance, bore wells have caused the water table to drop to 250 feet. 'And people spend Rs 20,000 every year to deepen the bore wells'. 'Some residents said that ten years ago they got water at 50 feet. The decline in the water table is alarming,"

- The dynamic groundwater resource have been assessed as 292 million cubic metres (MCM) and at present withdrawal of groundwater is mainly in south, south-west, New Delhi and central districts of the city.
- The growing population has exerted undue pressure on the groundwater resources.

Current Status and Future Prospects:

- The rapidly declining water level of Delhi is attributed mainly due to rampant urbanization and enhanced groundwater withdrawal and reduction in the available open space for recharge to groundwater.
- The situation can be improved by adopting rainwater harvesting and artificial recharge to groundwater measures.

Measures Adopted

- The Master plan for rainwater harvesting and artificial recharge of NCT Delhi estimated that nearly 440 MCM of rainwater can be harvested annually in Delhi and utilized for artificial recharge to groundwater.
- The artificial recharge to groundwater can be taken up by adopting 10 different measures like rainwater harvesting at the level of individuals, at the level of colonies and by the institutions
- The Central Groundwater Board of NCT Delhi has taken up the leadership of spearheading rainwater harvesting in NCT Delhi.
- The rainwater harvesting effort by CGWB in JNU and IIT campuses resulted in to rise in water level to the tune of about 2 to 3 meters in vicinity of the area where the project was implemented.
- Similar rainwater harvesting effort in President Estate resulted in the rise of water level in the range of 1 to 4 meters in the vicinity of the areas where the project was implemented.

Study of Groundwater Status in Geoinformatic Environment - A Case Study of Roun Tehsil of Bhind District (MP)

Dr. M.K. Ozha, Dr. Shilpi Banerjee and V.K. Soni
Bharti Enterprises, Tilak Path, Indore M.P. 452001

Abstract

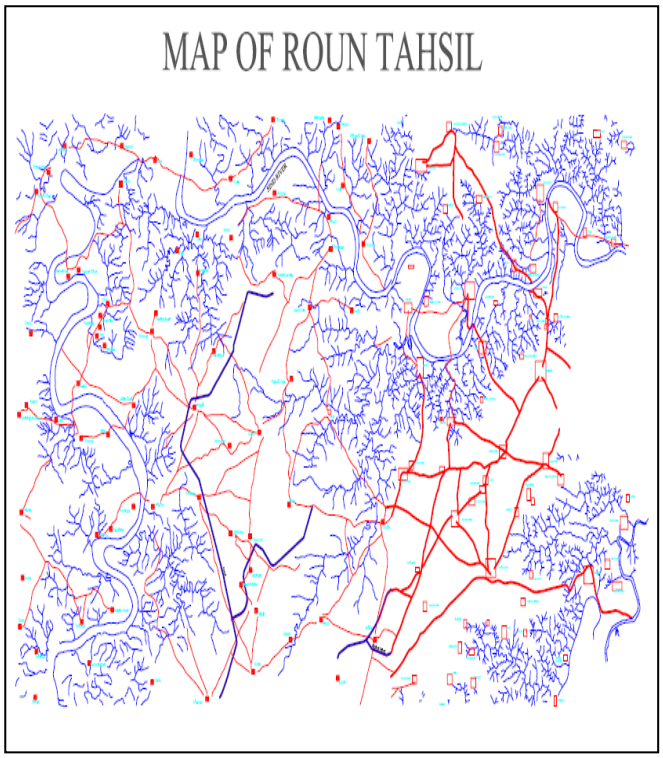
Water is an important natural resource and is very essential for life. It is available both on surface as well as sub-surface. But the amount of fresh water on earth is limited and its quality is under constant pressure. As the availability of surface water is erratic and irregular, one needs to study the underground water and reservoirs. Roun tehsil is covered with good fertile soil, which is drained by Chambal, Sindh and its tributaries, but it is also part of Chambal ravine. In spite of receiving good amount of rainfall, the terrain and soil conditions allow little storage of water. Hence, Roun tehsil has been selected for the study. It has been studied under the Geoinformatic environment.

Introduction

Water is an important natural resource and is very essential for life. Although water is in abundance (i.e., 70% of Earth is water), the real issue is the availability of fresh water. 97.5% of all water on Earth is salty water, leaving only 2.5% as fresh water. Nearly 70% of this fresh water is frozen in ice-caps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use. Less than 1% of world's fresh water is accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at and affordable cost. Only this amount is regularly renewed by rain and snowfall and is therefore available on a sustainable basis.

As the population growth is high, it is putting more pressure on our water supply i.e., demand is increasing and on the other hand the amount of water is effectively reduced by pollution and contamination i.e., supply is decreasing. Due to increasing demand of fresh water, we cannot depend on surface water. We are forced to explore water from sub-surface area. The use of sub-surface water is increasing day by day by using easily available water withdrawing devices such as tube-wells and hand pumps. As a result ground water level is decreasing. The use of these kinds of devices is very common in rural parts of our country. Due to easy availability under various government run programs and their low cost, trend of using hand pumps and tube-wells have increased. People are using it for their daily requirements. But due to overexploitation, underground water level is decreasing.

To study the groundwater status, we have selected Roun tehsil of Bhind district of Madhya Pradesh. It lies between 26°15' to 26°40' N and 78°15' to 79°05' E (Map-1). Roun tehsil comes under good fertile alluvium soil. It is drained by Sind and Chambal rivers and its tributaries. The entire tehsil lies under Chambal basin. Ravines and gullies are developed along the course of all rivers. A very fine network of gullies and forming dendric drainage network characterizes these. Climate of Roun tehsil can be characterized by hot summer and general dryness except during the south-western monsoon. Physiography of the area shows vast older plains, structural plains, hills and valleys with denudation slope. The area has very gentle slope towards north-east. The tehsil consists of 43 villages spread in about 261 Sq. K.M. area of which 30 Sq. K.M. is ravines.



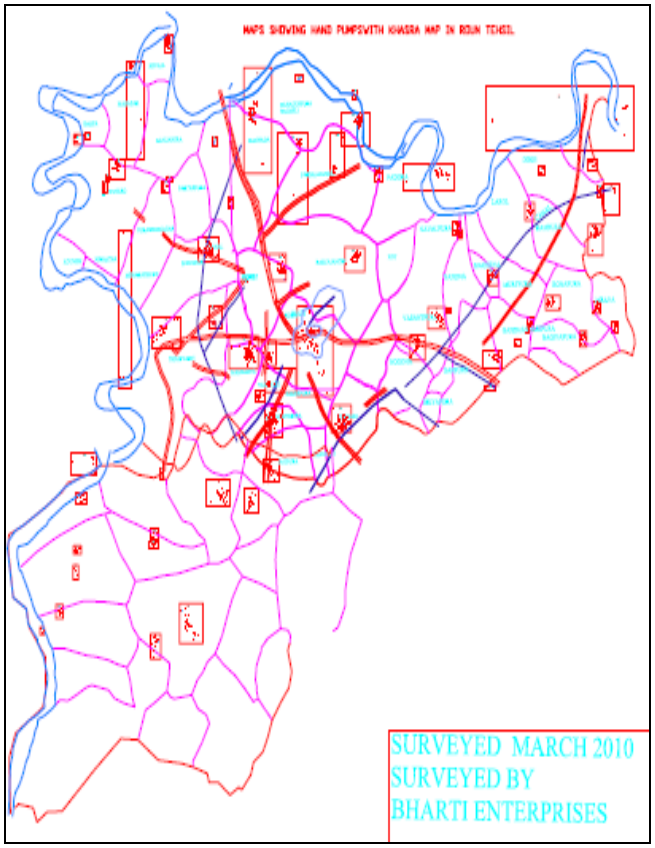
Map-1: Map of Roun Tahsil of Bhind district.

Methodology

During this study it was found that in these 43 villages about 1000 hand pumps and numerous tube-wells are

there in working condition (Map-2). Even though the area is well drained by surrounding rivers and receiving good amount of rainfall, there were complains of drying out of underground water. This was enough alarming situation to carry out the study. For close monitoring of the groundwater, we surveyed the location of hand pumps, their depth with the help of GPS.

Topographical details were traced out with the help of Cartosat- 1 imagery of March 2010. Khasra map was used to depict the village boundary. These all data were combined and analysis was carried out.



Map-2: Hand Pumps in Roun Tahsil of Bhind district.

Study Result

We found that during early days, sufficient water was collected in surface i.e., in ponds, wells etc. But because of increasing demand and cost of land, people have stopped constructing ponds but also started destroying the existing ones. The result is surface water which could be stored is going in vain and resulting into floods in rivers.

On the other hand population is growing day by day causing exploitation of underground water in the area. Common trends which were found in the area that each person wants the hand pump first in front of their house of nearby. This was also supported by local politician and as a result huge numbers of hand pumps are found in the villages of the tehsil, causing rapid decrease of groundwater level.

In the whole tehsil large number of hand pumps was found in Roun village. In the village where the hand pump density was large, depth of underground water level was 70 feet on an average and where the density was low (in the outskirts of the village) depth was 50 feet. It shows how the large number of water withdrawing devices decreases the level of groundwater though the slope of the area is very gentle.

Conclusion

By surveying the hand pumps of the villages we have received the exact position and depth of the underground water. It is clear by the results that, where the density of hand pumps are more the water table depth is low as compared to the places where withdrawing of underground water is less. Though from these hand pumps large amount of water cannot be drawn, but still the pressure of water crisis may rise if it is not regulated in time.

The main aim to study Roun tehsil was its good underground water potential, but over exploitation is causing depletion of underground water level. As it is a remote area, conservation activity of underground water is in initial stages, therefore from the beginning with the help of proper scientific and sustainable management, situation can be handled.

Therefore for a fertile and prosperous tehsil of Bhind, management of groundwater is of utmost necessity. There is need for regulation to check indiscriminate boring and withdrawing of groundwater in a scientifically suitable manner. Various method of water conservation like - water harvesting, which includes rainwater harvesting by bunding, vegetative and stone contour barriers, micro catchments, farm ponds etc. can be utilized. Direct surface water run-off harvesting can be done by roof water collection, digging of ponds and tanks, constructing stop dams, small check dams, percolation-tanks and by putting deep shafts of pipe in fields to percolate water. These kinds of small scale water harvesting technique provide direct solutions especially in rural areas.

Application of Remote Sensing and GIS Technique for Elucidation of Groundwater Potential Zones from a Part of Orissa Coastal Tract, Eastern India

Arkoprovo Biswas, Adarsa Jana and Shashi Prakash Sharma
Department of Geology and Geophysics, Indian Institute of Technology Kharagpur, India.
Email: arko@gg.iitkgp.ernet.in

Abstract

The present study attempts to select and delineate various groundwater potential zones for the assessment of groundwater availability in a coastal part of Orissa using remote sensing and GIS technique. Satellite IRS-IC LISS III, Landsat TM digital and SRTM data have been used in the present study to prepare various thematic maps, viz., landuse, geomorphological, geological, slope, drainage density, lineament density map. On the basis of relative contribution of each of these maps towards groundwater potential, the weight of each thematic map has been selected. Further, within each thematic map ranking has been made for each of the features. All the thematic maps are then registered with one another through ground control points and integrated step by step using the normalized aggregation method in GIS for computing groundwater potential index. On the basis of this final weight and ranking, the ground water potential zones have been delineated. Thus from the present study it is observed that an integrated approach involving remote sensing and GIS technique has been successfully used in identifying potential groundwater zones in the study area. Four categories of groundwater potential zones, viz., Very Good, Good, Poor and Very Poor have been demarcated. Major portions of the study area have "Very Good" as well as "Good" prospect while a few scattered areas have very poor prospect.

Introduction

Water is one of the most essential commodities for mankind and the largest available source of fresh water lays underground[1]. It is one of the most significant natural resources which support both human needs and economic development. Tremendous increase in the agricultural, industrial and domestic activities in recent years has increased the demand for good quality water to meet the growing needs. The movement of groundwater is controlled mainly by porosity and permeability of the surface and underlying lithology. The same lithology forming different geomorphic units will have variable porosity and permeability thereby causing changes in the potential of groundwater. This is also true for same geomorphic units with variable lithology. The surface hydrological features like topography, geomorphology, drainageetc., play important role in groundwater replenishment. High relief and steep slopes impart higher runoff, while the topographical depressions help in an increased infiltration. An area of high drainage density also increases surface runoff compared to a low drainage density area. Hence, identification and quantization of these features are important in generating groundwater potential model of a particular area[2].

Remote sensing is an excellent tool for hydrologists and geologists in understanding the "perplexing" problems of groundwater exploration. In recent years, Satellite remote sensing data has been used widely used in locating groundwater potential zones[3]. Satellite remote sensing data is not only cost-effective, reliable and timely but also meets the essential requirements of data in the Geographical Information System (GIS) domain, which are "current, sufficiently accurate, comprehensive and available to a uniform standard"[4]. Integration of the information on the controlling parameters is best achieved through GIS which is an effective tool for storage, management and retrieval of spatial and non-spatial data as well as for integration and analysis of this information for meaningful solutions. The technique of integration of remote sensing and GIS has been proved to be extremely useful for groundwater studies[5, 6, 7].

Satellite remote sensing provides an opportunity for better observation and more systematic analysis of various geomorphic units/landforms/lineaments due to the synoptic and multi-spectral coverage of a terrain. Investigation of remotely sensed data for drainage map, geological, geomorphological and lineament characteristics of terrain in an integrated way facilities effective evaluation of ground water potential zones. Similar attempts have been made in the generation of different thematic maps for the delineation of groundwater potential zones in different part of the country[8]. Analysis of remotely sensed data along with Survey of India Topographical and collateral information with necessary ground check helps in generating the base line information for ground water targeting. In the present study a part of the coastal tract of the eastern margin of Orissa has been selected for qualitative evaluation of ground water potential zones using remotely sensed data.

Study Area

The study area is a part of a coastal tract situated on the eastern margin of India (Fig. 1). It lies between (Lat - 19° 10' - 19° 30' N and Long - 84° 45' - 85° 10' E) and covers an area of about 750 sq. km. The width of the coastal tract varies from 8 to 12 km and extends for a length of about 70 km.

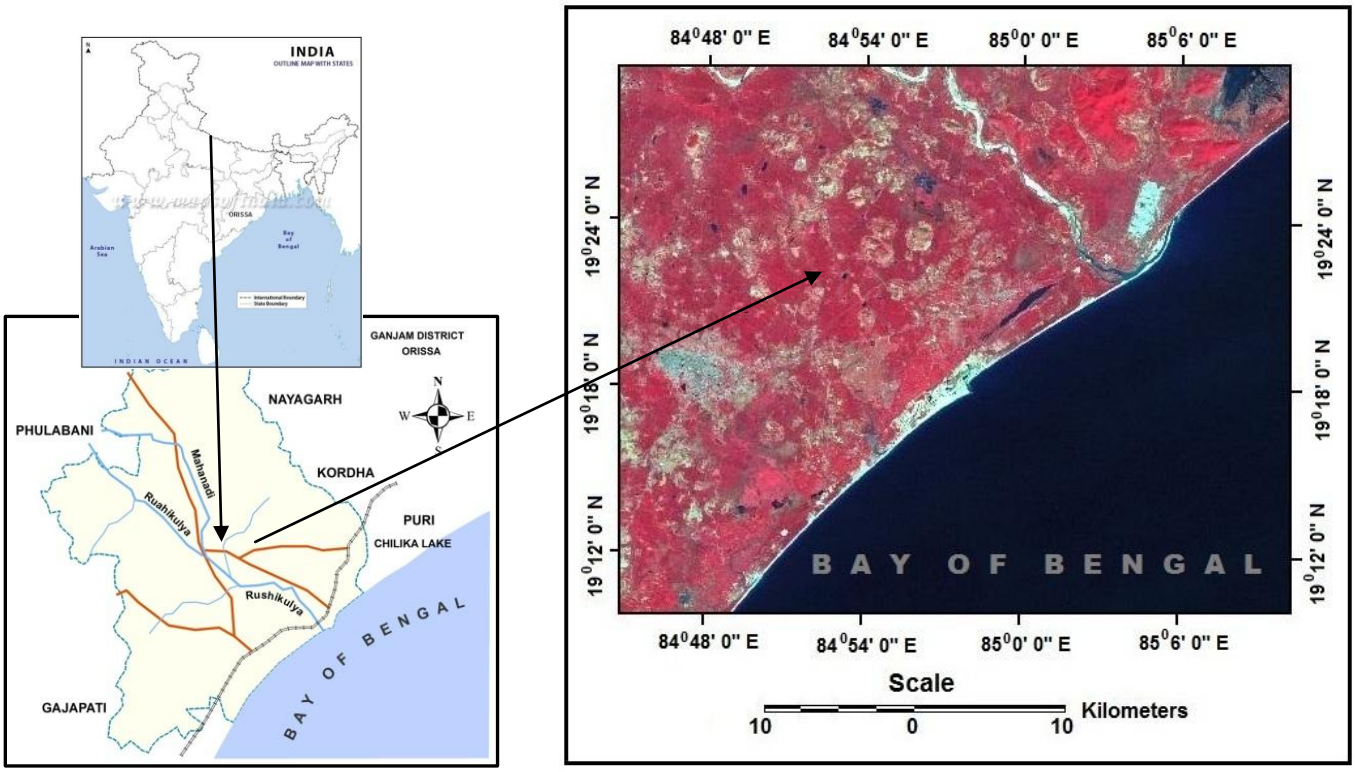


Fig. 1: Location Map of the Study Area

Geology and Geomorphology: Major parts of area are underlain by hard crystalline rocks of Archaean age. Sediments of Recent to sub-recent age occupy narrow discontinuous patches along the Rushikulya River and Bahuda River and also in the coastal tract. Sometimes laterite occurs as the capping over the older formations i.e. Khondalites. The Archaeancrystalline of the Eastern Ghat Group comprises of Granite and Granite gneiss, Khondalite suite, Charnokite suite, Pegmatite and Quartz vein[9]. The arearepresents a unique physiographic setting with highly rugged mountainous region in the West, North, Central, and Northern part and with dense forest covered and gently undulating plains and isolated hillocks in the eastern part. The average altitude in the hilly terrain ranges between 300 m to 700 m above mean sea level, with the highest of 949 m. The low-lying flood plains of the Rushikulya River and the intermontane valleys are characterized by gently undulating topography, scattered hills and mounds with an average altitude between 40 m to 140 m above mean sea level. The geomorphic units of the area are broadly classified[10] as: Structural Hills, Denudation Hills, Residual Hills, Inselberg, Linear Ridges, Pediment, Intermontane Valley, Pediment Inselberg Complex, Buried Pediplain (Shallow), Buried Pediplain, Buried Pediplain (Moderate), Buried Pediplain (Deep), Flood Plain, Coastal Plains and Sand Dunes.

Material and Methods

The Landsat TM data (Path-140/ Row-047) and IRS-IC LISS-III Digital data images (Path-106/ Row-058) and SRTM (DEM) are used in the present study. Survey of India (SOI) Toposheet (No. 74E/3, 74A/15, 74A/16) at 1:50,000 scales are also used. Secondary data on hydrology, ground water well data are collected from Central Ground Water Board, Bhubaneswar and from the field to support the mapping. Geographic Information System and Image Processing (ARC VIEW, ARC GIS and ERDAS IMAGINE software) are used for analysis and mapping of the individual layers as described in the flow chart (Fig. 2).Initially, all the images were rectified using the SOI Toposheet. This was followed by processing the digital images using the various processing techniques, viz., enhancement, filtering, classification and other GIS processes[11]. Subsequently, selective field checking was carried out.

All the available spatial data was assembled in the digital form and properly registered to make sure the spatial component overlaps correctly. Digitizing of all the maps and collateral data, followed by transformation and conversion from raster to vector, gridding, buffer analysis, box calculation, interpolation and other GIS processes were undertaken.

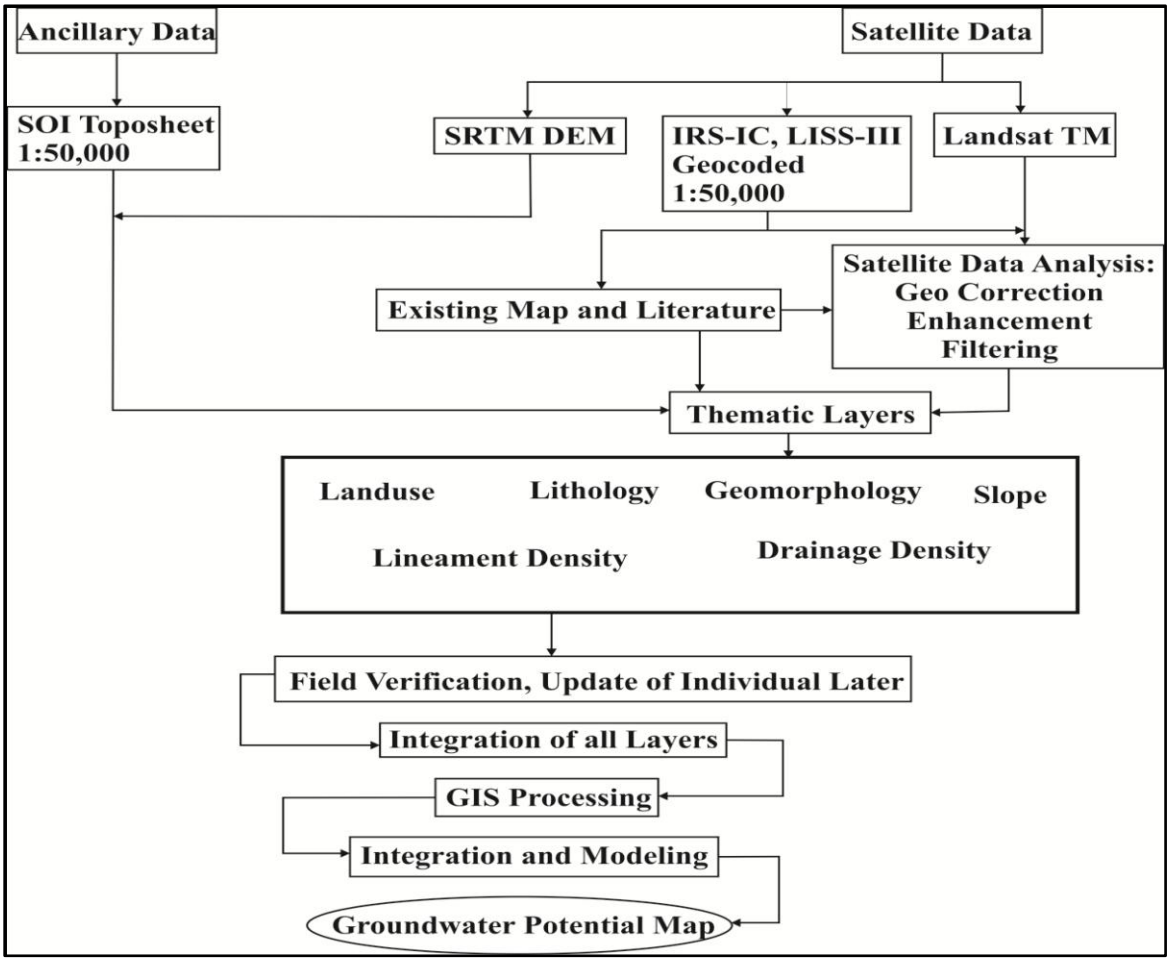


Fig. 2 : Flow Chart for Elucidating Groundwater Potential zones.

The influencing factors for groundwater are shown in Table 1. The effects of each major and minor factor are assigned a weightage of 1.0 and 0.5 respectively. The cumulative weight of both major and minor are considered for calculating the relative rates. Again, the rate is further used to calculate the score of each influencing factor. The score for each influencing factor is calculated by the formula[12].

$$\left[\frac{(A+B)}{\sum(A+B)}\right] * 100 \qquad (1)$$

Factor	Major Effect (A)	Minor Effect (B)	Proposed Relative rates (A+B)	Proposed Score of each influencing factor
Landuse	1+1	0	3	22
Lithology	1+1	0	2	15
Geomorphology	1+1+1	0	3	25
Drainage Density	1	0.5	1.5	10
Lineament Density	1+1	0	2	13
Slope	1+1	0.5	2.5	15
			∑14	∑100

Table 1: Influencing factor, relative rates and score for each groundwater potential factor

This stage produced derived layers such as Landuse, Geomorphology, Lithology, Drainage density, Lineament density, Slope etc. the entire input layers derived from stage 2 and 3 were processed to extract the spatial features which are relevant to the groundwater zone. This stage includes various analyses such as table analysis and classification, polygon classification and weight calculation. Polygons in each of the thematic layers were categorized depending on the recharge characteristics, and suitable weightage have been assigned to them (Table 2). The values of the weightage are based on[13, 14].The final stage involved combining all thematic layers and has been classified into four groups such as Very Good, Good, Poor and Very Poor using the Jenks (Natural Break) classification method.

Sl. No.	Theme	Features	Weight
1	Landuse	Crop Land	25
		Mixed Forest, Water Bodies, Sea, Dense Forest, River	16
		Sand, Wet Land,	10
		Laterite, Barren Land, Settlement	5
2	Geomorphology	Younger Coastal Plain, Young Flood Plain, Valley Fill,	25
		Water Logger area Water Bodies Lake	16
		Shallow Buried Pediplain, Sand dune, Beach, Spit	10
		Settlement, Residual Hill, Denudation Hill, Insitu Laterite, Transported Lateritic mound	5
3	Lithology	Beach Alluvium	15
		Lake, Water Bodies	12
		Khondalite	9
		Transported Laterite, Insitu Laterite, Pyroxene Granulite, Granitic Rocks, Unclassified crystalline Archaean, Settlement	5
4	Drainage density (Km/Km^2)	1.68-3.61 0.92-1.68 0.31-0.92 0-0.31	10 7 5 2
5	Lineament density (Km/Km^2)	111.43-268 56.76-111.43 18.92-56.76 0-18.92	13 9 5 1
6	Slope (degree)	14.79-39 5.94-14.79 1.22-5.94 0-1.22	15 12 8 4

Table 2: Classification of Thematic Map Weighted factor influencing Groundwater potential zones and Feature Ranking

Results and Discussions

*Generation of Thematic Maps:*Primarily IRS IC is used for generating the thematic maps. Landsat TM is useful in demarcating the water bodies and also in identifying numerous lineaments. SRTM (DEM) is also used in preparing the slope map along with the SOI Toposheet. These three data are useful in delineating the groundwater potential zones corroborated with limited field check.

Landuse Map: The different types of land-use in the study area classified into 11 classes (Fig. 3). Major part of the study area is covered by alluvium deposits. Most of the study area is covered by hard rock of Archaean age.

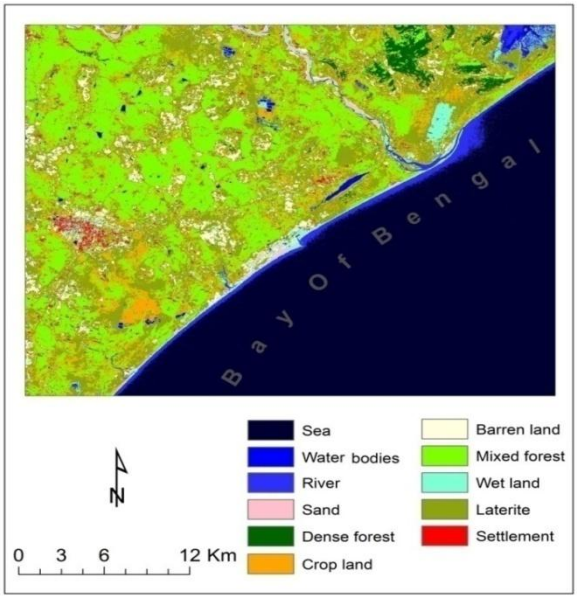


Fig. 3: Landuse Map of the Study Area

Lithology Map: Lithology is a very important aspect in predicting groundwater potential zones. Extraction of geological information from satellite data depends on the identification of different patterns on an image resulting from the spectral arrangement of different tones and textures. Depending on the rock reflectance properties, satellite images are used and they play important role in rock identifications. A lithology map is prepared using the IRS IC and Landsat TM Digital Data and simultaneously ground check verification is done in field (Fig. 4).

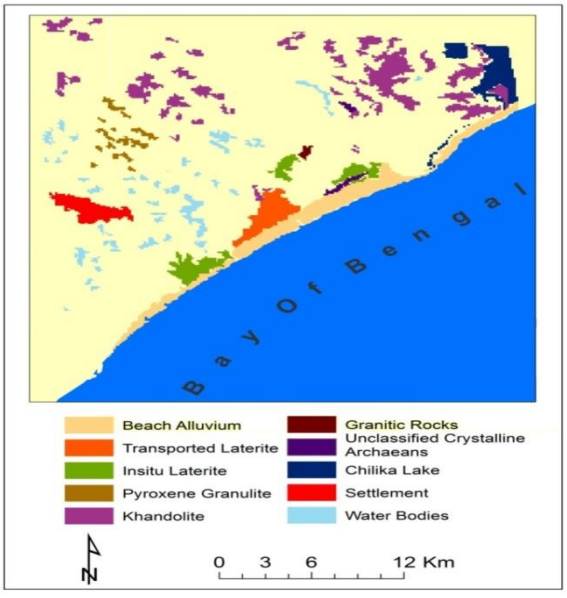


Fig. 4: Lithology Map of the Study Area

Geomorphology Map: Geomorphological map is prepared based on visual interpretation of Landsat TM and IRS LISS-III data on 50:000 scales and the geohydrology characters of the study area. Using the photogeologic elements [15], viz., tone, texture, shape, size, association etc. the various geomorphological units have been demarcated (Fig. 5).

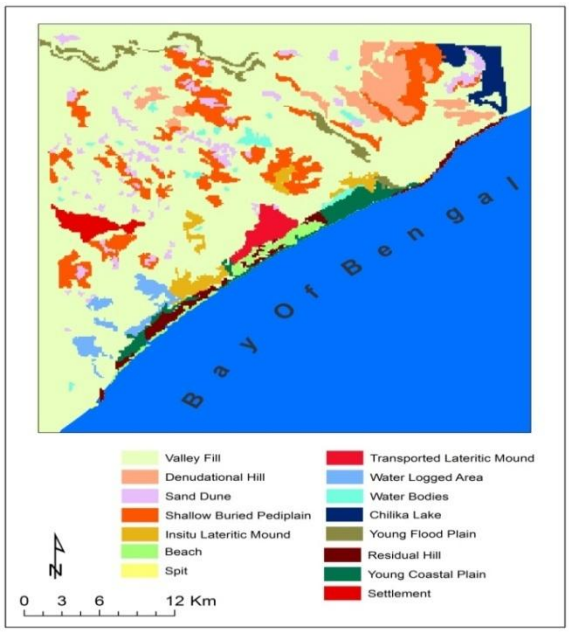


Fig. 5: Geomorphology Map of the Study Area

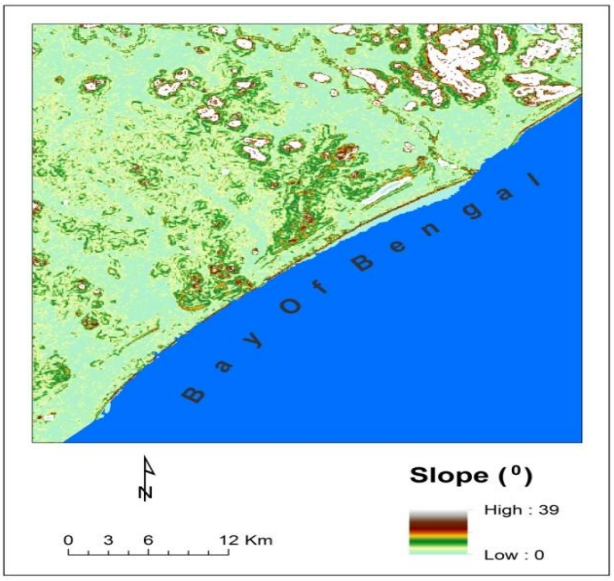


Fig. 6: Slope Map of the Study Area

Slope Map: Slope always plays a crucial role in groundwater potential mapping. Using the SOI Toposheet and SRTM data of the area, a slope map of the area is prepared. The area, in general is very gentle slope. However, in the north-eastern part of the study area, there is an increase in slope. Despite of this very gentle slope, a slope map has been prepared according to the following class interval (Fig. 6).

Drainage Density Map: A drainage density map is prepared on the basis of closeness of spacing of stream channels. It measures the total length of the stream segment of all orders per unit area. It is the inverse function of permeability. In this density map, the values have been assigned depending on the density of the drainage pattern and classified accordingly (Fig. 7).

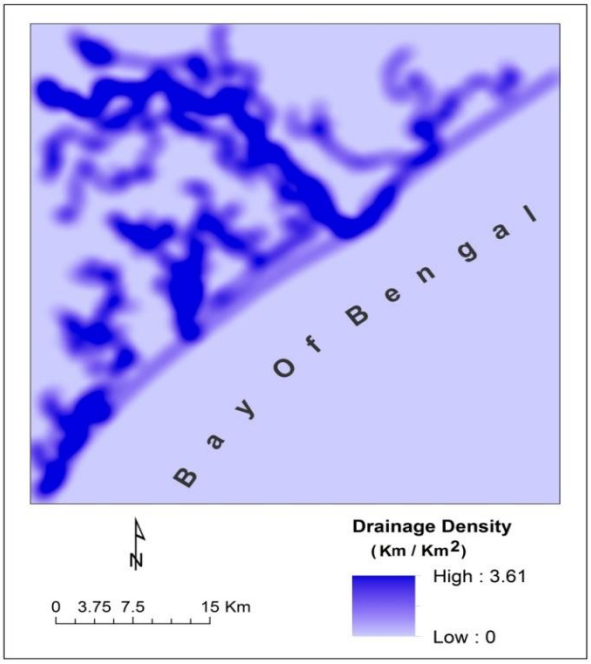


Fig. 7: Drainage density Map of the Study Area

Lineament Density Map: These are the structurally controlled curvilinear or linear feature depending on their alignment. The express the surface as well as subsurface structural features. Depending on various structures like faults, lineaments etc., and different zones have been classified. Areas with high lineament density shows good groundwater potential The lineament density map shows a low density in most of the area comparatively to other parts of the study area. (Fig. 8).

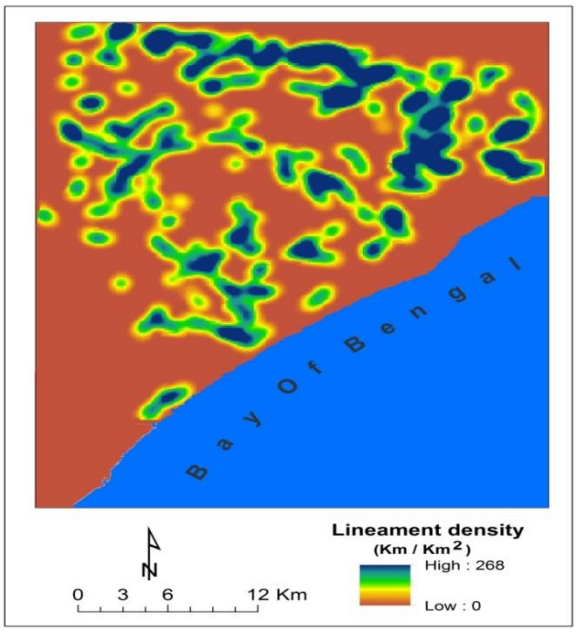


Fig. 8: Lineament density Map of the Study Area

Ground Water Potential Map : Depending on the groundwater potentiality, each class of the main six thematic layers (landuse, geomorphology, lithology, slope, drainage density, lineament density) are qualitatively placed into one of the following categories viz., (i) Very Good (13.96-20), (ii) Good (11.98-13.96), (iii) Poor (9.95-1198), (iv) Very Poor (6-9.95). All the thematic maps have been integrated in GIS. A final Groundwater Potential Map (Fig. 9) is prepared based on the above technique.

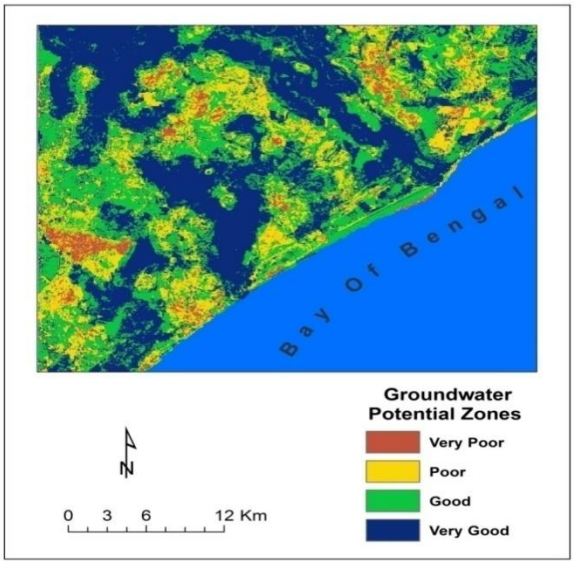


Fig. 9: Groundwater Potential zone Map of the Study Area

Conclusion

We have established successfully that Remote Sensing and GIS can provide the appropriate platform for convergent analysis of large volume of multi-disciplinary data and decision making for groundwater studies. These techniques have been successfully used and demonstrated for evaluation of groundwater potentiality of the area. The Weighted index overlay model has been found very useful in the mapping of groundwater prospective zones. Mainly IRS IC was used for preparing the thematic maps viz.,lithology, geomorphology, drainage. Landsat TM was useful in in identifying numerous lineaments. SRTM was also used in preparing DEM from which slope map is prepared. In this study area, five categories of groundwater potential zones have been delineated based on remote sensing and GIS technique. The four categories are: Very Good, Good, Poor and Very Poor. The

groundwater potential map (Figure9) near the coast line and in some parts of the north-eastern and north-western region shows excellent potential whereas greater part of the area shows good groundwater potential. Poor groundwater potentials are confined mostly in the hilly terrain and in settlement area. The quantitative amount of groundwater potential zones can be carried out if Geophysical Resistivity data is available.

References

1. Todd D K., Groundwater Hydrology, Second Edition, John Wiley and Sons Inc., New York, 556p, (1980)

2. Jensen J R., 1986, Introductory digital image processing, Third EditionPrentice Halls, Englewood Cliffs, NJ, 544p, (1986)

3. Srivastav P. and Bhattacharya A. K., Delineation of groundwater potential zones in hard rock terrain of Bargarh District, Orissa using IRS, *Jour. India. Soc. Rem. Sen*, 28(2-3), 129–140, (2000)

4. Phukan I., Ravindran K V. and Banerjee D M., Delineation of Groundwater Prospect Zones using Remote Sensing and Geographic Information System in the West Garo Hills District, Meghalaya, "*Geoinformatics: Beyond 2000", an International Conference on Geoinformatics for Natural Resource Assessment, Monitoring and Management*, Jointly Organized by Indian Institute of Remote Sensing (National Remote Sensing Agency) Dehradun, India and ITC (International Institute for Aerospace Survey and Earth Sciences) The Netherlands, 203-211, (1999)

5. Saraf A K. and Choudhury P R., Integrated Remote Sensing and GIS for Groundwater Exploration and Identification of artificial recharge sites, *Intl. J. Rem. Sen*, 19(10), 1825-1841, (1998)

6. Khan M A. and Moharana P C., Use of Remote Sensing and Geographical Information System in the Delineation and Characterization of Ground Water Prospect Zones, *Jour. India. Soc. Rem. Sen*, 30(3), 131-141 (2002)

7. SankarK., Evaluation of Groundwater Potential Zones Using Remote Sensing Data in Upper Vaigai River Basin, Tamil Nadu, India*, Jour. India. Soc. Rem. Sen*, 30(3), 119-129, (2002)

8. ObiReddy G P., Mouli K C., Srivastav S K., Srinivas C V. and Maji A K., Evaluation of Groundwater Potential Zones Using Remote Sensing Data- A Case Study of Gaimukh Watershed, Bhandara District, Maharashtra, *Jour. India. Soc. Rem. Sen*, 28(1), 19-32, (2000)

9. Mohanty B K. and Devdas V., Geological mapping of Quartenary formations in Rushikulya river basin in parts of Ganjam District, Orissa, *Rec. Geol. Surv. India*, 122(3), 5-6, (1989)

10. TripathyJ K., Panigrahy R C. and Kumar K V., Geological and Geomorphological studies of a part of Ganjam district, Orrisa by remote sensing techniques, *Jour. India. Soc. Rem. Sen*, 24(3), 169–177, (1996)

11. ESRI-ArcView GIS, The Geographic Information System for everyone, Environmental Systems Research Institute, USA, (1996)

12. Magesh N S., Chandrasekar N., Soundranayagam J P., Delineation of groundwater potential zones in Theni district, Tamil Nadu, using remote sensing, GIS and MIF techniques, *Geos. Frontiers*, 3(2), 189–196, (2012)

13. Krishnamurthy J., Venkatesa K N., Jayaraman V. and Manivel M., An approach to demarcate ground water potential zones through remote sensing and a geographical information system, *Intl. J. Rem. Sen*, 7(10), 1867-1884, (1996)

14. Krishnamurthy J., Arul Mani M., Jayaraman V. and Manivel M., Selection of Sites for Artificial Recharge Towards Groundwater Development of Water Resource in India, *Proceeding of the 18th Asian Conference on Remote Sensing*, Kuala Lumpur. 20 - 24 October (1997)

15. Lillesand T M. and Kiefer R W., Remote Sensing and Image Interpretation, Fifth Edition, John Wiley and Sons (Asia) Pte. Ltd, Singapore, 820p, (2000)

Exploration and Management of Ground Water Resources by using Remote Sensing Data and GIS tools in and around Dehra Doon Valley

Dr. D. K. Mandal
Department of Geography & Applied Geography, University of North Bengal
E-mail: dkmandalnbu@gmail.com

Abstract

Realizing the importance of Remote Sensing and GIS technology, the present study has been undertaken to study the geomorphology and delineate the prospective ground water zones in the Eastern Doon Valley and its surroundings falling in the newly formed State of Uttaranchal. For this purpose, the satellite imagery (PAN and LISS III) provided by IRS have been digitally enhanced using various techniques to improve the visual interpretability. These enhanced images were visually interpreted to map different landforms and geomorphic units existing in the area and to understand the processes of their evolution. Other parameters which control the occurrence and movement of ground water, such as Lithology/Rock type, structure, land use/land cover, drainage density were also interpreted using satellite imagery in conjunction with the existing maps and literature, and different overlays were prepared. Well data were collected from different government departments and analyzed. Based upon the well data, different maps like static water table map, aquifer thickness map, well discharge map, well specific capacity map and well yield factor map were prepared. Subsequently, all the layers important from ground water occurrence and movement point of view were digitized and integrated in the GIS environment using index overlay method. The weights to different units/ parameters and themes were assigned depending upon their importance. With this integrated GIS analysis, ground water prospects map of the study area was prepared. The ground water prospects have been classified qualitatively as Excellent, Very Good, Good, Moderate and Limited. The ground water prospective zones are essentially located in the intermontane Doon valley area, especially in the lower part under semi-confined to confined conditions. The denudo-structural hills of the Siwaliks and Pre-Tertiary rocks and residual hills of old Doon gravel form essentially the run-off zones, wherein the prospects exist only along the valleys/ topographic lows, suitable geological structures, springs and seepage zones.

Introduction

Lack of adequate potable and agricultural water supplies inhibits the progress of developing countries and is the cause of considerable hardship to humans worldwide. A thorough hydrogeologic understanding is often critical for cost-effective water resources development projects designed to alleviate these hardships. Since last decade, the value per barrel of potable ground water has outpaced the value of a barrel of oil in many areas of the world. Therefore, importance of ground water in various fields like domestic, industrial and agriculture and recycling of wastewater requires an emphasis. Establishing relationship between Remote Sensing data and hydrologic phenomenon can maximize the efficiency of water resources development projects. In spite of extensive research and technological advancement, the study of ground water has remained more of a speculative and intuitive science, as there is no method to facilitate direct observation of water below the surface. Its presence or absence can only be inferred indirectly by studying the geological framework through which it flows. There are a number of factors that control the ground water regime in a given area such as: Lithology, Stratigraphy, Structure, Landforms/ Geomorphology, Recharge Conditions, Slope, Soil, Land use/Land cover, etc. Remotely Sensed data by virtue of its synoptic coverage and multispectral nature help in identification and mapping of most of the above factors with selective ground checks in a cost-effective manner. An integrated analysis of these factors and the available well and ancillary data in the GIS environment helps in identifying the potential ground water zones.

Objectives

The prime objectives of the present study are as follows:

1. To identify and map different landforms/ geomorphic units and understand the geomorphic processes involved.
2. To identify and map other parameters controlling the ground water occurrence and movement, such as lithostratigraphy, structure, drainage density, slope, land use/land cover, etc.
3. To understand the nature and performance of aquifers based on tube well and dug well data.
4. To delineate the prospective ground water zones by integrating different controlling parameters along with the well data in the GIS environment.

Study area

The study area covers eastern part of Doon valley and its surroundings having association with lesser Himalayas in the north, Siwalik Hills in the south, River Ganga in the Southeast and Dehra Dun town in the west. It covers about 740 sq. km and is bound between 78º05'N and 78º25'E longitude, and 30º05' and 30º30'N latitude. It falls in SOI Toposheet Nos. 53J/3, 4, 7 and 8.

Data used

The following data have been used in the present study:
IRS-1C/1D PAN & LISS-III data
SOI Toposheets (53J/3, 4, 7 & 8)
Well data from UP Jal Nigam & Garhwal Jal Sansthan.
Information collected during selective field checks.

Methodology

The methodology adopted in the present study is given as a flow chart in Fig. 1. *The various steps involved are briefly described below*:

Problem Identification Water Resource is more versatile, vital and abundant for the existence of all forms of life. With increasing demands on water by growing world population and increased modern industrial and agricultural activities, no natural resources has perhaps given rise to deeper concern about its over-exploitation & conservation, than good clean water. It is in this context that the immense possibilities of utilizing the modern techniques of remote sensing and GIS as an aid in water resources survey are presently being realized & accepted. Considering the usefulness of remote sensing and GIS techniques coupled with the availability of data, approachability, etc, the eastern Doon Valley and its surroundings has been selected as study area for geomorphological and ground water studies.

Pre-Field Interpretation *The following procedure was adopted for preparing pre-field maps.* Digital image processing; especially georefrencing, digital image enhancement and merging of PAN & LISS III data to improve visual interpretability. Visual Interpretation of IRS-IC/1D (LISS III) & PAN imagery of the study area for preparation of geology, structure, geomorphology, hydrology, and land use/Land cover maps, taking the help of existing map and literature. Preparation of base map with the aid of SOI toposheet Nos. 53J/3,4,7 and 8 of Survey of India. Data transfer on base map in order to prepare the overlays of geology, geomorphology, land use, etc derived from imagery. Selection of critical traverses for field checks.

Field Survey *The following procedure has been adopted during the fieldwork.* Collection of existing well data from Govt. Depts. (UP Jal Nigam and Garhwal Jal Sansthan) Verification of lithological and geomorphological units, geological structures land use/land cover, etc by taking traverses mainly along the roads. Well inventory of tube wells and dug wells in the field.

Post-Field Interpretation and GIS Analysis *The following procedure has been adopted in this stage:* Correction of pre-field maps by incorporating field observations. Tabulation of well data and preparation of (a) iso-depth to static water table map, (b) iso-discharge map, (c) iso-aquifer thickness map, (d) iso-specific capacity map and, (f) iso-yield factor map. Preparation of slope map (amount and aspect) based on SOI toposheets. Digitization of thematic layers. GIS analysis using index-overlay method. Output generation and report writing.

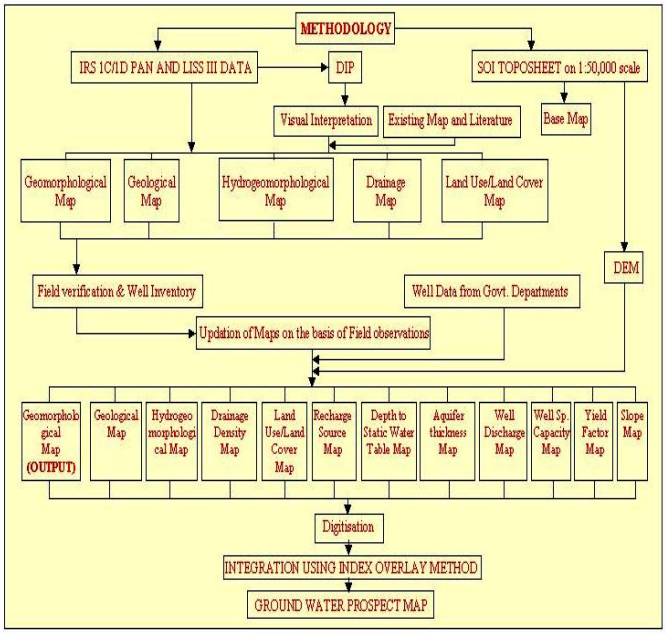


Fig. 1: Flow Chart showing methodology followed.

Integrated Analysis in GIS Environment: A direct consequence of integrated geoinvestigation approach has been realization of Geographic Information System (GIS). A GIS can be defined as an automated tool for efficient storage, analysis and presentation of geographically referenced data. In a comprehensive sense, GIS means identifying data needs, acquisition of data, management, processing and decision-making. In the present study, various thematic maps have been integrated in GIS environment in order to delineate the prospective ground water zones. The details are given in this chapter. For digitization and integration, ARC VIEW (Version 3.2a) software has been used.

Themes used for Integration:
The following themes which are important for characterizing the ground water regime of the study area have been digitized in different layers:

1. *Hydrogeomorphology*
2. *Drainage density*
3. *Depth to static water table*
4. *Well discharge*
5. *Well aquifer thickness*
6. *Specific capacity*
7. *Yield factor*
8. *Slope*
9. *Recharge Source*
10. *Land use/Land cover*

All the above themes have multiple classes. These themes/layers have been converted to raster form before doing the integrated analysis.

Method of Data Integration

In order to integrate various thematic layers index overlay method has been used. A rating has been developed for the integration of these thematic maps. A numerical rating system ranging from 1 to 10 have been assigned to various classes of individual themes, it is based on degree of influence of individual categories on ground water regime of the region. These are given in the tables below: Table 1 (1-10). Secondly, all the thematic maps have assigned a weightage factor, depending on the importance of themes. The final integrated output in raster format was classified into classes showing different ground water prospectives.

Table 1: (1-10) Numerical Rating System (NRS).

1. *Hydrogeomorphology Layer*

Unit	***Score***
Channal Bar	10
Active Flood Plain	10
Alluvial Plain	8
Palaeochannel	8
Lower Doon Valley Fan (Gullied)	5
Lower Doon Valley Fan	6
Upper Doon Valley Fan(Gullied)	2
Upper Doon Valley Fan	3
Residual Hill	0.1
Denudo-structural Hill of Middle Siwalik	0.1
Valley (Pre Tertiary)	5
Denudo structural Hills (Subathu & Pre Tertiary)	0.1

2. *Drainage Density*

Unit	***Score***
High Drainage Density	2
Medium Drainage Density	5
Low/very low Drainage density	8
River Bed	10

3. *Recharge Source Map*

Unit	***Score***
Only rain fall	5
Rainfall + canal irrigated	7

4. *Depth to Static Water Table*

Unit	***Score***
< 20 m	6
20 – 45	4
> 45 m	2
Run off zone	0.1

5. *Well Aquifer Thickness*

Unit	***Score***
< 20 m	2
20 – 30m	4
> 30 m	6
Run off zone	0.1

6. *Well Discharge*

Unit	***Score***
< 1000 lpm	2
1000 – 2000 lpm	4
> 2000 lpm	6
Run off zone	0.1

7. *Specific capacity*

Unit	***Score***
< 500 lpm/m	2
500-800 lpm/m	4
> 800 lpm/m	6
Run off zone	0.1

8. *Yield Factor*

Unit	***Score***
< 25 lpm/m/m	2
25 – 40 lpm/m/m	4
> 40 lpm/m/m	6
Run off zone	0.1

9. *Land use*

Unit	***Score***
Settlement	2
Agriculture land	6
River/ water body	10
Aerodrome	2
Plantation	6
Dense Forest	8
Open forest	6
Waste land	3
Fallow land	5
Barren land	3

10. *Slope*

Unit (In degree)	***Score***
0°-1°	10
1°-2°	8
2°-5°	6
5°-10°	4
10°-20°	2
20°-45°	1
> 45°	0.1

Index Overlay Method

This model is applied where maps are added together in a weighted combination. In this simplest type of weighted model, input maps are binary and each map carries a single weight factor. However, multi-class maps are also can be used; each class of every map is given a different rating score. This method allows more flexible weighting system. In case the map classes occurring in each map are assigned different score, as well as the map themselves receiving weights, the average score can be defined as:

Formula Used

$$S = \frac{\sum_{i=1,j=1}^{n,m} S_{ij} W_i}{\sum W_i}$$

Where, S is the weighted Score
W_i is the weight of the i^{th} input map
S_{ij} is the rating score for the j^{th} class

(Note: here, S is the weighted score for our area object (polygon, pixel), Wi is the weight of ith input map, and S ij is the rating score for the jth class of the ith map. The value of J depends upon the class actually occurring at the current location. Each map must be associated with a list of scores, one per map class. Class scores can be put into an attribute table of the individual layers).

Results

After assigning the score to different units/classes in occurring in each theme, ***all the 10 layers were integrated*** in the ***ArcView*** software using index overlay method described above. Here towards giving the weights each theme, we followed two methods- All the themes were given the same weights. Different weights were given to different themes depending upon the themes importance. Using the above 2 weighting systems, weighted scores were worked out and reclassified to represent different ground water prospects existing in the area. These classes are given below (Table 2):

Table 2: Ground Water Potential Zones.

Ground Water Potential Zone
Excellent
Very Good
Good
Moderate to Good
Moderate
Limited to Moderate
Limited
Mainly run-off zone (Prospects limited to valleys)

The final ground water prospects are shown in Fig. 2. As evident in this figure, high ground water prospects mainly exist in the lower part of the Doon Valley fan and alluvial/flood plains of present rivers. The denudo-structural hills of Siwaliks and Pre-Tertiary rocks, and residual hills of old Doon gravel and essentially from the run-off zones. The ground water prospects in these zones are limited to only along valleys/ topographic lows, suitable geological structures, the areas near the springs, also form the suitable zone for water resources development.

Concluding Remarks

Remote Sensing and GIS techniques are useful tools in geomorphological and ground water studies. Based on visual interpretation of satellite, different landforms/geomorphic units have been identified and mapped in the study area, viz. Denudo-structural hills-moderately/Highly dissected, Residual Hills, upper Doon Valley Fan, Alluvial Plains, Flood Plains, Channel/ Point/ Braided Bars, plaeaochannels, etc. The denudo-structural hills are basically formed by the Siwaliks and Pre-Tertiary rocks. Residual hill is formed by the old Doon gravel. The central and southern hill is formed by the old Doon gravel. The central and southern part of the area is occupied by the Doon Fan. The area on either side of the major rivers like Song and Jakhan Rao is characterized by fluvial deposits. The distribution and type of land forms/geomorphic units as mapped from the satellite data in conjunction with the field checks helped understanding the geomorphic processes involved in carrying out the present day topography. Integrated approach of Remote Sensing and GIS in conjunction with the available well data helped in delineating the prospective ground water zone in the study area. Productive aquifers in the study area are mostly confined to the lower part of the Doon Valley Fan and to the active flood plains/ alluvial plains of major rivers like Song River and Jakhan Rao River, wherein the ground mainly occurs in unconfined and semi-confined conditions.

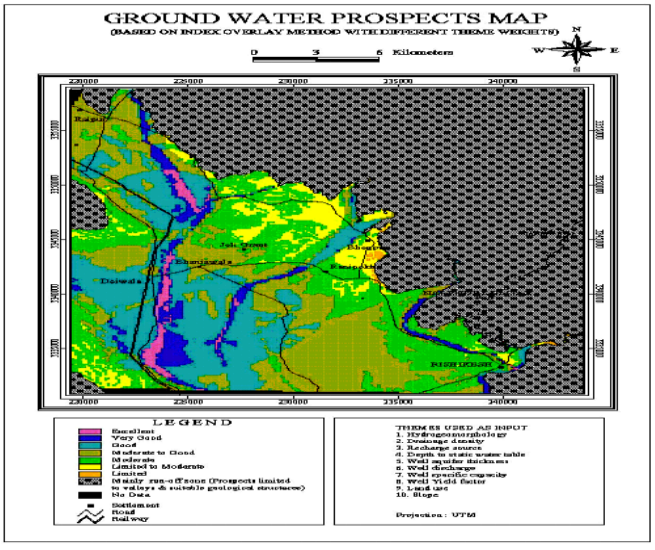


Fig. 2: Map showing Ground Water Prospects ones.

Morphometric and Hydrological Analysis for the Upper Part of the Dwarkeswar Watershed using Remote Sensing and GIS Techniques

Subodh Chandra Pal*, Manisa Shit and *** Dr. Subrata Pan**
** Research Scholar, Visva-Bharati, Santiniketan, W.B., India*
*** M.A. in Geography, C.S.J.M. University, Kanpur, India*
****Assistant Professor, Geography Dept. (HOD), Bankura Christian College*
E-mail: geo.subodh@gmail.com

Abstract

The study analyzes five morphometric parameters namely absolute relief, relative relief, dissection index, average slope, drainage density and ruggedness index, for better understanding of hydrologic processes in a watershed. The advanced application of Remote Sensing (RS) and Geographic Information System (GIS) techniques have lead to estimation of surface runoff and soil loss based on different parameters which generally used in most of the water resources applications. The Soil Conservation Service-Curve Number (SCS-CN) method is adopted for the estimation of surface runoff in the upper part of Dwarkeswar watershed using multispectral remote sensing data, curve number approach and normal rainfall data. The weighted curve number is determined based on antecedent moisture condition (AMC)-II with an integration of hydrologic soil groups (HSGs) and land use/ land cover LULC categories. The Universal Soil Loss Equation (USLE) is used for soil loss estimation with the help of rainfall and runoff factor (R), soil erodibility factor (K), slope length and steepness factor (LS), crop management factor (C) and conservation practice factor (P). These parameters are obtained from monthly and annual rainfall data, soil data, topographic map and satellite images. The Dwarkeswar watershed encompasses an area of about 1808.58 sq km. The average drainage density of this watershed is computed at 0.4 km/sq km with the average slope measuring about 1º42'32". It is observed that the average soil loss of this watershed is about 2.24 tons/acre/year.

Introduction

Watershed is a natural laboratory of hydrology. It can be defined as the area that drains the entire precipitation into a particular stream outlet. In other word it is the catchment's area from which all precipitation i.e. rainfall as well as snow melt water drained into a single stream. Remote sensing and GIS techniques are being increasingly used for planning, development and management of natural resources. The factors that play a greater role in the planning and development process of a watershed are its size, shape, physiography, slope, climate, drainage, geomorphology, soil, soil erosion zones, land use/land cover, surface water and groundwater etc. Remote sensing technology provides the vital spatial and temporal information on these parameters. So to study the morphometry and hydrological analysis on different watersheds need to concentrate on these factors. Runoff is one of the most important hydrologic variables used in most of the water resources applications. The Revised Universal Soil Loss Equation (RUSLE) calculates the long term average annual rate of erosion on a field slope based on the various morphometric parameters and physical properties as well. RUSLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might have occurred from gully, wind or tillage erosion. The present study is carried out with a view to preparing a land use map for the upper part of the Dwarkeswar watershed which leads to compute the volume of runoff using SCS method of runoff modeling by developing a suitable hydrological model, thereby enabling us to estimate soil loss by using RUSLE equation using digital remote sensing data.

Study area

The upper part of the Dwarkeswar watershed looks like a semielliptical shape and occupies the Kashipur block which is situated in northeastern part of Puruliya district, but the major part of this study area is situated in Chhatna and Bankura-I block of Bankura district of West Bengal state, India. This study area is bounded by latitudes $23^0$08'59", to $23^0$31'02" and from longitudes $86^0$31'09" to $87^0$8'19". This study (Fig. 1) area covers an area of 1808.5778 km^2. Gandheshwari is one of the major tributary of Dwarkeswar River which covers an area of 388.6015 km^2. The maximum altitude is 435 m., demarcated in the middle part and the minimum elevation is about 67 m. observed in the south eastern part of the watershed. This absolute relief map is generated as shown in Fig. 2

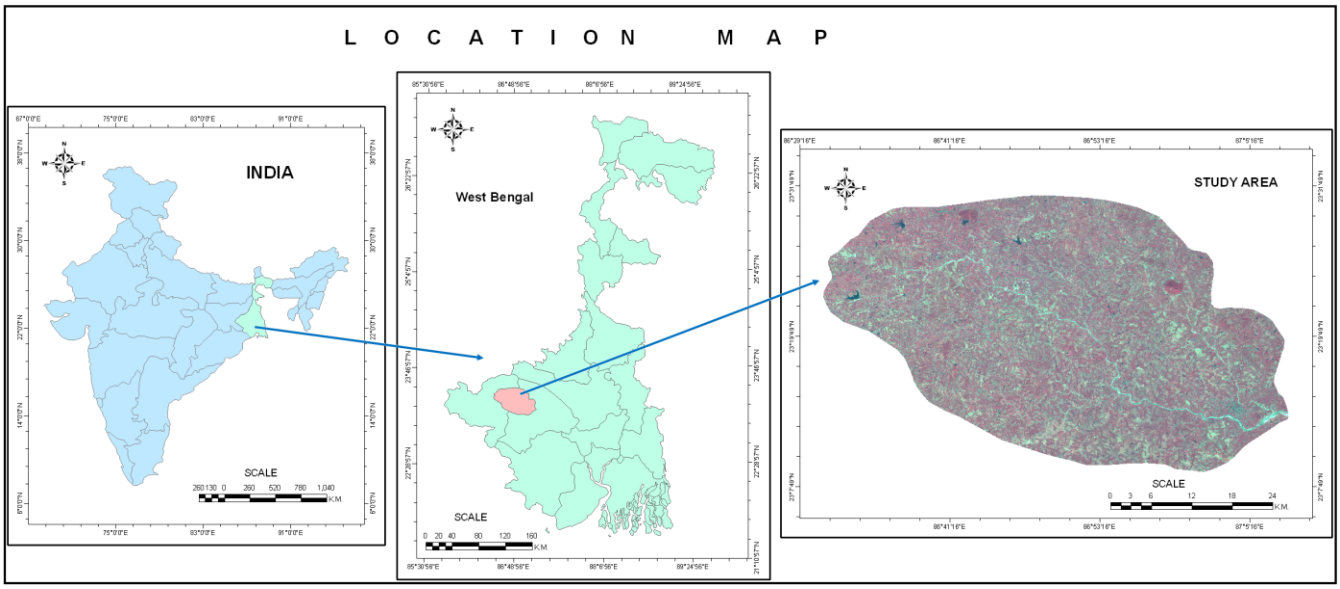


Fig. 1: Location map of the study area

Data used

Survey of India (SoI) topographical sheets (73 M and 73 I) on 1:250,000 scales have been used as a base map for the preparation of this study. Contours available on SOI topographical maps have been used for the preparation of Digital Elevation Model (DEM). SRTM, ASTERGDEM, Google earth image and Geological map (1:250,000 scale) published by Geological Survey of India were also used. Except these, one satellite data (Table 1) is also used for this work which is in the following.

Details of the satellite data used in this study					
Satellite	Sensor	Path/Row	Bands	Date of acquisition	Spatial Resolution
LANDSAT	ETM+	139/044	1,2,3,4	Nov. 18th 2006	30*30mts.

Table 1: Details of the satellite data used in this study

Objectives

The main objective of the present article is to estimate the runoff and soil loss potential of the entire study area.

Methodology

LANDSAT ETM+ Imagery, District map and Topographical map were rectified using Ground Control Point by the process of double image rectification in GIS software. UTM projection system and WGS84 datum and spheroid were used for this purpose. Then create a polygon vector layer of the study area to show the boundary of the study area. The study area was extracted by sub-setting from the main image using vector layer in the extraction method under spatial analyst program in GIS software. Maximum likelihood algorithm was used to classify the satellite image with their tonal values of different land use/land cover classes in the supervised classification techniques by using GIS software. We differentiated eight classes within the entire study area. These were water body, dense forest, mixed forest, agricultural land, agricultural fallow land, dry land, lateritic exposure, and built-up land. After field study we modify the classification by recoding techniques and composing the map we generate final land use land cover map (Fig. 9) as an output. The study area contains the following Land use /Land cover statistics (Table 3). After field study, the land use / land cover map is superimposed with soil texture map and find out the different hydrological soil groups and there statistics. Finally the surface runoff and soil loss estimation are performed using different algorithms as in the following.

Drainage system and channel morphometry

The morphometric study of the drainage basin is aimed to acquire accurate data of measurable features of stream network of the drainage basin. Author has computed some morphometric parameters like stream order (Fig. 6) which ranges between 1 to 4, stream length which is 726.72 km., Bifurcation ratio which ranges between 3.44 to 8, Stream frequency which is about 0.0835, and drainage texture which is 4.81.

Relative relief

Relative relief is defined as the difference in height between the highest and the lowest points in a unit area. It is an important morphometric parameter which is used for the overall assessment of morphological characteristics of terrain. The maximum relative relief (Fig. 3) for the part of the Dwarkeswar watershed is 320 m in the north-eastern part of the study area.

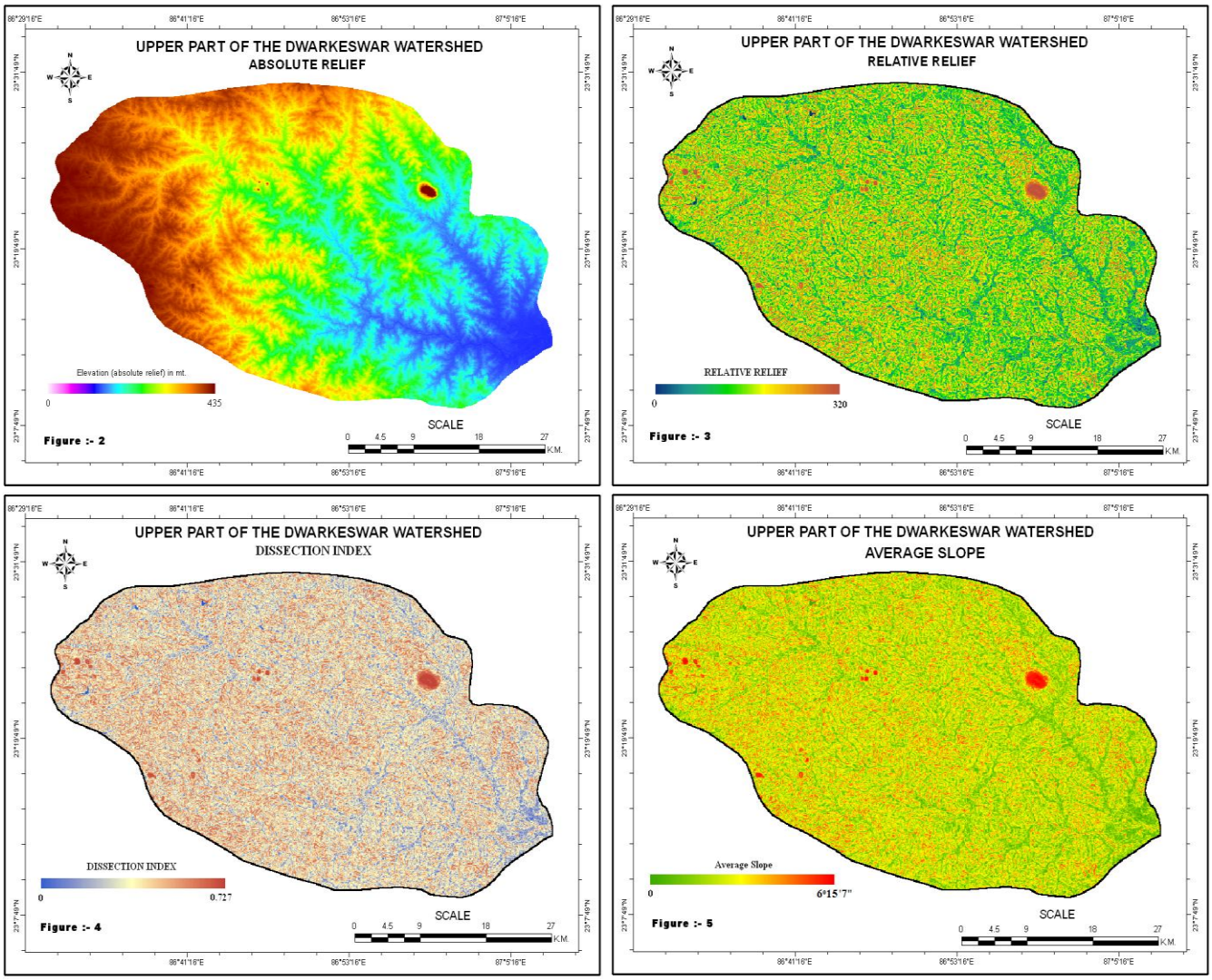


Fig. 2: Absolute relief, **Fig. 3:** Relative relief, **Fig. 4:** Dissection index and **Fig. 5:** Average slope

Dissection index

Dissection index is a parameter implying the degree of dissection or vertical erosion and expounds the stages of terrain or landscape development in any given physiographic region or watershed. The value of dissection index ranges from 0 to 1. Higher value of the dissection index represents larger is the undulation and instability of the terrain. Maximum dissection index is calculated as 0.73 in the north-eastern part of the watershed (Fig. 4).

Average slope

Erodibility of a watershed can be studied and can be compared from its average slope. More the percentage of slopes more are its erosion, if all other things are kept constant. In the gentle slope area the surface runoff is slow, allowing more time for rainwater to percolate, whereas high slope area facilitate high runoff allowing less residence time for rainwater hence comparatively less infiltration. Author has computed the maximum average slope of the study area, which is $6^0$15'7" (Fig. 5).

Drainage density

Drainage density is the ratio of total length of all stream segments in a given drainage basin to the total area of that basin. A high value of drainage density is the result of impermeable sub-surface material, sparse vegetation, mountainous relief which influences low infiltration capacity and higher runoff and soil loss. Maximum drainage density is calculated as 1.97 km. per sq.km (Fig. 7).

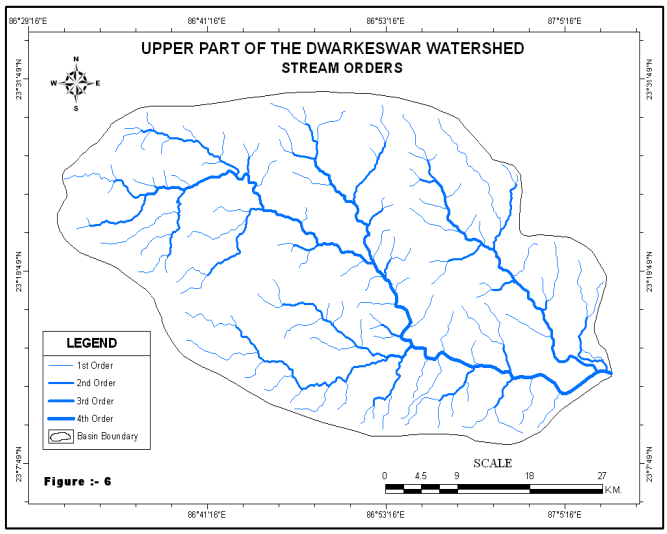


Fig. 6: Stream orders

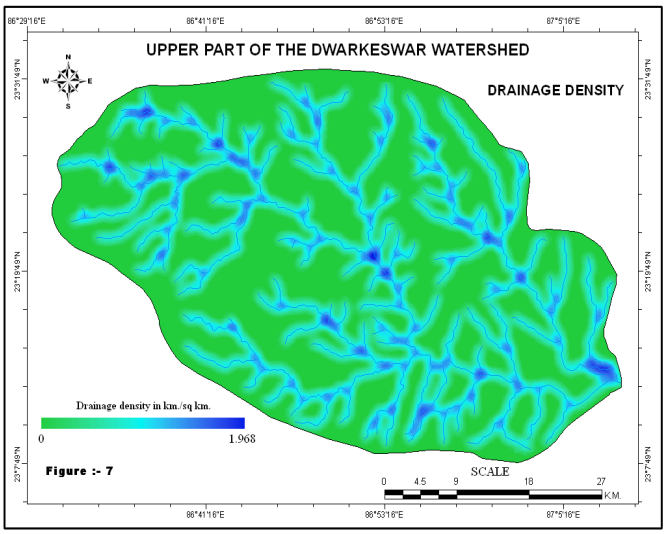


Fig. 7: Drainage density

Geology

The area comprises of Pre-Cambrian crystalline basement and recently deposited alluvium connected by an intervening tract. The area is predominantly a Precambrian gneissic terrain. Here, the extension of Chotonagpur plateau gradually merges with the alluvial plain. The main rock types are granitoid gneisses, quartz schists and amphibolites. The upland surface is composed of lateritic hard crust with jointed structures and granular materials. The valley fill surface and younger terrace are composed of gravels or coarse sands.

Soil characteristics

Soil texture and hydrologic soil group (Table 2 and Fig. 8) are very important parameters for estimation of runoff and soil loss. Here only seven types of soil texture are observed e.g. loam, clay loam, clay, sandy loam, sandy clay loam, and silty clay loam. The hydrological soil groups indicate the infiltration potential of different soils. The SCS model has classified all soils into four hydrologic groups. These are 1) **Group A** soils which have low run off potential and high infiltration rates because of having high amount of gravels. The USDA soil texture normally included in this soil group is loamy sand and sandy loam. These soils have a transmission rates greater than 0.76 cm/hr. 2) **Group B** soils that have moderate infiltration rates because of having high amount of sand. This type of soil is generally moderately coarse texture and also moderate rate of water transmission. The USDA soil texture normally included in this soil group is silt loam and loam. These soils have a transmission rate between 0.38-0.76 cm/hr. 3) **Group C** soils have low infiltration rates because of having high amount of silt. The USDA soil texture normally included in this soil group is sandy clay loam. These soils have a transmission rate between 0.13-0.38 cm/hr. 4) **Group D** soils have high runoff potential and very low infiltration rates because of having clay pan and clay layers under these type of soil group. The USDA soil texture normally included in this soil group is clay loam. These soils have a transmission rate between 0.0-0.13 cm/hr.

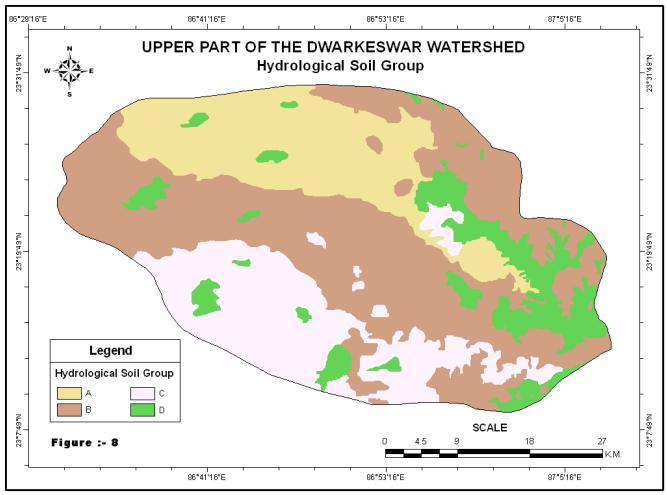


Fig. 8: Hydrological soil group

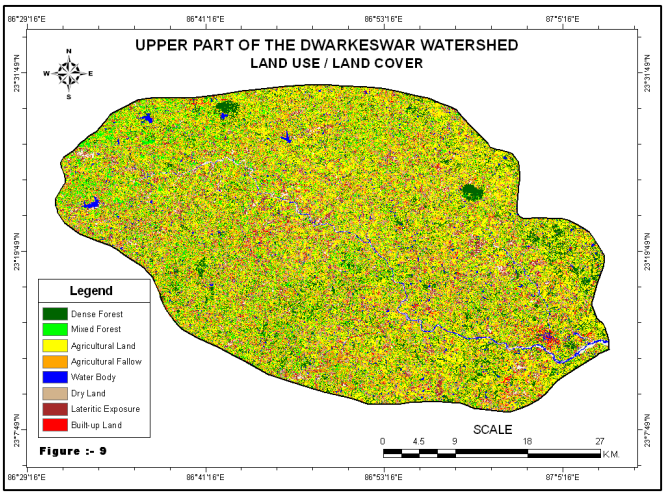


Fig. 9: Land use / Land cover

SL. No.	Hydrological soil group	Area (sq km)	Area (%)
1	A	401.2459	22.18571
2	B	838.7566	46.37658
3	C	386.2749	21.35794
4	D	182.3004	10.07977
	Total	**1808.5778**	**100**

Table 2: Details of the statistics for different hydrological soil groups

Land use / land cover

The terms land use and land cover (LULC) are often used simultaneously to describe maps that provide information about the types of features found on the earth's surface (land cover) and the human activity that is associated with them (land use). The land use and land cover is one of the principal tools for runoff and soil loss estimation. The land use and land cover data sets are generated from the digital image classification of LANDSAT, ETM + satellite image. The study area contains the following Land use /Land cover statistics (Table 3)

SL. No.	Land use & land cover	Area in (sq km)	Area (%)
1	Dense Forest	209.2517	11.56995845
2	Mixed Forest	229.5797	12.69393553
3	Agricultural land	611.0127	33.78415349
4	Agricultural Fallow	374.2039	20.6905061
5	Water body	42.3859	2.343603908
6	Dry land	204.5745	11.31134641
7	Lateritic exposure	85.3896	4.721367253
8	Built-up land	52.1798	2.885128856
	Total	**1808.5778**	**100**

Table 3: Details of land use / land cover statistics

Spatial modeling of surface runoff

The SCS model computes direct runoff (Fig. 11) through an empirical equation that required the rainfall and a watershed co-efficient as input. The watershed co-efficient is called the curve number (CN) which represents the runoff potential of different hydrological soil groups (Fig. 10). The SCS model involves relationships between land cover, hydrologic soil classes and curve number. Here the first equation is used to calculate the surface runoff for the upper part of the Dwarkeswar watershed.

$$\mathbf{Q = (P - Ia)^2 / (P - Ia + S)} \quad \text{- - - - - - - - - - - - (1)}$$

Where, **Q** is the actual surface runoff in mm.

P is the rainfall in mm.

Ia is 0.4*S

S is the storage capacity in mm which can be calculated using the equation 2

$$\mathbf{S = (25400/CN)-254} \quad \text{- - - - - - - - - - - - - - - - - (2)}$$

Where, **S** is the storage capacity in mm.

CN is the curve number.

Sl. No.	Land use & land cover	Hydrologic soil group	Curve number	Area (sq km)
1	Dense Forest	A	30	37.3424
		B	55	91.0408
		C	70	49.3252
		D	77	25.4444
2	Mixed Forest	A	36	56.1833
		B	60	97.6291
		C	73	47.2679
		D	79	15.8603
3	Agricultural land	A	95	137.5601
		B	95	276.6001
		C	95	125.5215
		D	95	68.2366
4	Agricultural Fallow	A	62	85.0929
		B	71	163.1999
		C	78	79.6434
		D	81	30.4763
5	Water body	A	100	9.67298
		B	100	21.2907
		C	100	8.21582
		D	100	4.18512
6	Dry land	A	74	44.9418
		B	83	112.5161
		C	88	46.4184
		D	90	21.2077
7	Lateritic exposure	A	68	19.583
		B	77	45.8632
		C	86	19.6824
		D	89	8.7854
8	Built-up land	A	77	10.8694
		B	86	30.6167
		C	91	10.2003
		D	92	8.10456
Total area in sq km				**1808.5778**
Weighted curve number				**79**

Table 4: Runoff curve Numbers for different land use / land cover and soil (AMC II)

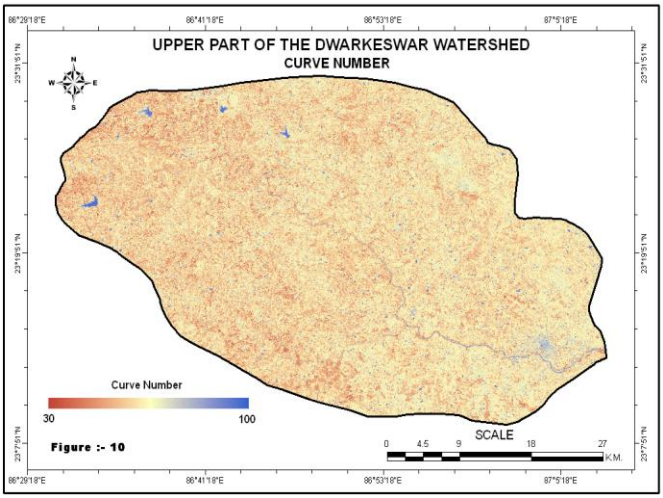


Fig. 10: Curve number

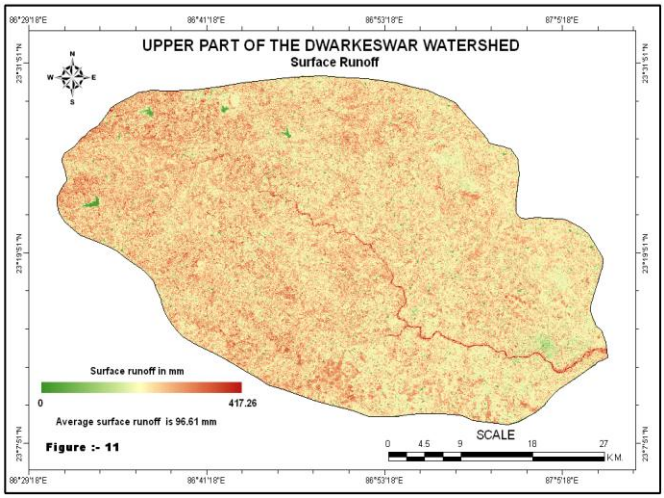


Fig. 11: Surface runoff

Spatial modeling of soil loss: Hydrologic calculation of soil loss for the upper part of the Dwarkeswar watershed is performed using revised universal soil loss equation (Renard, 1997); the total soil loss is measured for the upper part of the Dwarkeswar watershed. The revised universal soil loss equation (RUSLE) is—

A =R x K x LS x C x P …… (3)

Where,

A represents the potential long term average annual soil loss in tons per acre per year. This is the amount, which is compared to the "tolerable soil loss" limits.
R is the rainfall and runoff factor by geographic location.

K is the soil erodibility factor. It is the average soil loss in tons/acre per unit area for a particular soil in cultivated. **K** factor is calculated according to the soil texture type of the area, e.g. 0.24 for sandy clay, 0.32 for silty clay loam, 0.26 for silty clay, 0.20 for sandy clay loam, 0.30 for loam, 0.13 for sandy loam and 0.38 for silty loam.

LS is the slope length-gradient factor. The **LS** factor represents a ratio of soil loss under given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 72.6 feet. The steeper and longer the slope, the higher is the risk for erosion. The following equation is used to calculate the slope length-gradient factor.

LS= [0.065+0.0456(slope) +0.006541(slope) 2] x (slope length ÷ const) ^{NN}…… (4)

Where, slope is the percent of steepness (%), slope length is length of slope (ft.), constant is 22.1 and **NN** is 0.4 as slope is more or less 1%.

C is the crop/vegetation and management factor. The C Factor can be determined by selecting the crop type and tillage method that corresponds to the field and then multiplying these factors together. e.g. 0 for water, 0.002 for settlement, 0.004 for forest area, 0.050 for shrub land and grass cover land, 0.125 for agriculture and 0.5 for barren land.

P is the support practice factor. The P factor represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope e.g. value 0.60 for 0-7% , 0.70 for 7-14% , 0.80 for 14-21%, 0.90 for 21-28% and 1.0 for more than 28% of slope.

Results and discussion

The land use layer was superimposed with soil map and slope map to establish curve numbers under average antecedent moisture condition (AMC-II). The curve numbers for various land use classes were computed using standard tables available for the Indian conditions (Table 4). The weighted curve number for the watershed was calculated based. The weighted curve number for AMC II is found 79 for the total watershed area.

Land use/land cover, hydrologic soil characteristics, rainfall, curve number are used to estimate surface runoff by SCS model for the upper part of the Dwarkeswar watershed. There is a big amount of storm rainfall recorded as 503.36 mm, in the month of June, 2011. The above rainfall (503.36 mm) is introduced as an input in the SCS model and the result of this is about 417.26 mm surface runoff. In case of December, January and February the rainfall is very low so the estimated runoffs for these months are nil/ no runoff (Table 5). The calculated average surface runoff for entire study area is 96.61 mm which is almost 5.7 percent of the total storm rainfall.

Rainfall and runoff factor, soil erodibility factor, slope length and steepness factor, crop management factor and conservation practice factor are used to calculate the soil erosion in the watershed area following USLE model. Monthly and annual rainfall data, soil map of the region, DEM, RS techniques (with use of normalized difference vegetation index) and land use/land cover map are used for the estimation of runoff and soil loss as well. It is observed that the average soil loss of this watershed is about 2.24 tons/acre/year (Fig. 12)

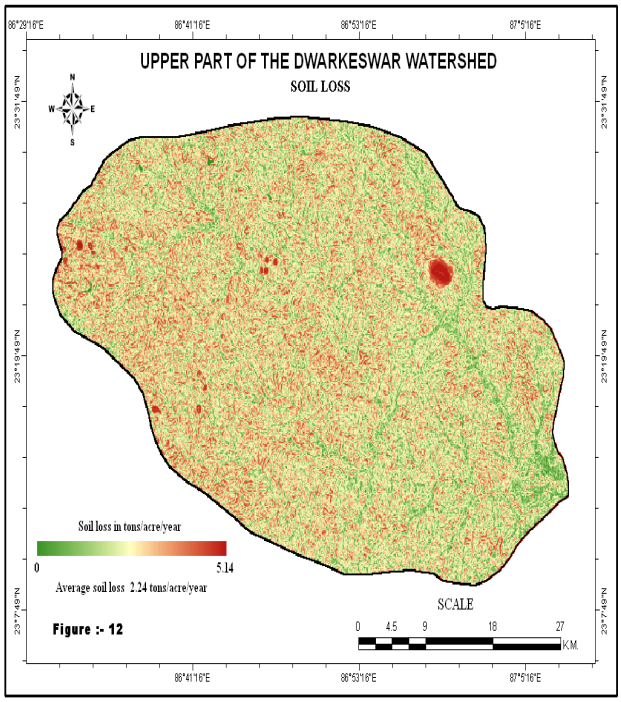


Fig. 12: Estimated soil loss due to erosion

Month	Rainfall (mm)	AMC	CN	S	Runoff (mm)
January	2.7	II	79	67.479	--
February	1.2	II	79	67.479	--
March	51.2	II	79	67.479	6.39
April	104.77	II	79	67.479	41.64
May	119.93	II	79	67.479	53.84
June	503.36	II	79	67.479	417.26
July	210.38	II	79	67.479	134.06
August	363.32	II	79	67.479	280.125
September	307.34	II	79	67.479	225.96
October	27.29	II	79	67.479	0.0123
November	4.05	II	79	67.479	--
December	0	II	79	67.479	0

Table 5: Estimation of runoff volume for the upper part of the Dwarkeswar watershed

Conclusion

Watershed is a basic unit for morphometric analysis and here some important morphometric parameters are also used to study the topographical and hydrological development. The spatial information on physiography, slope, present land use/land cover and soils derived through remote sensing and supportive data was utilized for estimation of runoff and soil loss using RUSLE model and integrated in GIS for the computation of quantitative soil loss. In this study, curve number is used as a model coefficient, which is determined by the factors based on land use/ land cover from classified LANDSAT image and soil groups for the estimation of runoff and associated soil loss as well. Moreover, this study shows that GIS and Remote Sensing based analysis offers an optimal method for runoff and soil loss estimation of an area in an effective and accurate manner. In this study, the methodology for determination of runoff, soil loss and spatial mapping are attempted for upper part of Dwarkeswar watershed using RS, GIS, RUSLE and SCS model. The results obtained helps to identify the areas prone to soil erosion in four categories namely severe, high, moderate and low. This approach could be applied in other watersheds or river basin for planning of various conservation measures.

Reference

1. Strahler, A.N. 1964: Quantitative Geomorphology of Drainage Basin and Channel Network, Handbook of Applied Hydrology: pp 39-76.

Slope Identification with GIS & Remote Sensing on a Part of Bundelkhand Plateau – A Micro Level Case Study of Central Sind Catchment

Dr. Prashasti Ashok, Prof. S. P. Singh, Prof. Dheer Singh & Shakti Saxena[1]
PDF-UGC, Dept. of Geology, Bundelkhand University, Jhansi
Email: drprashastisaxena@gmail.com, spsinghbu@rediffmail.com.

Abstract

The slope classification in central upper Sind catchment area of the Shivpuri district of granitic terrain of Bundelkhand with the incorporation of contour line on 10m interval in GIS and ERDAS Imagine environment using IMSD 1995 guidelines by NRSA has been carried out for slope analysis and determination of seven slope elements. The area has been identified because of its rain-fed condition where the source of water in the region is mainly based on Sind river catchment. The present study covers an area of 72879.83 ha and administratively it occupies 72 villages of Karera, Shivpuri and Narwar Tehsils of Shivpuri district around the newly constructed Mohini Dam on Sind River near Narayanpur and Siroha villages in Narwar tehsils. The highest elevation of the area is 440m and the lowest is 320m. The area is expanded between 25^0 $30'$ $00''$ N to 25^0 $45'$ $00''$ N latitudes and 77^0 $45'$ $00''$ E to 78^0 $00'$ $00''$ E longitudes on SOI Toposheet number 54G/14 on 1:50000 scale for micro level study. The slope and recharge aspect points and ground water potential zones parameters have been established for water harvesting in months of water scarcity. The analysis and incorporation of different thematic layers suggest major recharge at Akahi, Siroha, Sultanpur, Chulahi, Amarpura, Urwaha, Gopaliya and Panghata villages for better water resource harvesting conditions.

Introduction

Generation of contour map is the most common and oldest method for representing slope or terrain. The contour interval may vary from a few inches, or fractions to a feet, for detailed construction plans or very flat areas, to tens of meters for larger scale maps and more mountainous terrain. Contour plans may also incorporate spot elevations, especially at high points and low points, whose elevation would not otherwise be conveyed by the contours. These data-sets are often derived from spot elevations for existing terrain, or produced by landscape architects and engineers for new proposed surfaces. Contours may also be obtained from topographic maps, and other data sources. Contour lines are limited to representing surfaces which are continuous in two dimensions, in which no vertical, overhanging, undercut, or multilayered conditions can be adequately represented (except by confusing graphic techniques such as dotted lines, etc.) Consequently, especially for site scale design, cross-sectional drawings of terrain conditions are also often used. Contours are in fact themselves cross sections, taken horizontally; most other cross sections are taken vertically, at specified locations, to reveal a side-cut view. Terrain is rarely represented by real side views or elevations, because terrain usually has few or no vertical faces. The objectives of the study to generate the slope map for the demarcation of landforms and to suggest a sustainable land plan.

The study area

The study area exhibits between 25^0 $30'$ $00''$ N to 25^0 $45'$ $00''$ N latitudes and 77^0 $45'$ $00''$ E to 78^0 $00'$ $00''$ E longitudes on SOI Toposheet number 54G/14 (Ashok et al, 2004). It covers an area of 72879.83 ha and administratively it occupies 72 villages of Karera, Shivpuri and Narwar Tehsils of Shivpuri District around the newly constructed Mohini Dam on Sind River near Narayanpur and Siroha villages in Narwar tehsils (Fig. 1).

Material and method

The study is based on the interpretation of digital image of Sind River Catchment (Fig.1). The area is situated in district Shivpuri on Madhya bharat plateau. Primary data is based on Satellite imagery of the year 2005, intensive field survey and Ground truthing. ArcGIS, Arc map and Erdas Imagine software were used with digital image interpretation technique, analysis, classification and mapping of IRS P6 imagery. The base map was generated with the SOI Toposheet on 1:50000 scale. Following steps were adopted for generation of slope these are topology building, Georeferencing, Transformation, Root Mean Squire (RMS) Error check, Define Projection System, Creation of Geo-relational data base and generation of Aspect, TIN and slope layers.

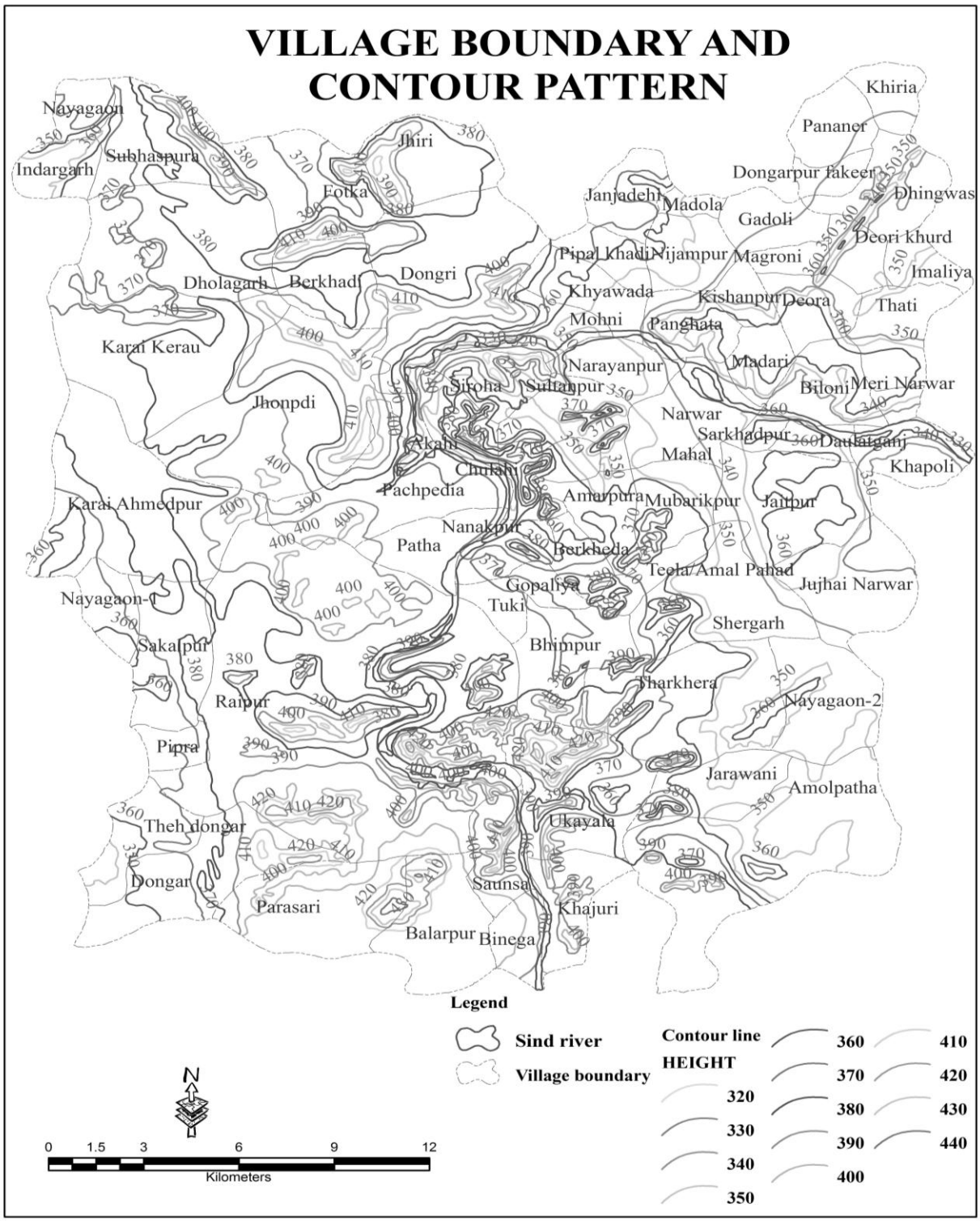


Fig. 1: Village boundary and contour map of Sind river catchment

Result and discussion

A. *Contours*

The contour lines were generated in arc-edit tools environment using large format digitizer (SG5). For the preparation of final contour map (Fig.1) and creation of attribute table (using Arc Map) the spot heights were also taken from the maps provided by Land Record office, Shivpuri and verified with Toposheet SOI. It is evident from the Fig. 1 that contour height ranges between 320 – 440m. The most undulating part of the region is south-central part because the contour lines are concentrated in south-central and central part of the study area. With the help of spot heights and IRS P6 imagery the contour interval was interpolated to 10meter interval. For the detailed study of the surface, the vector data related to contour was used for the generation of TIN (Fig. 2).

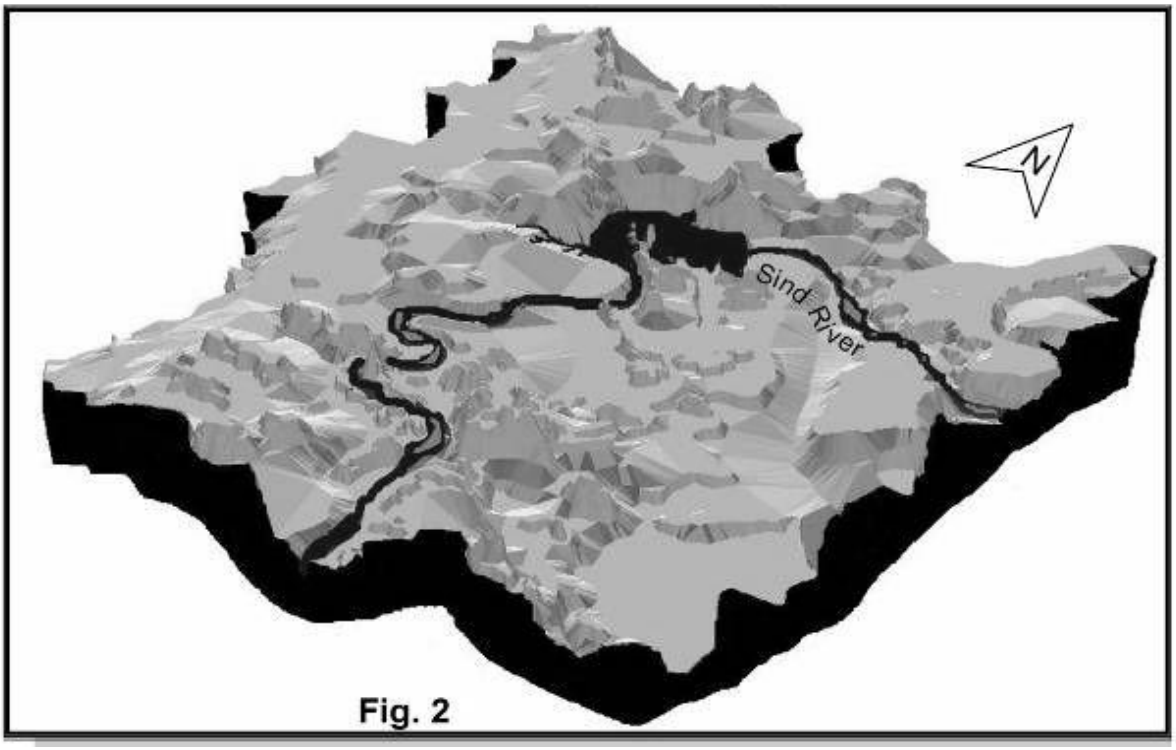


Fig. 2: Sind Catchment Triangulated Irregular Network Model

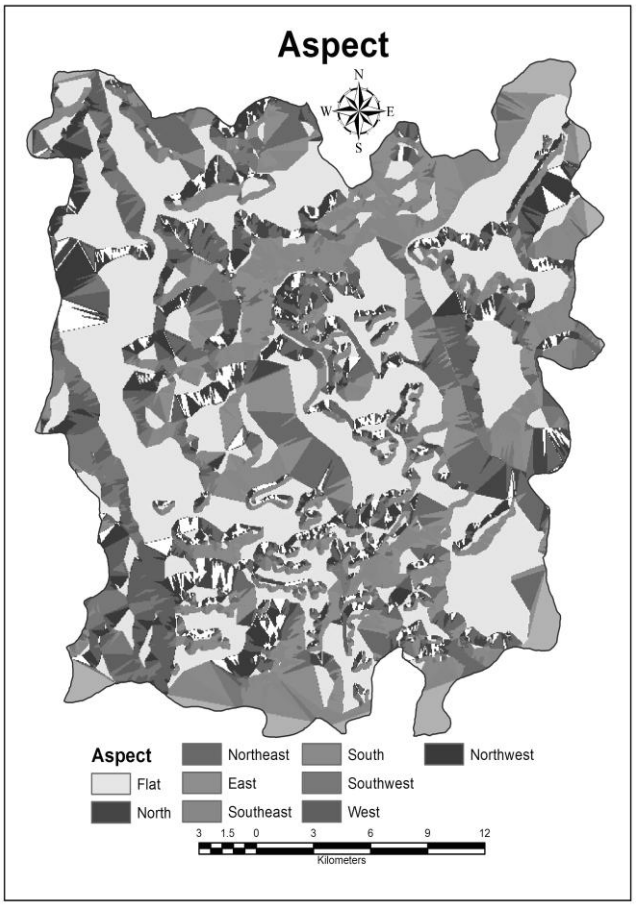


Fig. 3: Aspect: Direction of slope

The study of contour map (Fig. 1) of the region reveals that the central table land of the region was dissected by denudation processes specially running water and winds (Ravines area); Aspect map shows the general slope of the region was towards north-east (Fig. 3). The contour lines were concentrated in the southern part which shows the highest height and steep slope where as the gentle sloping plain of Karera and Narwar tehsils shows south to north and from west to north-east. The highest elevation (440 m) was recorded at Parasari hill in the region. The central table land of the region was dissected by river Sind from south to north at Mohini and again it tilted towards the east.

B. *Elevation*

The contour map (Fig. 1) was used for this study. The highest elevation (440 m) was recorded in the north-eastern part of the Balarpur village. Several hills varying from 380 m – 400 m were situated in the Raipur village where as 400-410 m elevated hills were situated in Jhopadi village. In the northern part of the study area, especially in the south and eastern part of the Fotka village, the height recorded above 400 m. The medium and low elevations were found in the eastern and western part of the study area. The medium and low elevations were found in the eastern and western part of the study area.

Local relief=max Zi-Min Zi (1)

Max Zi = the highest elevation value within a circle window defined radius around location i, and

Min Zi = the lowest elevation value within this window.

C. *Slope*

For the study of slope shapes 4 spots (A, B, C and D) were selected in the region situated in Dongari (*A*), Pachpedia (*B*), Parsari (*C*) and Raipur (*D*) villages. For the selection of sites three approaches viz., contour map, lattice map observation, ground truthing and field survey were adopted. Contour lines were transferred on lattice map to identify the convex and concave types of contour and associated slope shape. Based on the characteristics of the contour lines and extensive field survey, 13 slope elements were identified. The divergent and convergent nature of slopes are directly influenced the nature and amount of surface erosion (Ashok et al, 2011). The four slope categories were defined by their relative position in a top sequence between crests, depressions, flats and simple. The proposed algorithm identifies the slope elements

Average slope = $100(A^2+E^2)^{1/2}$

Ā=Average slope from west to east and diagonally through the centre cell

Ē= Average slope from east to west and diagonally through the centre cell

Based on this information 4 block diagrams were prepared showing the slope shape and surface flow lines. It was essential to generalize the slope types for the classification of landform units Evans, I.S., 1980.

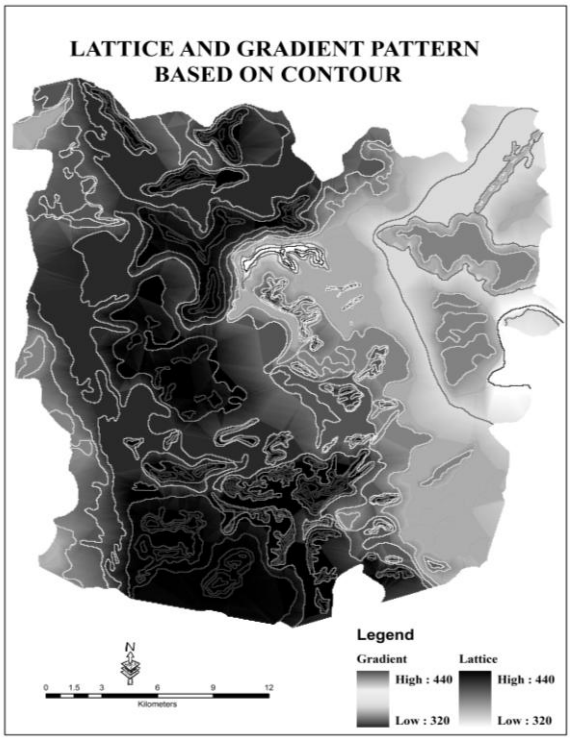


Fig. 4: Gradient and lattice map

The overlay analysis of aspect (Fig. 3), gradient (Fig. 4) and contour map, the slope has been classified into three major categories and thirteen slope elements (Table 1).

Table 1: Slope classes

Slope category	Slope element	Description
Steep slope	Crest	Level area in Upper slope
	Divergent shoulder	Convex upper, water shedding element
	Upper depression	Depression in upper slope position
Mid slope	Back slope	Mid-slope segment
	Divergent back slope	Ridge
	Convergent back slope	Through
	Terrace	Level mid-slope
	Saddle	Special case of a divergent foot slope
	Mid slope depression	Depression in mid slope position
Gentle slope	Foot slope	Concave, water receiving element
	Toe slope	Rectilinear in lower slope
	Level lower slope	Level in lower slope
	Depression	Concave element in lowest landform position

*Based on Macmillan and Pettapiece (2000) and IMSD 1995 guidelines by NRSA.

Conclusion

Based on the characteristics of the contour lines shown in the Fig. 5 and extensive field survey 7 major slope elements viz., divergent shoulder, convergent shoulder, divergent back slope, convergent back slope, divergent foot slope, convergent foot slope and gentle slope were identified. Fig. 5 and Table 1 represents the contour shapes found in the region and block diagrams related to these contours. The divergent and convergent nature of slopes are directly influenced the nature and amount of surface erosion. After the interpretation the four slope elements were defined by their relative position in a top sequence between crests, depressions or flats as:

1. *Steep slope*: slope element adjacent below a crest or flat but not adjacent above a flat or depression.
2. *Mid-slope*: slope element not adjacent below a crest or flat and not adjacent above a flat or depression.

3. *Gentle slope*: slope element, not adjacent below a crest or flat but adjacent above a flat to depression. Slope elements adjacent below a crest or flat and adjacent above a flat or depression were defined as Simple slope. The associated land elements and description of each class are presented in Table 1.

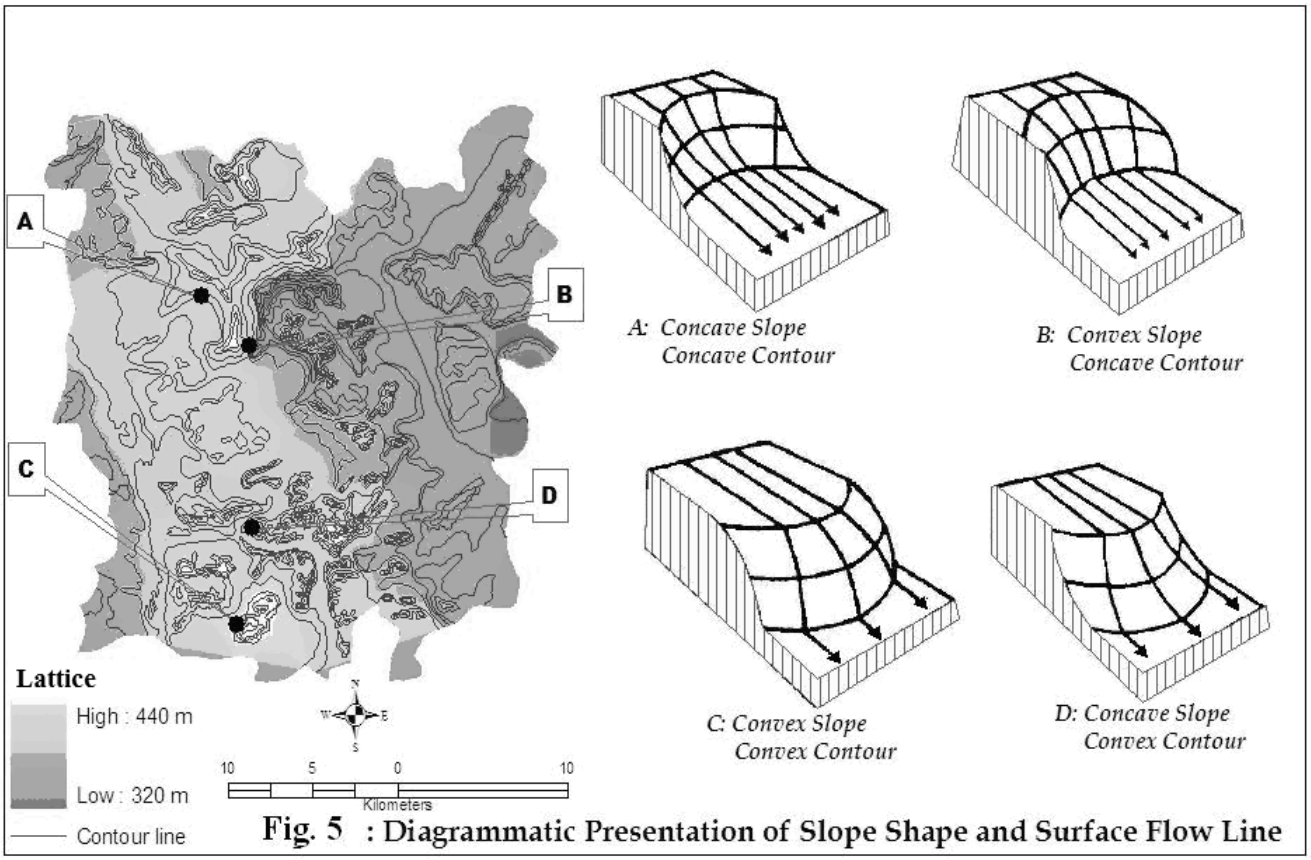


Fig. 5 : Diagrammatic Presentation of Slope Shape and Surface Flow Line

Acknowledgment

Dr. Prashasti Ashok thanks the **University Grant Commission** for Financial Support. A special thanks to National Informatics Centre Shivpuri for providing the statistical report of the concerned area.

References

1. Ashok P., Singh J.P. and Ekka N.S. 2004, "Application of satellite imagery and GIS in Land cover/Landuse monitoring and mapping in Central Sind Catchment", Indian National Cartographic Association, SOI, Hyderabad, pp 358-366.

2. Ashok Prashasti, Saxena Maneesh, Saxena Shakti, Singh Dheer (2011), "Landform Analysis and Classification with Geographic Information System & Remote Sensing - A micro level study," International Journal of Earth Sciences and Engineering, ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp 330-333.

3. Evans, I.S., 1980, an integrated system of terrain analysis and slope mapping. Zeitschrift fur Geomorphologies Supplement Band, 36, 274-295.

Urbanization and Size of Population in Burdwan City: A Cartographic Approach

Dr. Jitendra Shukla*, Debashree Roy **
*Assistant Professor, Dept. of Geography**
*Research Scholar***
Dept. of Geography
Ranchi University, Ranchi

Abstract

Urbanisation gained momentum in the nineteenth century following the industrial revolution and discovery of the steam engine. The era saw a phenomenal development of transport as well industrial production which provided employment to the rural surplus labour leading the concentration of people in settlements specializing in non primary production system. It has been estimated that before the start of the nineteenth century only 3 percent of the population lived in towns of over 5000 people. By 1950 the population rose to 28% and by 1970 the growth rate of urban population increased only marginally, but there after the decadal growth rate exhibited a sudden increase.

Urbanization and population growth are closely inter-correlated. In the last few decades, urbanization has become a powerful force throughout the world, especially in developing countries. The problem of accelerated growth of population in large urban centre has been compounded by entirely limited financial resource. This has a severe strain on their already week and inadequate basic infra structure, resulting in deterioration in all aspect of environment quality at the household, neighbourhood and city levels. There has been an accelerated growth of population in the Burdwan city. Phenomenal growth of population has extended the urban area. As per 2011 census, Burdwan urban agglomeration has a population of 347016, constituting 56% of the total population of the district. Burdwan Sadar north consists of two municipalities and six Community Development (CD) blocks and Burdwan south has six CD blocks. The phenomenal growth of population in the city has led to the rapid urbanization. The present paper is the highlight of urbanization and population status of the city through the cartographic approach.

Introduction

Urbanization Refers to a process of transformation particularly in the size and dynamics of population. Urbanization and population growth and size are closely inter correlated and hence there is fore front of researching social sciences. Most of the nations of the world has energized there in industrial growth network of transport and communicational growth, educational and cultural growth. All this has attracted more population to resident a concentrated conditional. Presently urbanization is most important powerful Socio-economic component of modernity. The current era is regarded as metropolitan civilization based on Industrial and multi-national commercial development.

Urbanization is regarded as the proportion of urban population to the total population residing in urban places. In other words the urbanisation can attributed with shift of population from village to city or transformation of villages into small towns. The Riesman interprets urbanization a whole process of changes and its consequences when a society gets transform from an aggrient economy and a small homogonous society to a large heterogonous mass (Reissman, 1964). Carter 1979 visualizes to the mortification point of concentration and to an increase in the size of individual concentration both of which far reaching implication in terms of special interaction.

Burdwan city is the historical importance where phenomenal growth of population has led to the rapid urbanization. The most significant factor behind the growth of urbanization and its impact on structure and growth of population is the regional business centre, well connected network, district headquarter and industrial development. Presently, the total population of the city has reached 347016, which is 56% of total district's population.

Study Area

Burdwan City 87°51'39"E and 23°14'18"N is the district head quarters, situated on both Banka river and the Damodar river flows nearby. The east of the city is Monteswar; Memari district west of the city is Khandaghosh district and north of the city is Bhatar district &south of the city is Raina district. City was known for the 'Bardhhaman Raj.' Later on during the Mughal Empire the city came into existence on the map of Burdhaman estate.

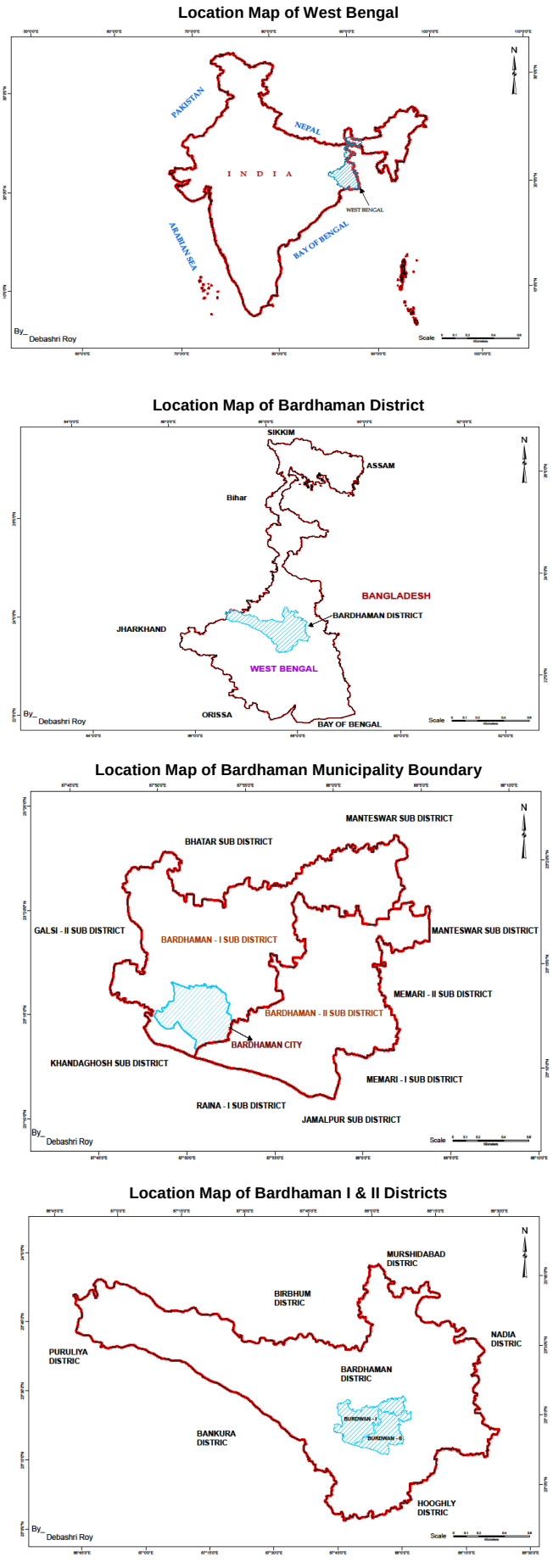
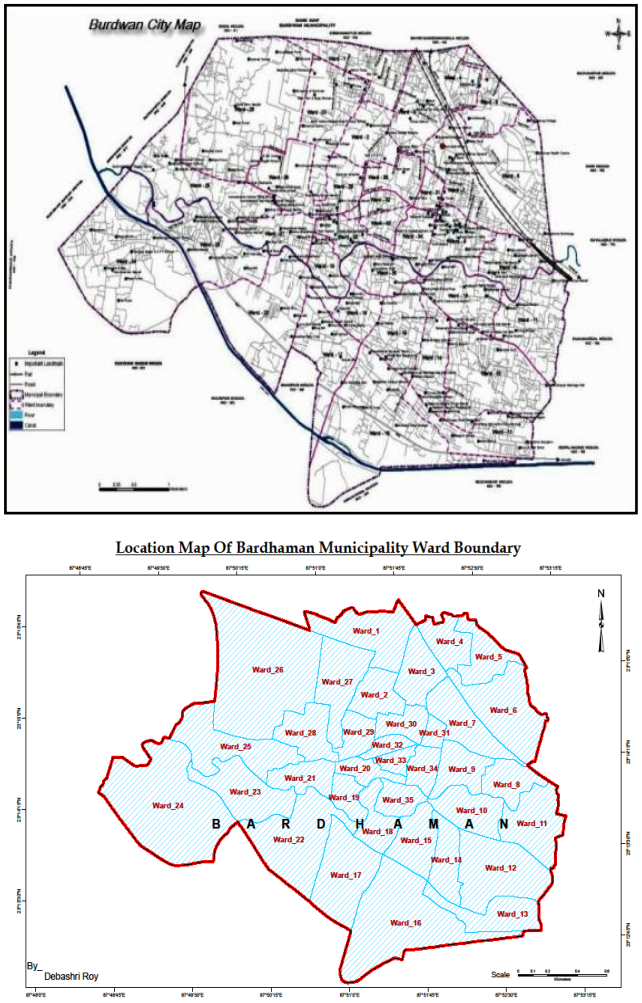


Fig. 1: Location Map of Study Area

Burdwan City

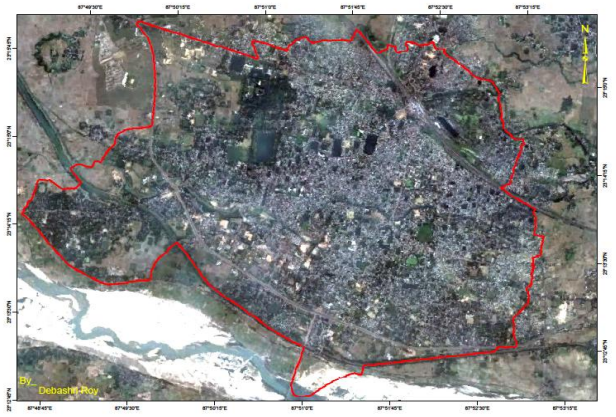
It is a historical city and population is growing in the city from the very beginnings In 2011 census, Burdwan urban agglomeration had a population of 347016 constituting 56% of the total geographical area of Burdwan city constitutes 28.79 sq.km i.e. 0.40% of the total area of the district. The city of Burdwan consists of 35 wards. The total length of the railway of the city is18.94 sq.km. The main road, Grand Trunk road is 14.77 sq.km in length. The length of the NH2 road is 9.28 sq.km and the length of NH2B which is from Kolkata to Berhampur is 0.15 sq.km the length of SH7 is 3.31 sq.km the road which is covered the whole city is called B.C road (2.53 sq.km). Hence, there is another road also as Sarat Palli road (0.54 sq.km), Mithapukur road (0.72 sq.km), Khosbagan road (1.21 sq.km) etc.

Fig. 2: Bardwan City and Municipality ward Boundaries.



The forest area of Burdwan city is 2.16 sq.km which is the 1.02% of the district forest covered area. The open area of the city is 5.14 sq.km and the area of pond 2.16 sq.km in the city .The area of the park of the city is 0.53 sq.km. The length of Banka River is 0.24 sq.km and the agricultural land is 1.90 sq.km in the city. The total residential area is 16.68 sq. km in the city.

Bardhaman Municipality Boundary With Satellite Image



Objective of the Investigation

The present research is concerned with urbanization

and size of population and also to identify the problems created by population and suggestion to overcome these. Urbanization has also assumed a new dimension in Burdwan city. The main objective of the research has been outlined under

1) To limelight the problems related to the population growth, pressure on household, inadequacy of water supply, insanitation and health problem.

2) To bring into limelight pressure of population on the existing land-use.

3) To make a plan for the improvement and development of the problems.

4) To limelight the socio economic relevance of the impact of urbanization on the growth and structure of population and the problems associated with it.

5) To bring in to the limelight the problems created due to impact of urbanization on the growth and structure of population of Burdwan city.

Data Base and Methodology

The present research paper is based on the census data of different census years as well as data acquired by the local authority like B.M.C. District statistical Hand Books, D.M. office, urban Planning Office as well as the personal field works collection. G.L.S. tool will be also deployed for acquiring data relevant to the topic.

Urbanization is the result of continuous population growth. Urbanization and thus it is result of urban population growth. Volume and size of any city largely depends on its population size that exists on different part of the city. In the present study of urbanization and its impact on population growth and structure of Burdwan city an attempt will be made to evaluate the various aspect of measurement of degree of urbanization and various aspect of population and demographic properties. Degree of urbanization will be obtained by the various population measures. Different parameters of population and demographic scale are helpful in the degree of urbanization.

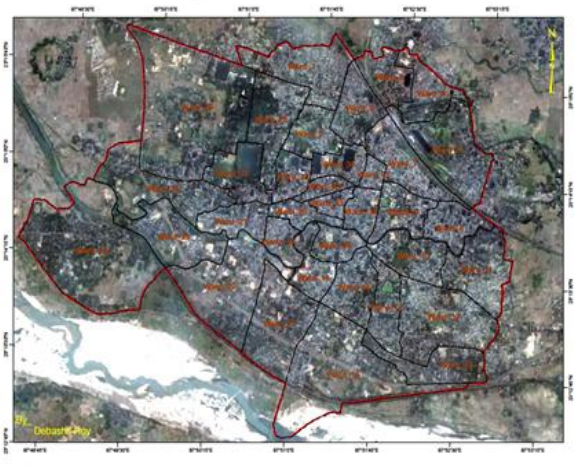
Pattern and growth of urbanization will be analyses after correlating the variables of urban parameters and various population aspect of Burdwan city.

Analysis

Urbanization and population growth are the closely intercorrelated. Urbanization has been estimated that before the start of the 19th century only 3% of the population lived in towns of over 5000 people. It has been suggested that while the whole world becomes predominant urban 2000&2001, the developing world become predominantly urban 2015.

Burdwan is a district city which was a town before few years ago. The total population of the city according to 2011 census is 314638 which is the 56% of the total population of district. According to 2001 census total population of the city is 285602 and the total population of the city is 245079 (1991census). From 2001to 2011 the growth rate of the city is 10.16% whether the district growth rate is 13.96%. According 2011 census it had a population 160631 male and 154007 female the sex-ratio of the city is 959 per 1000. Among the total population (314638) the literate's 26, 0564 in which male are 13, 8067 and female are 122497. The average literality of the city is 89.07% in which male are 92.52% and the female are 85.48%. The total population of the city (2011census) is 0.34% of the West Bengal. Burdwan has the 5th rank of the populated city in West Bengal. The population of the city is 1196 per sq.km.

Bardhaman Municipality Ward Boundary With Satellite Image



The growth rate of Burdwan city is very high for the following points.

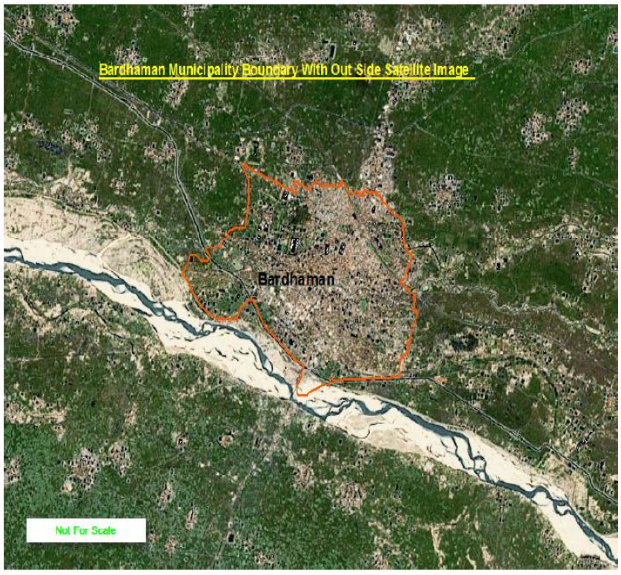
1) In an urban centre, the increase in functional units is closely related with the growth of urban population
2) The increase in infrastructure facilities like the development of roads, railways and communication etc. the causes of development.
3) Burdwan is the agriculture based city. Many rice mills are situated here. Major people's life style is not high. The cost of living of the people is very cheap than the other city of the district. So the urbanization rate is very high.

Problems and Prospects

The rapid and random expansion of urban centers along their periphery is a typical phenomenon of urban landscape in Burdwan city .The population growth has created and unplanned and imbalanced growth of Burdwan city and its environs. The greatest change in the city and its environs is a result of growth itself. Urbanization has also assumed a new dimension in the Burdwan city .It has drastically created complexities in the existing pattern of land-use. The rapid increase in population was to sudden for the city to accommodate and provide urban services like dirking water, sanitation, education, health, transportation etc. The problem of accelerated growth of population in large urban centre has been compounded by entirely limited financial resources of the developing countries.

This has put a severe strain on their already week and inadequate basic infrastructure, resulting in deterioration in all aspect of environmental quality at the household neighborhood and city levels. They manifest themselves in limited and unequal access to civic needs, such as appropriate, sanitary toilets, safe water, sewerage and solid water disposal systems which is inevitably creates health hazards.

Burdwan is a historical city and population is growing in the city from very beginning. The educational and health services of the city are popular in the district. The essential commodities are cheap than other cities of the district. There is no burden of religious pressure on the people of Burdwan city. There are various temples, tombs, churches (Sarbanmongla temple,108 Shiv temple, Bardhameneswar, Kankaleshari temple and Pirbaharam, Nawabhat Mosjid and Burdwan church etc) are the also tourist spots. The another tourist spots are Curzon gate, Golapbag, Rajbati, Krishnasayar park and Romnabagan etc. are very popular to tourist also. Various hotels and restraints are also helps in urbanization in Burdwan city the people of the other district also come to the Burdwan city for marketing for the cheap rate of goods. The daily commuters are chosen to live in the city for its cheap rate of lively hood. So the city's urbanization and its size of population will be very high in coming days also.



Conclusion

The present research is highly beneficial and relevant for the development and planning of the city. A detail analysis of impact of urbanization (urban population growth and structure) and problem related to it is highly beneficial, relevant to the present day problem and need of the society. The pressure of population on urban land is very high. Burdwan is an old city and accelerated population growth has created various environmental issues.

Detailed survey and observation of the impact of urbanization on size of population growth and structure on Burdwan city is to be studied and measures to sort out the problem will be produced.

This research work will contribute a significant role for the urban development as well as for development of various urban issues. The present research is highly beneficial and relevant for the development and planning of the city.

I assume, the present research will be helpful in improving the standard of living of the city's people and a planned development of the city may also be achieved. This will help the planning development of the city. Proper development of the city and betterment of city population the need of the present day society.

Development of Land Based Mobile Mapping System

[1]Salil Goel, [2]Manohar Yadav, [3]Anjani Kumar Singh, [4]Bharat Lohani

Geoinformatics Laboratory, Department of Civil Engineering, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh, India
E-mail: [1]goel.salilg@gmail.com,[2]ssmyadav@gmail.com, [3]anjanisin@gmail.com, [4]blohani@iitk.ac.in

Abstract

To keep up with the increasing demand for 3D data, it is required to develop technology which allows capturing large volumes of data with least investment. Mobile Mapping Systems (MMS) is one such system but such a system cannot be used very frequently because of the large amount of monetary investment involved. The high cost of MMS is attributed mainly to the lack of technical expertise in integrating different technologies and developing software required for processing the captured data and taxes imposed by the government on procuring the system from abroad. Developing this system indigenously would bring down the costs to a large extent. This paper attempts to integrate navigation and mapping sensors to develop a land based mobile mapping system and develop algorithms and software for processing the data. The sensors integrated in MMS include a GPS, IMU and a Laser scanner. GPS/IMU integration provides position and orientation information of the sensors. A software based synchronization system was developed for synchronizing the sensors. The algorithms and software for calibration and processing are developed in MATLAB. A simulation software package was also developed to verify and understand the equations. Field tests were performed using the developed MMS. Results indicate the successful development of a land based Mobile Mapping System

Introduction

The increasing demand for large scale data acquisition with minimal effort and minimal time has led to the development of mobile mapping systems. Conventional methods such as aerial photogrammetry, terrestrial surveying using total station, GPS surveying etc. were used to acquire such data. Acquiring data using terrestrial surveying with total station and GPS is labour intensive and time consuming while in aerial surveying features like electric poles, sign boards are not visible properly from the altitude. Mobile mapping system which is equipped with mapping and navigation sensors is capable of acquiring three dimensional data (including features like electric poles) serves as a better tool for capturing large amount of data in a short time span.

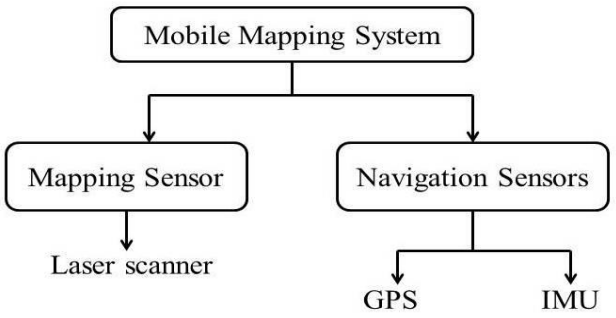


Fig. 1: Components of a hybrid land based mobile mapping system.

Some of the applications of mobile mapping system are listed as follows:

- Highway applications like Traffic sign inventory, Road surface condition inspection, Monitoring of encroachments, Highway mapping etc.
- Railway applications like minimum road clearance.
- Mapping of areas in and around the airports.
- Generation of 3D maps which are becoming quite useful and has various applications.

A. Mobile mapping systems

Some of the mobile mapping systems have been developed across the world. The first land based mobile mapping system was developed by Ohio state university in 1991. It was called GPSVAN [1] and was integrated with a GPS receiver, two CCD cameras and several dead reckoning sensors. University of Calgary developed another such system called VISAT [2] which consisted of INS, GPS receivers and a cluster of CCD cameras. GEOMOBIL [3] is another such Mobile Mapping System comprising of IMU, two set of GPS antenna-receivers, DMI (Distance Measurement Indicator). Software called POSPac was also developed for processing GPS data and integrating GPS solution with observation of the other sensors. ICC (Cartographic Institute of Catalonia) has developed its own mobile mapping system called GEOVAN [4] consisting of a pair of digital cameras, orientation subsystem based on GPS/INS integration, synchronization subsystem and control subsystem. STREETMAPPER [5] is another Mobile Mapping System which uses four Riegl 2D laser scanner integrated with a GPS/INS system. [6] provides a detailed history of the developments of Mobile

Mapping Systems along with the theory behind georeferencing. Though many mobile mapping systems have been developed all over the world, literature shows no such attempt has been made in India and therefore, there is a need and scope of a mobile mapping system to be developed in India.

B. Need of development of MMS in India

Many mobile mapping systems have been developed across various countries and procuring this technology from abroad is very costly. Roughly, the cost of such a system is about Rs 4 crores and procuring the system would be even costlier because of the imposed taxes. The major portion of this high cost of the system is mostly due to calibration, computation models used and the associated software. Developing a mobile mapping system indigenously would be much cheaper. Also, the software for each of the system varies and there is no standard software available and hence there is no possibility of customizing the procured mobile mapping system to meet the local needs. This technology once developed can be improved upon further by adding better equipments and India being a fast growing economy would need such technology in the coming days so as to cater to the demands of good quality data which need to be obtained by investing least amount of time and resources. In view of above, the development of mobile mapping system should be carried out in India.

Methodology

This section explains the method adopted for developing the mobile mapping system.

C. Simulation

Simulators were developed so as to validate the equations needed for the development of complete system. The simulators could also be used to study the effect of errors in the system.

1) Laser scanner simulation

Laser scanner simulation was performed so as to simulate raw laser range first and then geolocated laser footprints. Furthermore, effect of errors introduced by instruments and calibration parameters in geolocated laser footprints can be estimated beforehand. Simulated laser data is used to check the performance of the algorithms being developed. Furthermore, comparison of simulated data and ground truth enabled the optimization of the system parameters during the development of MMS. Sensor equation (Eq. 2) and equation for computing intersection point of simulated terrain model (given by Eq. 1) and striking laser beam on the terrain form the basis of laser scanner simulation.

$$Z = (X, Y) \quad (1)$$

Sensor equation used for transforming laser footprints in local orthogonal coordinate system (origin in the project area) is given by:

$$\eta_{local} = \eta_{fp} \times R_z(\eta) \times R_{las}^{IMU} \times T_{las}^{GPS} \times M_{IMU}^{local} \quad (2)$$

Where,

$$M_{IMU}^{local} = R_{IMU}^{tangential} \times R_{tangential}^{local} \times T_{GPS}^{local} \quad (3)$$

And

$$\eta_{local} = [X_{local}, Y_{local}, Z_{local}] \quad (4)$$

$$\eta_{fp} = [0, l_{range}, 0] \quad (5)$$

Where, η_{local} is the vector of laser footprint in local system. η and l_{range} are scan angle and laser range.

R_{las}^{IMU}, $R_{IMU}^{tangential}$ and $R_{tangential}^{local}$ are the rotation matrices from the instrument reference system (origin at scanner bolt hole) to IMU body coordinate system, IMU to earth tangential reference system (origin at phase centre of GPS antenna) and GPS to local defined orthogonal coordinate system. Here GPS measurements adopt local reference system. The matrices T_{las}^{GPS} and T_{GPS}^{local} are translation matrices from laser scanner bolt hole to the phase centre of GPS antenna in IMU body coordinate system and GPS to origin of local defined orthogonal coordinate system.

Algorithms for simulating scanning patterns for rotation and oscillating mirror type scanners, trajectory and calibration parameters have been developed.

Using these simulated parameters and sensor equation, the vector η_{local} is computed. This vector is in terms of variable laser range. Coordinate of vector η_{local} (Equation 4) satisfy the terrain defined by Equation 1 and gives new Equation 6.

$$Z_{local} = f(X_{local}, Y_{local}) \quad (6)$$

By solving equation (6), true laser range is obtained, further by performing back substitution in the sensor equation we get true simulated laser footprint.

Real simulated footprint $\eta_{localerror}$ is derived by adding the sensors error and sensor integration errors in sensor equation. Final propagated errors in the geolocation process are given by

$$\delta\eta_{error} = \eta_{localerror} - \eta_{local} \quad (7)$$

In the equations described above R_A^B and T_A^B denotes a rotation and translation matrix which performs a

rotation and translation from 'A' coordinate system to 'B' coordinate system. These matrices are of the dimensions 4x4. The notation lfp denote the right handed orthogonal coordinate system in which Y-axis is towards the laser range and X-axis towards right side if the observed is pointing to the laser beam when looking from the scanner side. The notations las, IMU, GPS and $local$ denote laser scanner, IMU body, earth tangential and local defined orthogonal right handed coordinate system respectively.

D. System design

All the sensors are to be mounted on top of the vehicle using a mounting platform. The components used in the development of mobile mapping system are described here. The mounting platform parameters (angles and the heights at which the sensors are to be mounted), Kalman filter design for navigation solution are derived in this section.

The different hardware components used in the development of mobile mapping system are as follows: -

- ILRIS 3D optech laser scanner
- Microstrain 3DM-GX1
- Trimble R3 GPS receiver
- Two laptops
- External Batteries for powering Microstrain and laptops.
- Wires and accessories.

1) Design for laser scanner

The mobile mapping system is to be designed to scan the road and road side features and hence the scanner is to be tilted downwards by an angle θ. The angles and heights at which the sensors are to be mounted are computed as follows.

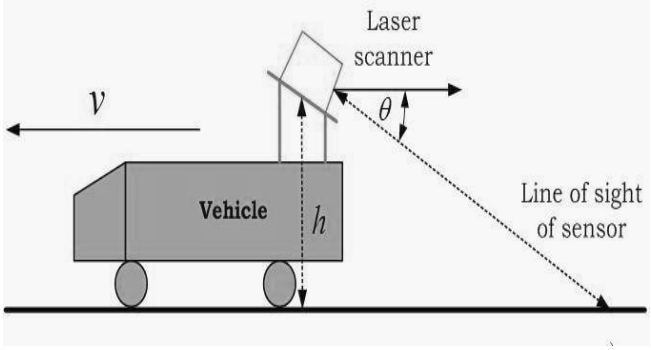


Fig. 2: Side view of proposed land based mobile mapping system.

In the figures (3) and (4):

- B is the point where the laser scanner is mounted (on top of the vehicle).
- FG = W, is the swath covered by the laser scanner.
- OY is directly above the road boundary and OX is the line perpendicular to OY.
- OA makes an angle with OX. Note that YOX is at the same height as the point B.
- "d" is the horizontal distance of the point B from the road boundary.
- Vehicle is moving along the direction YO at a speed "v".

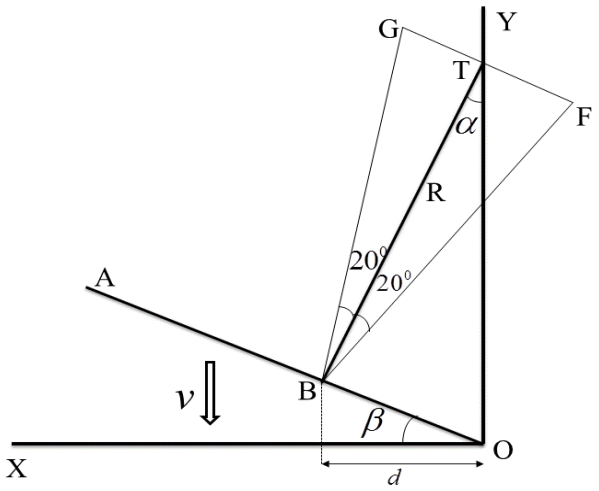


Fig. 3: Top view of land based mobile mapping system. The laser scanner is mounted at point 'B'.

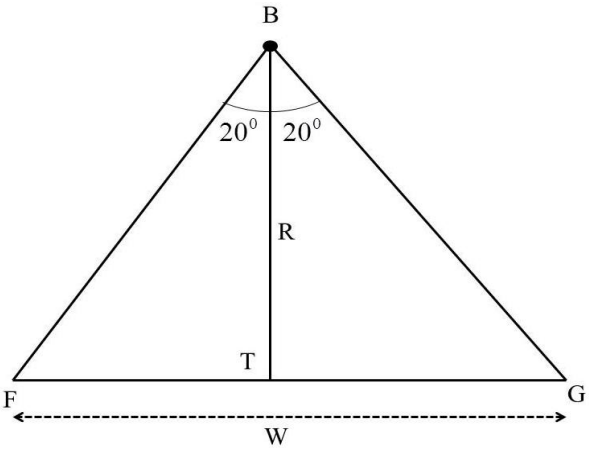


Fig. 4: Back view of land based mobile mapping system. The vehicle is moving in a direction going inwards i.e. inside the page.

Using the figures shown, following equations can be obtained:

$$\sin(\beta)\cos(\theta) = \sin(\alpha) \tag{8}$$

$$\tan(\alpha) = \frac{d \times \sec(\beta)}{R} \tag{9}$$

$$\frac{h}{R} = \sin(\theta) \tag{10}$$

$$\frac{W}{2R} = \tan\left(20^0\right) \quad (11)$$

Solving Equations 8, 9 and 10 for α and β using chosen desired parameters values gives (i) For $\theta = 20^0$, $h = 2.5m$ and $d = 1m$, we obtain $\alpha = 7.87^0$ and $\beta = 8.39^0$. Equation 11 gives swath covered by the laser scanner.

A large number of values were tried for these equations but the above set of values seemed feasible for the given hardware and the various constraints imposed in the implementation of the project.

E. System fabrication

The sensors are fixed on the vehicle along with all the connections. Figures 5 and 6 show the developed and based mobile mapping system.

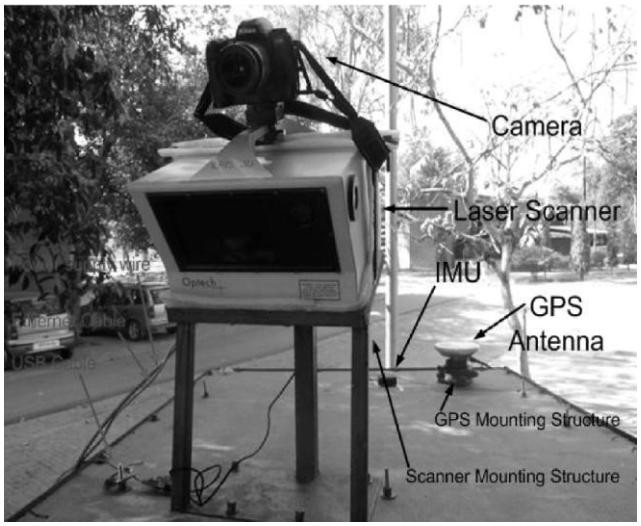


Fig. 5: Sensors mounted on the top of vehicle using various types of mounting mechanisms.



Fig. 6: Complete (developed) land based mobile mapping system along with the vehicle.

F. System calibration

After calibration of individual sensors, the system is assembled and the next step is to perform system calibration. System calibration involves:

- Determination of offset vector i.e. GPS vector from GPS to other sensors like laser scanner.
- Determination of bore sight values i.e. orientation of sensors (laser scanner) with respect to IMU body coordinate system.

Sensor equation for geolocating laser footprints form the basis of the determination of offset vector and bore sight values. These calibration parameters have been computed using mixed adjustment model of least squares approach. Observations and parameters in mixed adjustment model are related in an implicit way. The so developed mathematical model using sensor equation is given as:-

$$F_i(l_a, c_a) = r_{global}(i) - r_{las}(i) \times R_{las}^{IMU} \times T_{las}^{GPS} \times M_{IMU}^{global} \quad (12)$$

Where

$$F_i(l_a, c_a) = 0$$

$$M_{IMU}^{global} = R_{IMU}^{tangential} \times R_{tangential}^{global} \times T_{GPS}^{global}$$

$$T_{GPS}^{global} = T(X_{GPS}, Y_{GPS}, Z_{GPS})$$

The vector $r_{global}(i)$ refers to the control point (corner point) on the stationary metal frame (see fig 7(a)).

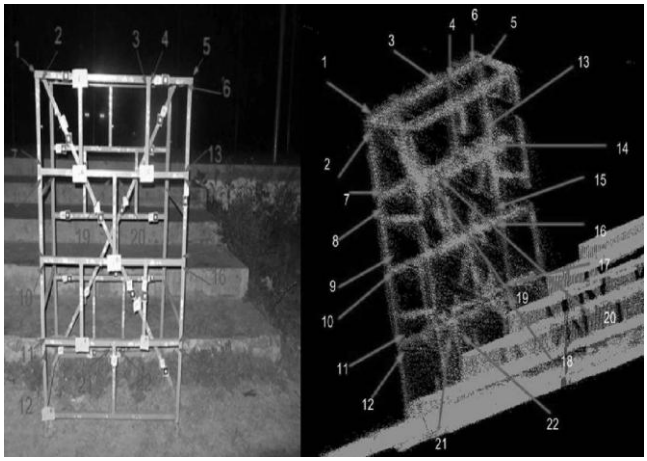


Fig. 7: (a) Showing (left) the metal frame used for the calibration. Corner points were used as control points which were identified using total station. Principle of triangulation was used to locate these points. (b) Showing (right) the scanned point cloud of the same metal frame. The corners can be easily identified in this point cloud.

The location of the control point was computed by total station in WGS84-Universal Transverse Mercator (UTM) geographic coordinate system. $r_{las}(i)$

also refers to the same control point on the scanned metal frame (see Fig. 7(b)), in laser scanner reference system. The metal frame was scanned by 3D laser scanner (mounted on the vehicle) in 3D mode while the vehicle was stationary. Furthermore, observations were also recorded by both IMU and GPS, which were mounted on the vehicle. IMU and GPS observations were required to establish relationships among UTM, IMU body and Earth Tangential coordinate system. The position of the vehicle was given by the GPS mounted on the vehicle. All these observations i.e. position and orientation information were used as observation vector 'l' in the mixed adjustment model.

Rotation and translation matrices containing bore sight values and offset vector are given as:-

$$R_{las}^{IMU} = R_x(\alpha_0) \times R_y(\beta_0) \times R_z(\gamma_0)$$

$$T_{las}^{GPS} = T(dx, dy, dz)$$

$$offsetvector = [dx, dy, dz]$$

The offset vector and bore-sight values $(\alpha_0, \beta_0, \gamma_0)$ are used as parameter vector 'c' in the developed mixed adjustment model. Finally, fundamental equations of mixed adjustment model and equations described in this section were used for developing software package. This software gives adjusted calibration parameter vector 'c_a' as the output. The notations '*i*' and '*a*' indicate the location of control points on the metal frame and adjusted calibration parameters respectively.

A. Test field, data collection and processing

The chosen test field is a small area inside IIT Kanpur which is relatively free from overhead obstructions like trees which might obstruct GPS signals and has identifiable features like boundary wall etc. The field is a small portion of the road and is about 200m long.

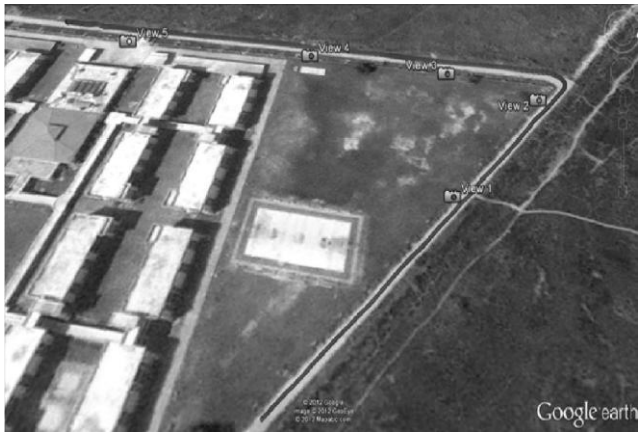


Fig. 8: Google earth image of the test field. The line shows the vehicle trajectory obtained by GPS-INS integration.

The developed mobile mapping system was operated in the test field. Differential GPS was used for measuring the trajectory using data of base station located at a point inside IIT campus. GPS used in this project was a single frequency GPS and hence an initialization time of about 20 minutes was provided during which the vehicle on which the GPS is mounted, is kept stationary. The vehicle was driven at speed of 5 km/hr near the road boundaries, so as to capture the road as well the features alongside the road. Vehicle speed was chosen as 5 km/hr so as to have a uniform laser data density allowing for a better feature identification. While the vehicle is moving, laser scanner is scanning the area and storing in the laptop's hard disk, the PRF is noted down from the scanner display screen before starting the vehicle and at regular intervals, IMU is capturing data at 50 Hz and storing it in another laptop's hard disk, GPS is collecting data at 1 Hz and storing in the controller.

1) Processing

Collected data was processed for getting the georeferenced, laser point cloud of the scanned test field. For getting the complete navigation solution, INS angular rate and acceleration data should be continuously integrated. This requires initial knowledge of orientation known as alignment. However, the initial angles provided by the available IMU were used as alignment. 1Hz GPS and 50Hz IMU data were used in developed Kalman filter to compute the vehicle trajectory and orientation at 50Hz. Software based approach was followed for time synchronization of navigation and laser data at PFR rate. This synchronized data along with the calibration parameters when fused in the sensor equation give the geolocated laser footprints. Once the trajectory and orientation of the vehicle is obtained, laser foot prints can be calculated. The output of this developed software is a point cloud having X, Y and Z coordinates. The whole process was realized by the software packages designed in MATLAB.

Results and Discussion

Different stages of data processing through designed algorithms gave promising results. GPS/INS integration resulted in to vehicle trajectory which is shown by the line in Fig. 8. Laser point cloud is displayed by assigning a color to laser points based on their elevation. The images shown below are the zoomed in views of the selected area segments from the scanned test field.



Fig. 9: Screenshot of laser point cloud (left) obtained from the developed land based mobile mapping system along with the corresponding digital image (bottom right) of the same location.

Boundary wall, bushes, road and low height trees can be clearly seen in the image as well the laser data, as shown in Fig. 9. In the Fig. 11, part of the road and bushes alongside it can be easily identified. It is observed that the straight railing in the digital images appears to be wavy in the scanned point cloud. This behavior is due to poor quality IMU used in the project. Entrance and part of the security check post can be seen in the Fig. 12. The associated image taken with a hand held digital camera is also attached.

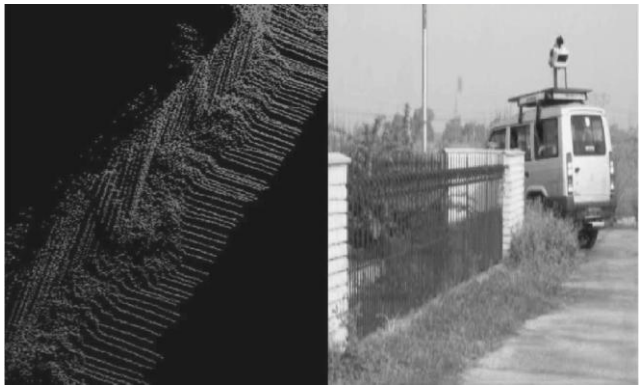


Fig. 10: Obtained point cloud (left) and digital image of the corresponding area (right).



Fig. 11: Obtained point cloud (Top left and bottom left) and digital image of corresponding area (top right and bottom right). Features such as road, bushes, elevated side platform are clearly visible.



Fig. 12: Obtained point cloud (left) and digital image of corresponding area (right). Features like wall of security check post, road etc. are clearly visible.

By comparing the geometry obtained by the laser data with the geometry visible in the corresponding digital image, the validity of the equations can be checked. Comparison of the digital image and laser data shows promising results where common features are visible and identifiable in both the digital image and point cloud.

Conclusion and Future work

The paper covers different stages of development of a land based Mobile Mapping System (MMS) using terrestrial laser scanner. The methodology and involved critical equations for the complete MMS development are described, including the simulator, mounting platform designing, system calibration, software based time synchronization subsystem and the soft-ware packages for data processing. GPS and INS data synchronization is done in post processing mode. This data is used as input in Kalman filter, which is used to perform the computations of the trajectory at decimeter accuracy. The testing of the land based MMS using laser scanner has given promising results. Some errors like the waviness of a straight wall, undulations in the flat road were observed. Unavailability of a good quality IMU was the cause of such errors and these errors can be eliminated or minimized by using better quality IMU and sensors. Though no statistical methods were used to evaluate the accuracy of the developed MMS, visually comparing the laser data with image shows promising results. The scope for improvement in the developed system can be grouped under the following categories:

- System integration enhancement by using better and compatible sensors.

- Designing of a stable mounting platform.
- Development of robust hardware based synchronization subsystem.

All the software is developed in MATLAB which is limiting the performance of the software. The performance of this software can be enhanced greatly if they are developed using the standard software development methodology.

Acknowledgement

The authors would like to thank Geoinformatics Laboratory, IIT Kanpur and Geokno India Private Limited for assisting in carrying out the field experiments.

References

1. C. C. Goad, “The ohio state university mapping system: the positioning component,” in Proceedings of the 47th Annual Meeting, The Institute of Navigation (ION), June 10-12 1991.

2. N. El-Sheimy, “The development of VISAT: a mobile survey system for GIS applications.” Ph.D. dissertation, Univ. of Calgary, Calgary, 1996. [Online]. Available: http://hdl.handle.net/1880/29328

3. R. Alamus, A. Baron, J. Casacuberta, M. Pla, S. Sanchez, A. Serra, and J. Talaya, “GEOMOBIL: ICC land based mobile mapping system for cartographic data capture,” in 22nd International Cartographic Conference, Corunna, Spain, 2005, p. 9.

4. J. Talaya, E. Bosch, R. Alamus, A. Serra, and A. Baron, “GEOVAN: The mobile mapping system from ICC,” in Proceedings of the 4th International Symposium on Mobile Mapping Technology (MMT’2004), Kunming, 2004.

5. G. Hunter, C. Cox, and J. Kremer, “Development of a commercial laser scanning mobile mapping system - STREETMAPPER,” in Proceedings of the Second International Workshop on The Future of Remote Sensing, Antwerp, Belgium, October 17-18 2006, p. 9.

6. C. Ellum and N. El-Shimey, “Land-based mobile mapping systems,” Journal of Photogrammetric Engineering and Remote Sensing, 2002

Surveillance system based on Flash LiDAR

Bharat Lohani, Siju Chacko, Suddhasheel Ghosh and Sandeep Sasidharan
Geoinformatics Laboratory, Department of Civil Engineering,
Indian Institute of Technology Kanpur
Kanpur, India 208 016
Email: blohani@iitk.ac.in

Abstract

The present day surveillance methods offer limited degree of efficiency and use for protecting one's own territory and assets. There exists a need for investigating the new technologies available now for their possible application in surveillance. Flash LiDAR based range camera is one such newly introduced and promising technology. It has a number of advantages over conventional laser scanners which guarantee its application in a variety of fields including surveillance. The potential of this new technology in surveillance has still not been fully exploited which is the motivation behind this paper. Therefore, the goal of this paper is to propose a complete surveillance system using Flash LiDAR range camera with detailed investigation on data processing to identify and locate the intruders.

In view of the non-availability of Flash LiDAR camera with the authors, the paper designs a system to simulate Flash Lidar data through an Optech ILRIS36D Terrestrial Laser Scanner (TLS). Further, the paper also proposes algorithms to detect the intruders and map its movement. The presence of the intruder has been simulated by placing a few dummies in the test area. TLS data are captured in field with few dummies placed, which show the presence of an intruder. The resulting intensity and range data are interpolated using an approach that ensures that data are analogous to those captured by a Flash LiDAR camera. The surveillance system proposed suggests capturing the range and intensity images of the area of interest at a pre-defined frequency which is decided on the basis of usual movement of an intruder. A set of such images, collected over different time-periods, when processed for change detection, yields the presence of potential intruder. Further algorithms separate signal from noise and identify the presence of a human intruder and its movement. The paper has shown successful use of the Flash LiDAR technology for surveillance, which has potential to become a non-intrusive, all-weather, day light independent, fully-automatic, long-range system in near future.

Introduction

The need for surveillance of a nation's boundaries and assets has led to the development of a large variety of technologies ranging from the simple barbed wire to sophisticated sensors capable of detecting the movement or intrusion of any object considered to be hostile. India has a long international boundary with not-so-friendly neighbours surrounding it on all the sides. Thus, the security forces have to maintain a constant vigil for guarding the nation to protect it from regular infiltration of anti-national elements across its boundaries with the neighbouring nations.

The monitoring of the international boundaries and the line of control is currently done using various physical as well as electromagnetic measures. The physical measures include the laying of minefields, booby traps, barbed wire fences, ditches, watch towers etc. The electromagnetic measures presently being used include Underground Sensors, Surveillance Radars and Unmanned Aerial Vehicles. These measures have their own pros and cons and offer some degree of efficacy. However, there still is a need for furthering the efficiency and effectiveness of the existing surveillance systems with improved technologies which can offer better results in the long run. Any such new technology other than being capable of being effective in different environmental and weather conditions should also offer resistance from enemy jamming and detection.

Existing methods for surveillance

The technical report on Ground Surveillance Radars and Military Intelligence [1] classifies the intelligence gathered on the basis of their sources, namely, human intelligence, imagery intelligence, signal intelligence and measurement based intelligence. Manual surveillance of sensitive assets like data centers, petroleum refineries, railroad tracks, and airfield areas of operations are difficult. In such a scenario, video based surveillance systems have been found to be efficient. A smart video surveillance system using computer vision and pattern recognition has been discussed in [2].

An approach for total airport perimeter surveillance has been discussed in [3]. The system covers the long range using integrated and overlapping ground

surveillance radars, including forward looking infrared. A software algorithm has been implemented for counting people and matching system for use on a bus [4]. [5] describe a framework that is capable of tracking multiple objects (multiple people and their body parts) in real image sequences. This system also allows only one user to interact. The system should be able to allow more than one user. The framework will be useful for face/gesture recognition systems.

A system that is capable of tracking multiple moving objects has been described in [6]. This system has a number of pan-tilt cameras associated which yield almost real-time response. This surveillance system tracks multiple moving objects independently. LiDAR based systems can be used to tracking movement [7]. For the work, the LiDAR device Velodyne HDL-64 with a practical range of 120 meters was used. It operates at 10Hz and is capable of collecting 1.3 million 3D points a second, or approximately 130,000 points in each frame, depending on the content of the scene. These do not possess the field-of-view necessary to recognize moving objects in real-time without the aid of additional sensors. The result is a dense point cloud of precise 3D data representing a wider field-of-view of its surroundings, capable of monitoring an entire room without additional sensors or manual intervention. By processing a sequence of point clouds from successive rotations of the sensor, a computer is capable of capturing a dynamic scene of moving objects.

Intruder detection using LiDAR

Various processes of segmentation, grouping, linking pixels with symbolic data structures, computing attributes, and classifying entities in LiDAR images have been discussed in [8]. Thereafter simple algorithms have been developed for recognition of human forms in various positions in a variety of environment. This approach has tried to segment the human forms from the range image. Segmentation of colour images is often difficult, particularly for images in a natural environment with clutter and shadows. A LiDAR range image pixel has an attribute of range in addition to attributes of intensity or colour. [7] have described an approach wherein a single stationary 3600 LiDAR sensor has been used to detect and track people who are moving throughout a scene in real-time. Surface tracking has been used by initially segmenting a group of points based on spatial separation using 3D occupancy grids over the scene [7]. These point groups were considered candidate human targets based on simple constraints of dimensions and orientation.

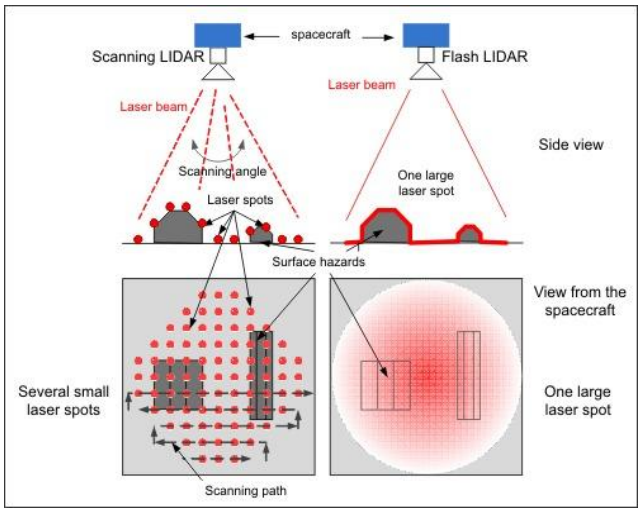


Fig. 1: LiDAR vs. Flash LiDAR technologies (Courtesy www.fosternav.net)

The currently prevalent methods of surveillance of international boundaries and assets have limitations in terms of detection of the correct position of the intruders in real time. LiDAR based techniques and algorithms can also be said to be in a state of infancy in terms of surveillance methods. In this paper, we study a new emerging technique known as Flash LiDAR which has been described in the following section and attempt to develop algorithms to detect algorithms and plot the path of movement of the intruders.

Flash Lidar Technology: System design

The 3D Flash LiDAR (3DFL) uses a single pulse of 5ns duration and energy of 1.5 to 2.8 mJ to illuminate a scene. The pulse returns from the surface of target are focused on an array of smart pixels, specifically an Avalanche photodiode (APD) array with a CMOS readout integrated circuit (ROIC), that collects and stores digital and analogue data representing the flight time and laser pulse characteristics. The APD detector converts photons to electrons with considerable gain, and timing circuitry on the ROIC provides an output of time-of-arrival and intensity at each pixel. The system supports different ranges and horizontal fields of views depending on the laser energy and optics used for the laser and receiver. It could use a sequence of 3D frames to identify and track moving targets, then communicate the information.

The 3D Flash LiDAR enables real-time 3D imaging, and has a number of advantages over conventional point scanner and other stereoscopic systems. The Advanced Scientific Concepts (ASC) Inc. has developed and demonstrated such a camera system on

the lines of the Flash LiDAR technology. The company has claimed scanning target areas from 5 cm to 5 km using various combinations of the lenses available. Colour-coded images are used to display either the intensity of signal returns for each pixel, or the range distance to the surface at each pixel position.

The technical specifications of a Flash LiDAR system are given in Table 1.

Operating wavelength	Eye safe 1.574μ
Sensor	InGaAs APD (128x128)
Laser energy	2.5 - 12mJ
Accuracy	~ 15cm @ 500m
Time of flight	600ns for 100m range
Field of view	**Range**
$45°$	60m
$9°$	450m
$3°$	600m
$1.5°$	1100m

Table 1: Technical specifications of the Flash LiDAR camera (Courtesy: www.advancedscientificconcepts.com)

Objectives

In the light of the discussion in the previous sections, this paper will aim to address the following research objectives: (a) establishment of a methodology for the detection of intruders using Flash LiDAR, and (b) develop algorithms for emulating the Flash LiDAR.

Materials and methods

System specification:

We envisage a Flash LiDAR camera based surveillance system as follows:

1. The data generated should be in the same format as that of the Flash LiDAR camera, i.e. range and intensity rasters of 128×128 pixel resolution.
2. It should have the capability to capture a range of 6 frames per second.
3. Field of view (FOV) $1.5° \times 1.5°$, thus giving the maximum range and resolution.
4. The Flash LiDAR camera based surveillance system should be mounted on a rotary base allowing systematic controlled angular steps. This will also help in having a surveillance covering $360°$ FOV.

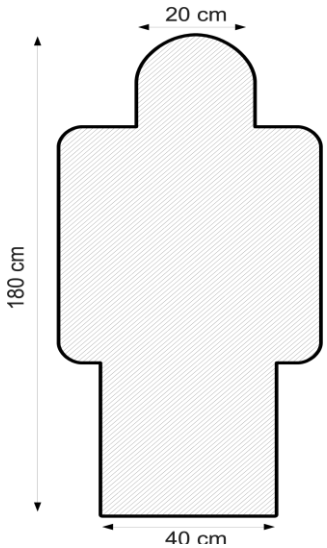


Fig. 2: Design of the dummy

The rotary base is a stepper motor device which would make angular steps of $10°$ per second. Thus it would cover the field of view once in a period of four seconds. Once the region is scanned it would begin all over again from the starting position.

Emulation of Flash LiDAR system:

During the writing of this paper, the Flash LiDAR data capturing system was not available with the authors. As a result, it was decided to emulate the data procurement using an ILRIS 3D Terrestrial Laser Scanner (TLS). The TLS is capable of capturing data in two returns although it stores either first or second return data. The scanner is operated either through a laptop or a hand held PDA using a controller program.

Design and insertion of the intruder

For the purposes of this study, intruders were depicted using dummies. These dummies were made of 5mm thick plywood, and were 180cm tall with an average width of 40cm. A design of the dummies is shown in Fig. 2.

Scanning of the scene:

The controller program was used to set the scanning parameters of the TLS. For the purposes of this study, data were captured at 2500 data points per second, with a range limit of 300m. The spacing between the points was approximately 15mm and the field of view was set to be $1.5° \times 36°$. The scene was scanned without and with the dummies which were placed at various positions in the field. The dummies were staggered and placed in the target area intended to be covered by the scanner. It has been assumed that the Flash LiDAR based surveillance with the rotary base

would complete the scan of a $36°$ field of view in about 4 seconds.

The data thus obtained contains *x*, *y* and *z* coordinates and 16-bit and 8-bit intensity values. We have used the 8-bit intensity values for this study.

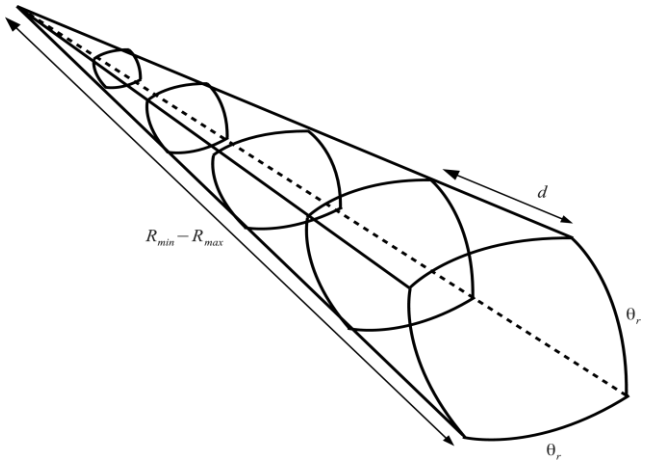


Fig. 3: Prismatic arrangement for computation of range and intensity values

Algorithm 1: Partition of the scanned data into cells. $[GR, \Phi_{max}, \Phi_{min}, \Lambda_{max}, \Lambda_{min}, R_{max}, R_{min}] = Partition(\mathbf{P})$

Require: A given scanned dataset **P**

1: **return** GR, a grid cell of dimension 128 x 3072
2: $\theta_r \coloneqq \frac{1.5}{128}$
3: Compute $\Phi_{max}, \Phi_{min}, \Lambda_{max}, \Lambda_{min}, R_{max}, R_{min}$
4: Let GR be an empty grid cell of dimension 128x3072
5: **for** each $\mathbf{p}(\phi, \lambda, \rho, \iota) \in \mathbf{P}$ do
6: Compute $i = \left\lfloor \frac{\Lambda_{max} - \lambda}{\theta_r} \right\rfloor$.
7: Compute $j = \left\lfloor \frac{\phi - \Phi_{min}}{\theta_r} \right\rfloor$.
8: $GR(i,j) \longmapsto GR(i,j) \cup \{\mathbf{p}\}$
9: **end for**

Data interpolation technique:

It is known from the system design for Flash LiDAR that 128x128 range and intensity images are captured during the scanning process. Each of these images has an angular dimension of $1.5° \times 1.5°$. Thus, for one single scan of the entire field of view, 24 images can be generated each for range and intensity. A single scan containing the data points is first converted into spherical coordinates (azimuth, elevation and range) and then interpolated into a depth and intensity valued raster using algorithms [1] and [2].

Algorithm [1] partitions the scanned dataset into a cell grid of dimension 128×3072. In algorithm [2], the range and intensity values corresponding to each cell are computed by dividing the cell into a prismatic arrangement as shown in Figure [3]. The points corresponding to the cell are partitioned by their range values into sub-cells. The sub-cell containing the highest sum of intensity values is selected for computing the average intensity value and the average range value. Algorithm [3] is used to compute the range and intensity value rasters *DR*1 and *IR*1 for the dataset procured without the dummies. For the dataset with dummies the range and intensity rasters *DR*2 and *IR*2.

Algorithm 2: Computing the intensity and depth values of a particular cell

$[r, h] = RangeIntensity(S, R_{min}, R_{max}, d)$

Require: Point list S corresponding to a single cell from GR, R_{min}, R_{max} and range resolution d

1: return Range value r and intensity value h for the cell
2: Construct cell vector V with $\left\lceil \frac{R_{max} - R_{min}}{d} \right\rceil$ cells
3: for $\mathbf{p}(\phi, \lambda, \rho, \iota)$ in S do
4: Compute $k = \left\lfloor \frac{\rho - R_{min}}{d} \right\rfloor$
5: $V(k) \longmapsto V(k) \cup \{\mathbf{p}\}$
6: end for
7: find ℓ such that the sum of intensities is maximum in cell vector V.
8: Compute average intensity h for $V(\ell)$.
9: Compute average range r for $V(\ell)$.

Algorithm 3: Computation of intensity and range value rasters

Require: Scanned dataset P and range resolution d

1: return IR and DR, the intensity and range value rasters.
2: Convert Cartesian coordinates into spherical coordinates.
3: $[GR, \Phi_{max}, \Phi_{min}, \Lambda_{max}, \Lambda_{min}, R_{max}, R_{min}] = Partition(\mathbf{P})$
4: Let IR and DR be empty rasters each of dimension 128×3072.
5: **for** i from 0 to 127 **do**
6: **for** j from 0 to 3071 **do**
7. $DR(i,j), IR(I,j)] = RangeIntensity(GR(I,j), R_{min}, R_{max}, d)$
8: **end for**
9: **end for**

Algorithm 4: Emulated rasters for Flash LiDAR $[GIR, GDR] = ComputeEmulatedRaster(IR1, IR2, DR1, DR2, \sigma_r, \sigma_i)$

Require: Interpolated rasters $IR1$, $IR2$, $DR1$ and $DR2$ and standard deviations σ_r, σ_i

return Simulated raster cell grids GIR and GDR
  Declare GIR and GDR to be 25×24 cell grid rasters.
  for i from 1 to 25 **do**
    $PIR1 := IR1 + N(0, \sigma_i)$
    $PDR1 := DR1 + N(0, \sigma_r)$
    $PIR2 := IR2 + N(0, \sigma_i)$
    $PDR2 := DR2 + N(0, \sigma_r)$
  for j from 1 to 24 **do**
    $c = (j - 1) \times 128$
    if $j = i - 1$ then
      $GIR(i,j) = PIR2\,(0\!:\!127, c\!:\!c + 127)$
      $GDR(I,j) = PDR2(0\!:\!127, c\!:\!c + 127)$
      else
      $GIR(i,j) = PIR2(0\!:\!127, c\!:\!c + 127)$
      $GDR(I,j) = PDR2(0\!:\!127, c\!:\!c + 127)$
      end if
    end for
  end for

Emulation of Flash LiDAR data:
After the range and intensity rasters, namely *DR*1, *DR*2, *IR*1 and *IR*2, are calculated using algorithm [3], an emulation of the Flash LiDAR frame-wise capturing is conducted using algorithm [4]. Here, each of the 4 scan strips is calculated by adding Gaussian noises with zero mean and standard deviations σ_r and σ_i to DR1 and IR1, respectively and taking one 128×128 frame from DR2 and IR2 with added noise, respectively.

Detection and reconstruction of intruder:
The dummies were placed such that the emulated rasters contain only one dummy in a frame as the intruder is moving. Therefore, the detection of an intruder is conducted by taking a simple difference of the current frame and the previous one. If the difference for a particular pixel is greater than a user provided threshold τ, then the corresponding pixel in the resultant boolean raster is given a value of **true** else is given a value of **false**. This computation of the boolean raster is described in algorithm [5].

Algorithm 5: Creation of a Boolean image. $I = CreateBoolean(I_1, I_2, \tau)$

Require: Images I_1 and I_2, and threshold τ
return Boolean image I
$I_3 = I_1 - I_2$
Let h be the number of rows and w be the number of columns of I_3
  Let I be a Boolean image of dimension $h \times w$ with all its values as *false*
  for i from 0 to $h - 1$ **do**
    for j from 0 to $w - 1$ **do**
      if $I_3(i,j) > 0$ then
        if $I_3(i,j) > \tau$ **then**
          $I(i,j)$ = *true*
        end if
      end if
    end for
end for

Algorithm 6: Detection of possible intruder $[DIR, DDR] = IntruDetect(GIR, GDR, \tau_i, \tau_r)$

Require: Interpolated cell grids GIR and GDR, and thresholds τ_i, τ_r
  return Difference Boolean rasters DIR and DDR
  Declare DIR and DDR to be 24×24 cell grid rasters.
  for i from 1 to 24 **do**
  for j from 1 to 24 **do**
    $DIR(i,j) = CreateBoolean(GIR(i,j), GIR(i+1, j), \tau_i)$
    $DDR(i,j) = CreateBoolean(GDR(i,j), GDR(i+1, j), \tau_r)$
    end for
  end for

Algorithm [6] takes τ_r and τ_i as input from the user for thresholding the range and intensity rasters, respectively and computes a grid of difference boolean rasters. The difference images will have the intruder as the signal and noise due to noise present in the successive frames of Flash LiDAR. A 5×5 median filter is used to clean up this noise. This is followed up with a morphological closing operation. Blobs are then identified in these boolean images frame by frame.

Algorithm 7: Reconstruction of intruder. $FI = IntruReconstruct(I, hr_1, hr_2)$

Require: I, a Boolean frame calculated from the previous step and two thresholds hr_1 and hr_2
  return Figure of the intruder FI
  $I1 := MedianFilter_{5\times5}(I)$
  $I2 := MorphologicalClose\ (I)$
  $BLIST := DetectBlobBoundaries(I2)$
  Compute height to width ratios hr for each of the blobs
  If $hr_1 \le hr \le hr_2$ then accept blob boundary as intruder
  Calculate FI

To identify whether a blob belongs to an intruder, they are firstly assessed based on their perimeter and area. This is then followed by their height to width ratio. The

range of maximum and minimum height and width of average human are assumed and their ratios are determined. The blobs satisfying the height/width ratio are then extracted and labelled as intruders. This forms the basis for algorithm [7].

Plotting of motion graph:
The centroids of the blobs identified thus point to the frame numbers where they belong. The centroids are used to back calculate the elevation and azimuth angles in the original point cloud data. A three dimensional traverse is then generated from the coordinates of these blobs. The range information obtained from the range image along with the azimuth and elevation determined from the centroids is then used to plot the traverse of the likely intruder.

Results and discussion

The aim of this paper is two-fold: (a) we establish a methodology for detection of intruders for Flash LiDAR data, and (b) we use TLS data to emulate the conditions of the Flash LiDAR camera and generate similar datasets to prove the methodology. In this section, we present the results from the data procured using TLS at the premises of the Indian Institute of Technology Kanpur (IITK).

Procurement of the dataset through TLS:
The north-east side of Staff Gymkhana ground located inside the campus of IITK was selected as a site for scanning by TLS. About 765980 points were procured in a field of view $1.5° \times 36°$. The point to point spacing in a step stare scan was maintained at 15mm. The colour photograph of the site, and intensity coloured 3D views of the dataset with and without the dummies are presented in Fig. 4.

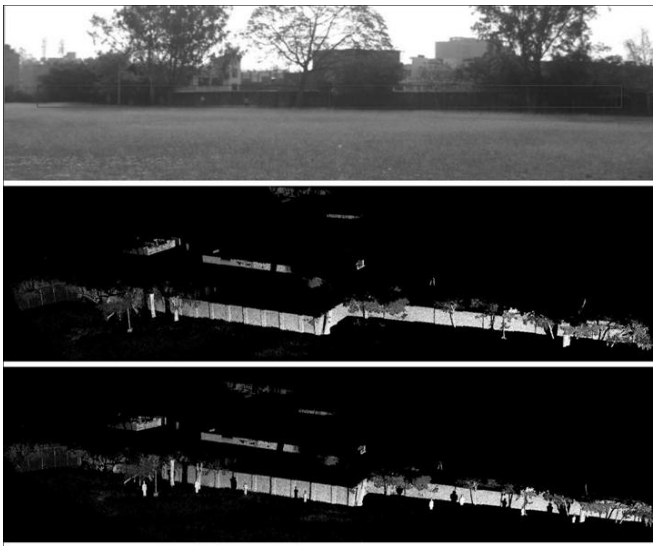


Fig. 4: Procured dataset and its 3D view

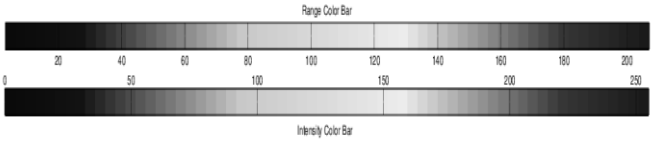


Fig. 5: Range and intensity colour scales used in the paper

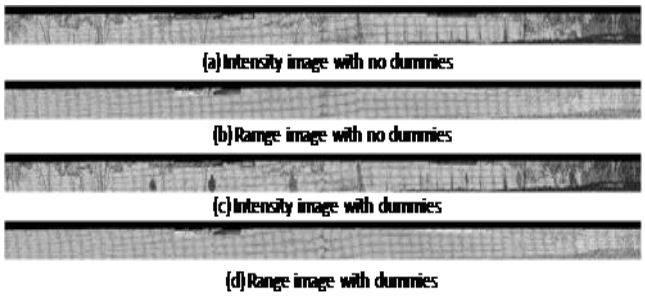
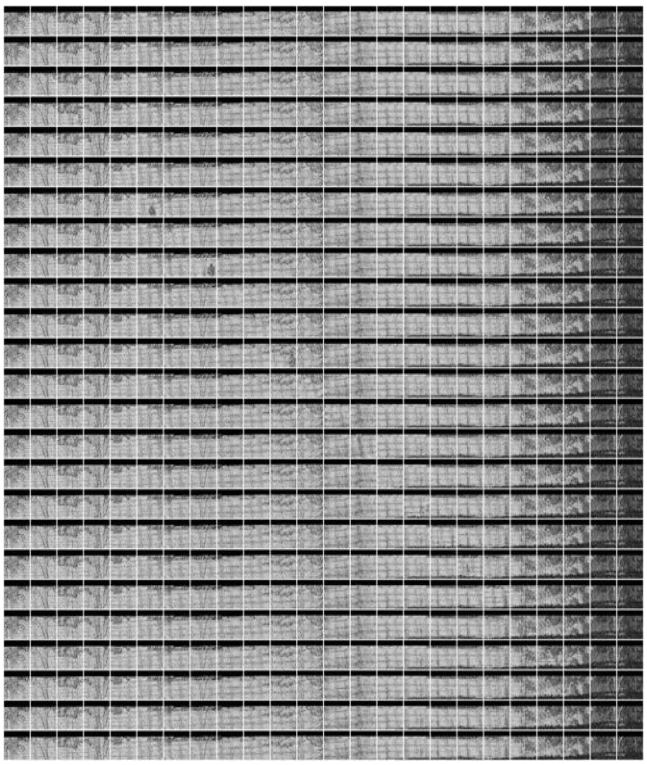


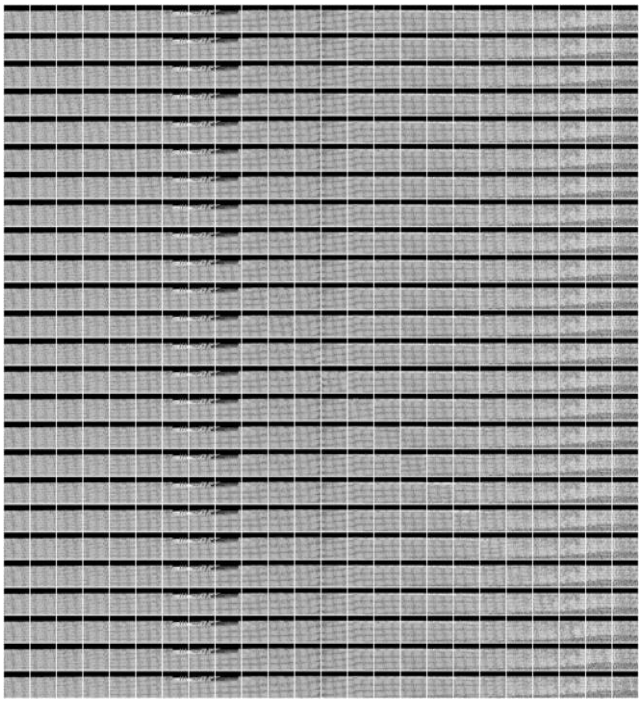
Fig. 6: Interpolated rasters from the test dataset. Without and with the dummies

Generation of the raster strips:
Conventionally data interpolation is conducted using methods like nearest neighbour, bilinear convolution, bicubic convolution, inverse distance weighted interpolation etc. However, in this paper, we have presented a novel technique of binning the dataset, so as to create intensity and range value rasters to generate data as in Flash LiDAR. Algorithms [1] and [2] are used to compute the intensity and range valued raster strips of dimension 128×3072, for scans without and with the dummies. A discretized view of these rasters is presented in Fig. 6. In this view, the lower values are represented with blue and the higher values are represented with red. The colour ramp used for this study is given in Fig. 5. It can be clearly seen from the presented views that the dummies are seen with red colour in the intensity based raster for the dataset with dummies. In range images the dummies are not seen at the selected colour scheme as these are being mixed with the background at the chosen level of binning.

Generation of emulated rasters for Flash LiDAR camera:
Algorithm [4] is now used to compute the various frames for emulating the Flash LiDAR camera. For each of the scan strips, Gaussian noises for range ($\sigma_r = 0.15m$) and intensity ($\sigma_i = 2$) are added to the rasters as per the noise specifications of the Flash LiDAR camera. Fig. 7a and 7b show the images which would be captured by Flash LiDAR. Each strip has 24 images and there are 25 such strips showing multiple scans of the area of interest.



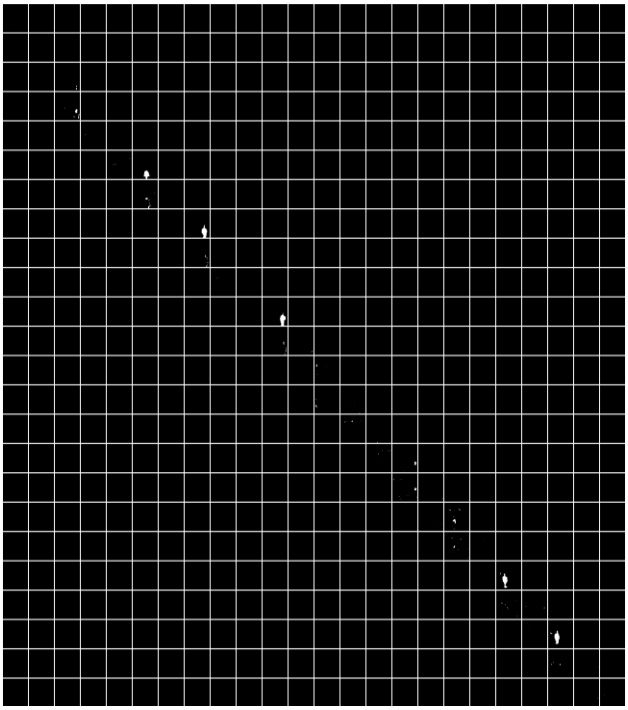
(a) Frame set of discretized intensity images



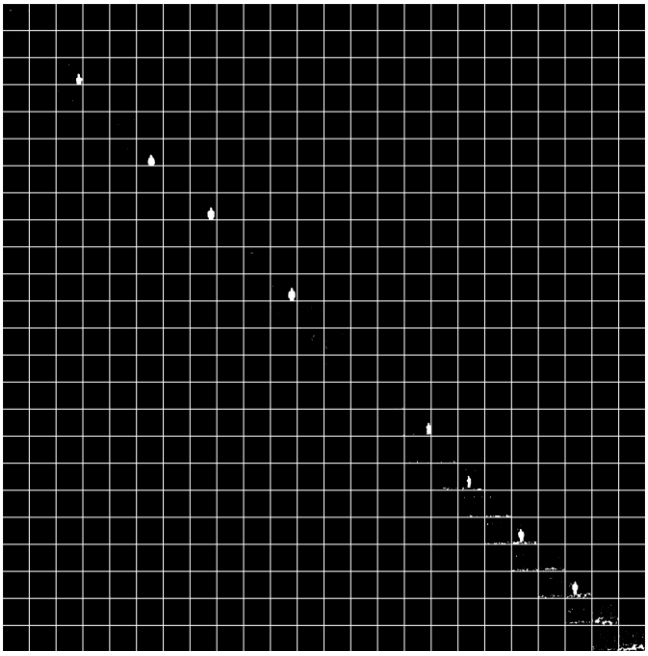
(b) Frame set of discretized range images

Fig. 7: (a) Discretized representation of the raster generated from intensity values, (b) Discretized representation of the raster generated from range values

Detection and reconstruction of the intruder:
Using algorithms [5] and [6], the Boolean images are created by differencing the corresponding frames from each subsequent pair of rows. The thresholds σ_i and σ_r are input by the user. In our case, we chose these thresholds empirically.



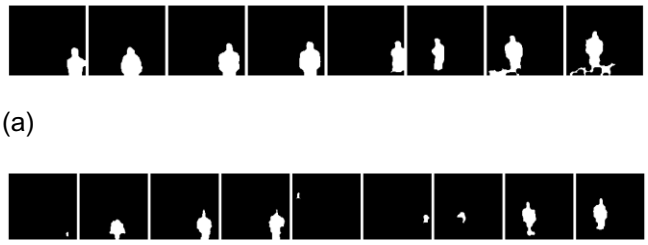
(a) Frame set of differenced and thresholded intensity images



(b) Frame set of differenced and thresholded range images

Fig. 8: (a) Intensity grid created through differencing and thresholding (b) Range grid created through differencing and thresholding

The reconstruction of the intruder is done using algorithm [7]. The reconstructed intruders have been presented as blobs in Fig. 9.

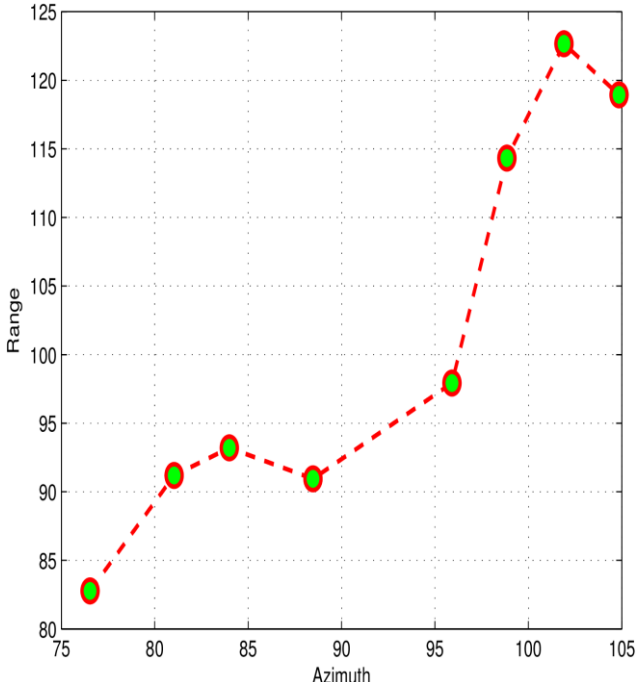


(a)

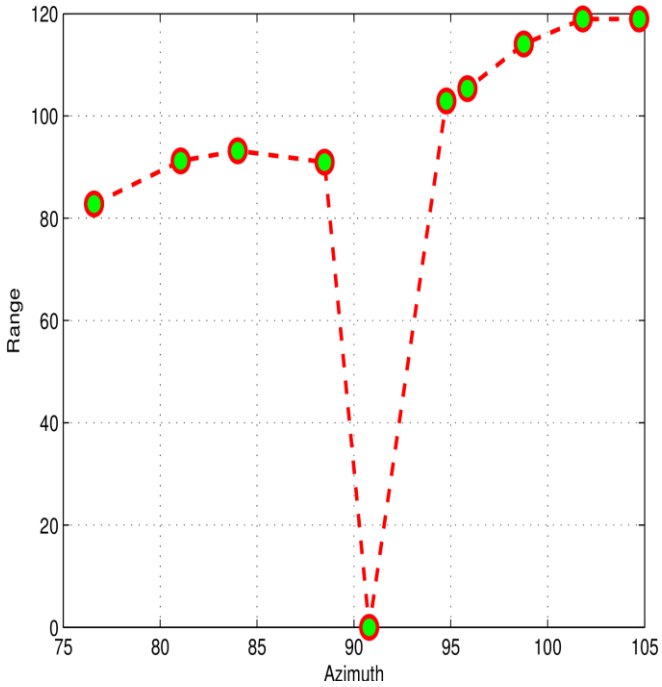
Fig. 9: Detected blobs from thresholded difference images

It is seen that the blobs detected from the intensity data are not so well shaped. This may be attributed to the fact that the reflectance from the material of the dummy might be confused with the reflectance from the surrounding objects.

Motion of the intruder:
The centroids of the blobs detected are calculated and are mapped backed to the Cartesian space to find the locations of the intruders. A map of the path of the intruder is given in Fig. 10. It is seen that the maps of the path digitized using range and intensity data are consistent with one another, barring one point. This may be attributed to the noise present in the dataset during the procurement.



(a) Intruder motion based on range difference images



(b) Intruder motion based on intensity difference images

Fig. 10: Path of the intruder. Both paths are consistent barring one point, which may be attributed to the noise present in the datasets.

Conclusion and future scopes of work

In this paper we have proposed a system design along with a set of algorithms for the purposes of surveillance using a Flash LiDAR camera. However, owing to the absence of the Flash LiDAR camera, the dataset was emulated by using a Terrestrial laser scanner. The paper has successfully demonstrated the use of the proposed algorithms for detection, and reconstruction of the intruder, as well as plotting the motion of the same. We perceive various applications of these algorithms in the field of security and surveillance. In the future, we plan to develop a template matching algorithm to recognise patterns for various human poses to detect human presence in a scene.

References

1. L. Varshney, “Ground surveillance radars and military intelligence,” Syracuse Research Corporation, Tech. Rep., 2002.
2. Y.-l. Tian, L. Brown, A. Hampapur, M. Lu, A. Senior, and C.-f. Shu, “IBM smart surveillance

system (s3): event based video surveillance system with an open and extensible framework," *Mach. Vision Appl.*, vol. 19, no. 5-6, pp. 315–327, Sep. 2008. [Online]. Available: http://dx.doi.org/10.1007/s00138-008-0153-z

3. T. Pearson, "Describing a "total solution" approach to airport perimeter security," July 2009, (Last accessed September 10, 2012). [Online]. Available: http://trynix.com/docs/Trynix-Airport-Security-White

4. J. Sallay, "Automatic people counting and matching," Master's thesis, Utah State University, 2009, paper 499. [Online]. Available: http://digitalcommons.usu.edu/etd/499/

5. E. Polat, M. Yeasin, and R. Sharma, "Tracking body parts of multiple people: A new approach," *Multi-Object Tracking, IEEE Workshop on*, vol. 0, p. 0035, 2001.

6. C.-M. Huang and L.-C. Fu, "Multitarget visual tracking based effective surveillance with cooperation of multiple active cameras," *Systems,Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on*, vol. 41, no. 1, pp. 234–247, February 2011.

7. J. Shackleton, B. VanVoorst, and J. Hesch, "Tracking people with a 360-degree lidar," in *Proceedings of the 2010 7th IEEE International Conference on Advanced Video and Signal Based Surveillance*, ser. AVSS '10.1em plus 0.5em minus 0.4emWashington, DC, USA: IEEE Computer Society, 2010, pp. 420–426. [Online]. Available: http://dx.doi.org/10.1109/AVSS.2010.52

8. J. S. Albus, T. Hong, and T. Chang, "Segmentation and classification of human forms using ladar data." in *AIPR*.1em plus 0.5em minus 0.4emIEEE Computer Society, 2006, p. 7. [Online]. Available: http://dblp.uni-trier.de/db/conf/aipr/aipr2006.html#AlbusHC06

Comparison of Kinematic GNSS Processing: Relative vs. PPP Approach for Processing of Airborne Camera Data

T.E Rani, E. Anantha Padmanabha and S. Muralikrishnan
Indian Space Research Organization,
National Remote Sensing Centre,
Balanagar, Hyderabad-500 037
(rani_te, anantha_p, muralikrishnan_s)@nrsc.gov.in

Abstract

Traditionally for photogrammetric processing, aerial camera exposure station co-ordinates are derived using Global Navigation Satellite System (GNSS) data in relative positioning mode. This requires two GNSS receivers, one at base station within the study area and the other as a rover onboard aircraft in kinematic mode during aerial photography. The limitations with this procedure are error in base station, additional effort to setup a base station, more residual errors with increase in the baseline distance and operation restrictions during disasters and in inaccessible areas. Precise Point Positioning (PPP) is an alternative method to derive exposure station co-ordinates with one receiver onboard using readily available precise ephemeris data and clock information. This technique is accurate, simple, cost effective and feasible in any situation as there is no need for a base station operation. The main objective of this study is to compare camera exposure station co-ordinates derived through kinematic PPP and relative mode. Exposure station co-ordinates derived through block adjustment are considered as reference for validation. The study was carried out for various flight time and base distance. This paper reveals that PPP gives better solution compared to relative mode with base operated ata distance of around 100 km and accuracy is directly proportional to duration of flight. Inaccessible areas/during disasters PPP is the best alternative approach.

Introduction

During last one decade, with the advent of technology, the traditional analog film based cameras have been replaced by more fragile digital camera in airborne remote sensing. The introduction of airborne Large Format Digital Cameras (LFDC) seems to facilitate a more accurate and reliable digital surface model compared to analogue systems due to higher radiometric, colour and geometric resolution. The LFDC uses multiple CCD arrays to increase the format size that is comparable to conventional cameras (Honkavaaraet al., 2006). There are numerous advantages of digital aerial cameras compared to analog film based cameras. The data can be used immediately after acquisition of flight as there is no delay due to film processing and scanning. With better radiometric resolution of digital cameras the data can be acquired for longer duration during a day. Data can be simultaneously acquired in both panchromatic and multispectral bands (Ananthaet al., 2008). Images can be captured with more overlaps with in the strip without any additional cost (Zebedin et al., 2006) so that in high urban canopy areas, true ortho can be generated.

The geometric relation between the images and ground can be derived through aerotriangulation process by using ground control points (GCPs). Since collection of GCPs is a long drawn process, generally very few GCPs are used in photogrammetric processing to obtain precise coordinates with support of exterior orientation (EO) parameters from onboard GNSS and Inertial Measurement Unit (IMU) that gives the exposure station coordinates and attitude parameters of the platform. The recent approach of orienting image data directly using EO parameters is called Direct Geo-referencing (DG). Of late DG approach has gained due popularity for obvious reasons of time, effort and cost saving. The accuracy that can be achieved through DG mainly depends on the accuracy of GNSS and IMU. It also depends upon the precision with which all the systematic errors have been modeled and compensated (Anantha et al., 2008).

Conventionally the exposure station coordinates are derived using GNSS observations processed in relative mode. This process requires a GNSS base station to be operated within the study area as a reference. For data acquisition of large areas multiple

base stations need to be operated to keep the baseline distance within the limit as the differential processing accuracy mainly depends on the base line distance. There is an element of uncertainty in aerial data acquisition as it requires clear weather conditions. After image data is acquired quality of the data has to be checked for any gaps and clouds. Re-flying over the area of interest may be required if the quality report is not meeting the project specifications. So all the base receivers need to be stationed within the flying area till the final acceptance of the data. This may substantially increase the project cost. Critical conditions like inaccessible areas and disasters may not permit a base station operation within the area of interest. If the base station is operated at a convenient location away from the area of flying, the accuracy of differential processing degrades with the base line distance.

Precise Point Positioning (PPP) is an alternative method to derive exposure station co-ordinates from un-differenced observations of a single onboard GNSS receiver in kinematic mode using precise ephemeris data and clock information. PPP employs high resolution carrier phase and pseudo-range observations in processing algorithms, in which precise satellite orbits and clock information are used instead of broadcast information. The final precise satellite ephemeris and clock offsets having latency of approximately two weeks are available for downloading from the International GNSS Service (IGS) site. (http://igscb.jpl.nasa.gov/ components/ prods_cb.html). IGS can provide precise satellite orbit and clock error products with accuracies of 5 cm and 0.1 ns (3 cm) (XiuxiaoYaun et al, 2009). PPP method has many advantages and disadvantages over relative positioning (Ola Ovstedal et.al, 2006).

The method of PPP was first developed for static applications. (Zumberge et. al, 1998, Kwo-Hwa Chen et al, 2009). In the recent years PPP method is modified to get better solutions in kinematic measurements also. This technique is simple, cost effective and practically feasible in any situation as there is no need for a base station operation (Tuchband T et al, 2011,Angel et al, 2012). Fig. 1 and Fig. 2 shows the aerial photography with relative and PPP positioning techniques respectively. The accuracy that can be achieved through PPP processing of onboard GNSS data is directly proportional to the duration of data acquisition, since the accuracy of phase ambiguity increases as a function of time (Ola Ovstedal et.al, 2006). It is required to ascertain the accuracy of PPP processing for different flying durations and also as an input for DG.

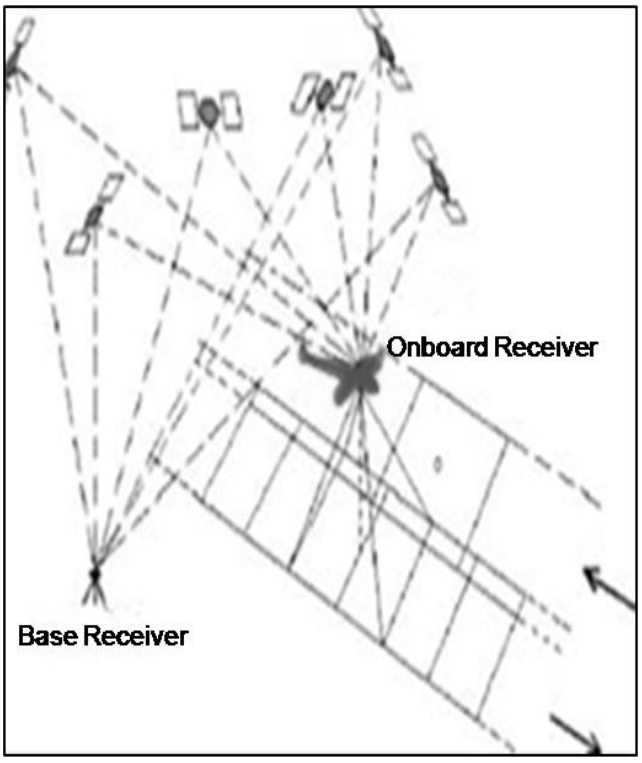


Fig. 1: Relative kinematic mode

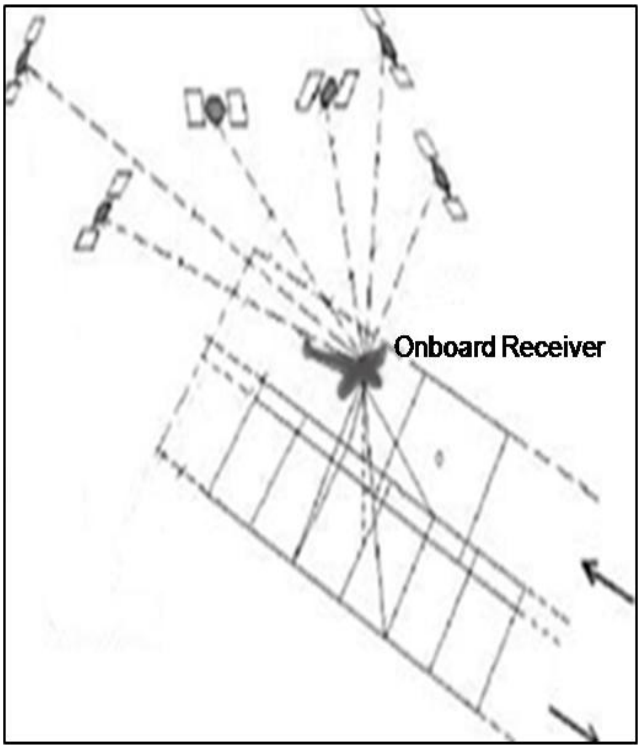


Fig. 2: PPP kinematic mode

Objective

The main objective of this study is to ascertain the applicability of exposure station coordinates derived through PPP for photogrammetric processing of airborne digital camera data. This is validated with relative positioning technique at exposure station level (space) and at the ground level by DG of the digital images. The effect of flying duration and varying baseline distances with PPP accuracy would also be analyzed.

Study area and Data used

For the present study, GNSS data collected at base and onboard receivers during aerial photography of three towns namely Damtari, Durg and Rajnandgaon of Chattisgarh state of India is considered. Aerial Photography for these towns was carried out from 15-12-2010 to 26-12-2010 with 10 cm Ground Sample distance (GSD).The onboard GNSS receiver and base receiver were operated in kinematic and static mode respectively with 0.5 second sampling rate during entire flight mission. GNSS data was also simultaneously collected at multiple base stations located at different distances to compare the PPP result with different base distances. The flight duration of three towns was 3.5hrs, 2.5 hrs and 1.5 hrs respectively. The distances of different bases from the flying area and flight durations of each town are shown in Table 1.

The base station operated within flying area was considered as local base. The precise co-ordinates of all base stations (Table 1) were derived with an accuracy of 5 cm from a zero order station in relative mode. The base co-ordinates were in International Terrestrial Reference Frame (ITRF) 2005 with the epoch of flying date i.e., December 2010 since precise ephemerides used for PPP processing are in same epoch.

Methodology

The study is carried out in two phases, first the accuracy assessment at exposure level (space) and second at the object level (ground) through direct geo-referencing of digital images.

Position of each exposure station of Damtari town is derived in relative post processing mode with each base (Table 1) that integrates onboard GNSS data with base station GNSS data to eliminate common errors and also in PPP mode that uses precise ephemeris and correct clock estimates with dual frequency carrier and pseudo-range signals. Grafnav and Aero-office software are used for computation.

Table 1: Name of base stations and distances from project area

TOWN NAME	FLYING DURATION	BASE NAME	DISTANCES IN Km
DAMTARI	3.5 HOURS	DAMTARI	Local
		DURG	70
		BILASPUR	175
		JAGDALPUR	190
		PPP(No Base)	-
DURG	2.5 HOURS	DURG	Local
		RAIPUR	50
		BILASPUR	150
		KORBA	200
		PPP(No Base)	-
RAJNAND GAON	1.5 HOURS	DURG	Local
		RAIPUR	75
		BILASPUR	175
		KORBA	250
		PPP(No Base)	-

For the first study validation, reference exposure station co-ordinates are generated using traditional photogrammetric processing i.e. Bundle block adjustment is carried out using the exposure station co-ordinates of each image of Damtari town derived in relative mode with local base station data along with GCPs. After block adjustment, the refined exposure co-ordinates are considered as reference (true) co-ordinates.

Exposure stations derived with respect to each base station and PPP are compared with reference exposure station co-ordinates to study the difference at space level. The same process is carried out for the remaining two towns. For the second study, DG is carried out using exposure coordinates derived from relative and PPP. The accuracy of DG data is compared with GCPs for three towns.

Results

In the first study, the maximum, minimum and Root Mean Square Error (RMSE) of difference of reference co-ordinates with co-ordinates derived with local base station and PPP are shown in Table 2. The RMSE of the difference of reference exposure station co-ordinates with co-ordinates derived with each base for all towns are shown in Fig. 3, Fig. 4 and Fig. 5.

Table 2: Difference of Exposure station coordinates (ref. vs. relative & ref. vs. PPP)

		Relative mode (local base)			PPP		
Flying duration	Difference	Easting (m)	Northing (m)	Height (m)	Easting (m)	Northing (m)	Height (m)
3.5 hrs	Maximum	0.659	0.455	0.348	0.998	0.959	0.392
	Minimum	0.004	0.000	0.000	0.006	0.237	0.000
	RMSE	0.314	0.134	0.135	0.420	0.520	0.126
2.5 hrs	Maximum	0.739	0.748	0.836	1.258	1.105	0.821
	Minimum	0.000	0.000	0.000	0.020	0.003	0.000
	RMSE	0.222	0.335	0.217	0.608	0.740	0.225
1.5 hrs	Maximum	0.648	0.728	0.367	1.353	1.207	0.470
	Minimum	0.001	0.001	0.001	0.002	0.326	0.000
	RMSE	0.209	0.290	0.124	0.599	0.782	0.199

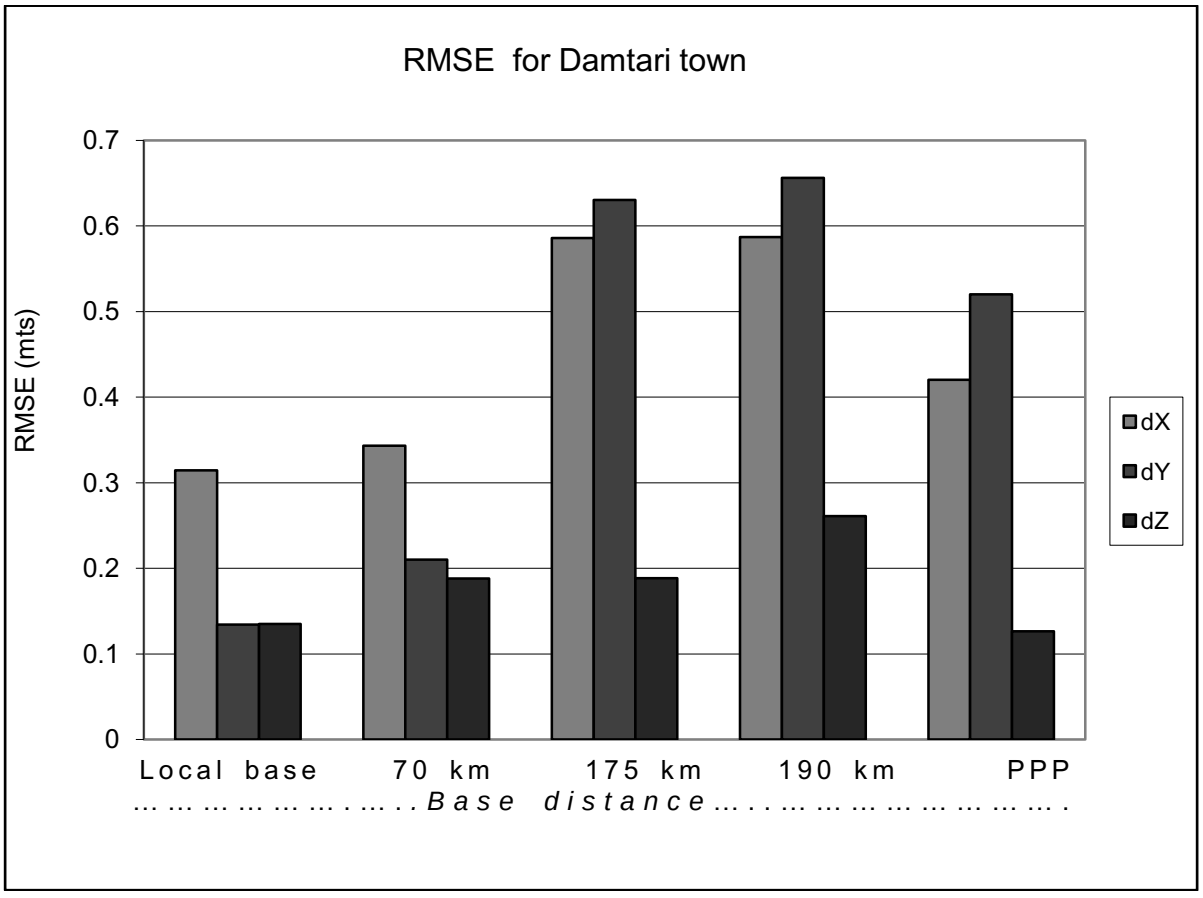


Fig. 3: Comparison for 3.5 hour flight duration: Error in exposure station (space)

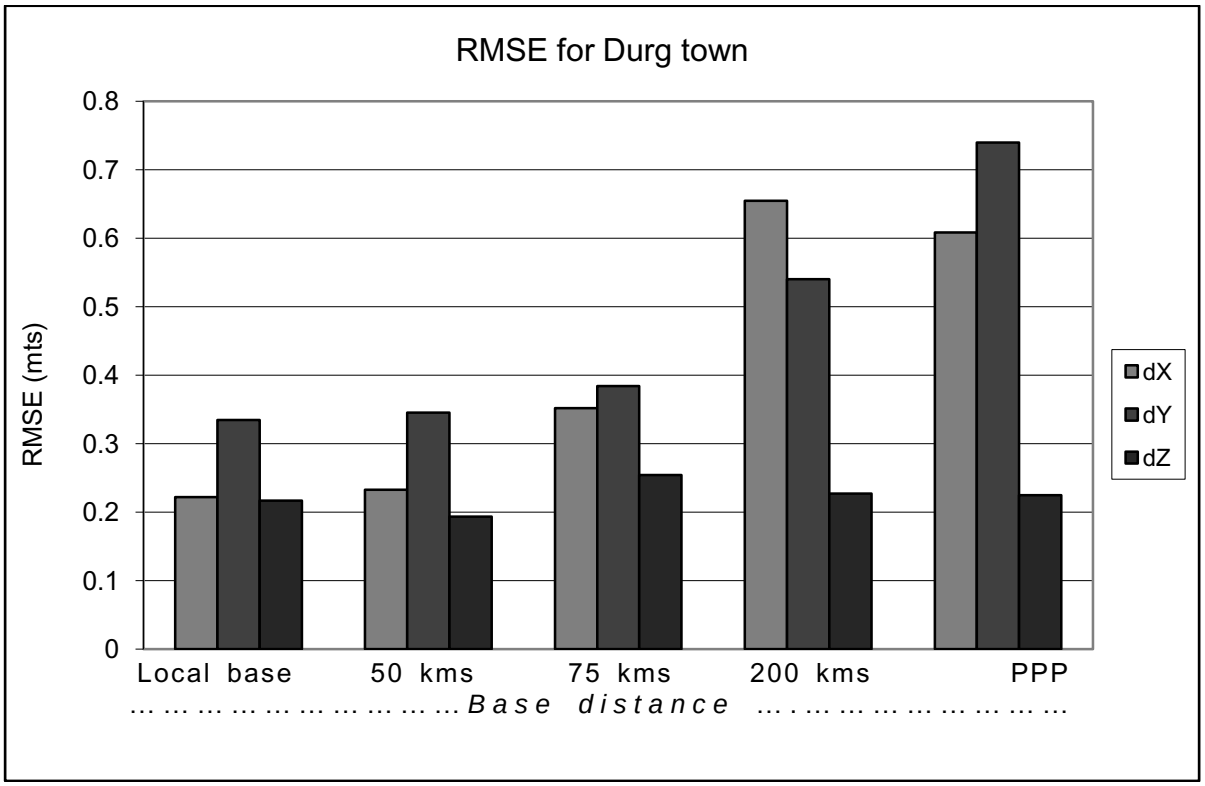


Fig. 4: Comparison for 2.5 hour flight duration: Error in exposure station (space)

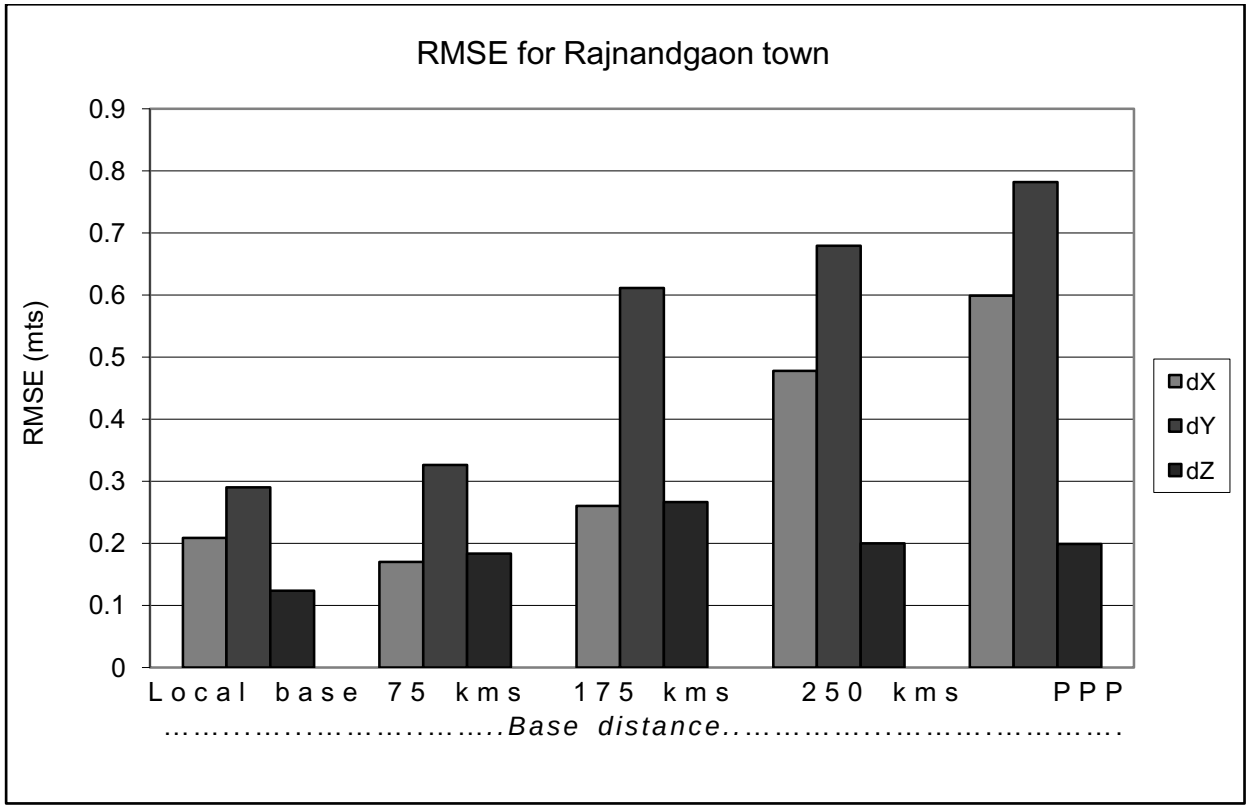


Fig. 5: Comparison for 1.5 hour flight duration: Error in exposure station (space)

It is observed that for flight duration of 1.5 and 2.5hrs, the exposure station co-ordinates derived with PPP are inferior accuracy in comparison with relative mode of any base distance. For the flight duration of 3.5 hrs, exposure station co-ordinates with PPP are found to be closure to the co-ordinates with base at a distance of 70 km and above.

For the second study, the RMSE of differences between the GCP co-ordinates and DG image is found to be better than 30 cm in planimetry and 40 cm in height for 3.5 hr flight duration. For flight duration of 1.5 and 2.5 hrs the RMSE is above 50 cm in planimetry and 40 cm in height. The RMSE values for different flight durations are shown in Fig. 6.

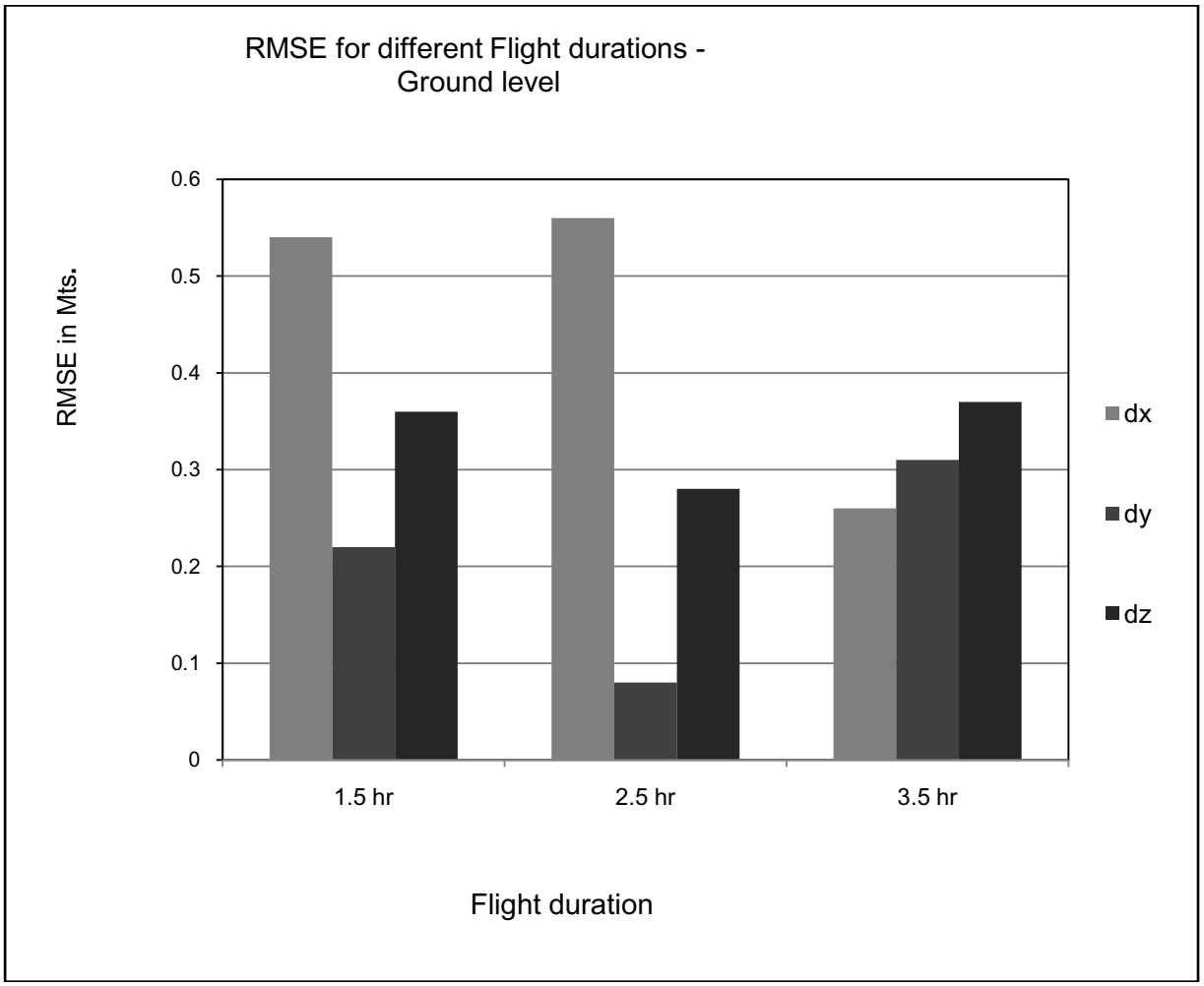


Fig. 6: RMSE for different flight durations - Error in ground level (DG vs. GCPs)

Conclusion

This paper demonstrated the applicability of PPP method for deriving exposure station coordinates for photogrammetric processing of airborne digital camera data for different flight durations of 1.5, 2.5 and 3.5 hours. It is concluded that operating a base station within the study area is always ideal to derive maximum accuracy. However, if the bases are away from the study area due to accessibility issues, PPP method would provide an alternative without diluting the accuracy standards. It is also evident that PPP method of processing requires minimum 3 to 4 hours of aircraft flying so that the error due to phase ambiguity is minimised.

Acknowledgements

The authors thank Dr. V.K. Dadhwal, Director, NRSC and Mr. P. Srinivasulu, GM (AS&DM), NRSC for providing all the help and encouragement during the course of study. The authors are also wish to acknowledge the support received from AS&DM / NRSC airborne and ground survey team.

References

1. Anantha Padmanabha. E, J. Nalini, I. Jayalakshmi, S. Muralikrishnan and V. Raghu venkataraman (2009), *Direct georeferencing of LFDC imagery for*

disaster management support, presented at ISPRS international workshop, at INCOIS Hyd, India.

2. Angel Martín, Ana B. Anquela, José L. Berné and Miriam Sanmartin (2012), *Kinematic GNSS-PPP results from various software packages and raw data configurations*, Scientific Research and Essays,Vol. 7(3), pp. 419-431.

3. Honkavaara, E., Ahokas, E., Hyyppä, J., Jaakkola, J., Kaartinen, H., Kuittinen R., Markelin, L., Nurminen, K. (2006), *Geometric test field calibration of digital photogrammetric sensors*, ISPRS Journal of Photogrammetry & Remote Sensing,60, pp. 387-399.

4. http://igscb.jpl.nasa.gov/components/prods_cb.html for down loading ephemeris.

5. Kwo-Hwa Chen, Hsin-Ta Liu and Jin-Tu Huang, (2009), *The Kinematic Positioning Accuracy of Using GPS Precise Point Positioning (PPP) Technique: a case study in supported Aerial Triangulation,* ISPRS Journal of Photogrammetry and remote Sensing, Volume 14, No.1.

6. Ola OVSTEDAL, NarveSchipper KJORSVIK and Jon Glenn Omholt GJEVESTAD (2006), S*urveying using GPS precise point positioning,* Shaping the Change, XXIII FIG congress, Munich, Germany,8-13.

7. Tuchband T. (2011), *GPS Precise Point positioning with kinematic data,* POLLACK PERIODICA, Vol.6, No.2.

8. XiuxiaoYaun, Jianhong FU, Hongxing Sun and CharlesToth (2009), *The application of GPS precise point positioning technology in aerial triangulation,* ISPRS Journal of Photogrammetry and remote Sensing, 64, pp. 541-550.

9. Zebedin, L., Klaus A., Gruber-Geymayer, B., Karner, K. (2006), *Towards 3D map generation from digital aerial images,*ISPRS Journal of Photogrammetry & Remote Sensing, 60, pp. 413-427.

10. Zumberge, J.F., Heflin, M.B., Jefferson, D.C., Watkins, M.M & Webb, F.H. (1998)*Precise Point Positioning for the efficient and robust analysis of GPS data from large*

11. *network*, J. Geophysical Research, Vol.102, No. B3, pp. 5005-5017.

GPS Permanent Station (PS) Data Archival and Analysis

U. N. Mishra
Director, Geodetic & Research Branch
& Virendre Dutt, Officer Surveyor
Survey of India, Dehradun

Abstract

Geodetic measurements obtained with the Global Positioning System (GPS) are increasingly more widely applied in geophysical studies. The Department of Science and Technology has launched a National Programme on Global Positioning System (GPS) for geodetic studies and monitoring the Crustal deformations due to earthquake occurrence and other geophysical phenomena, on the recommendations of an Expert Group set up by DST for the purpose. The Group recommended that an extensive GPS control network consisting of permanent stations (PS), semi-permanent stations and field stations should be established. Already, 44 permanent GPS Stations and 20 GPS stations collocated at tidal observatories all over India have been established and initiative is being taken to establish more permanent stations in future. A number of semi-permanent stations have also been established all over the country with the help of different universities and research organizations. A National GPS Data Centre has been established at Survey of India, Dehradun, where all the data of permanent stations are being stored and analyzed. The GPS data of PS is also being supplied to researchers on their demand. In addition to the above more than 2500 GCP has also been established under the Phase-I and Phase-II of GCP library scheme.

In this paper, we have analyzed the GPS data collected at Indian Permanent Station (PS) and in Antarctica during the last few years. The GPS data has been processed using Bernes 5.0 software. While processing the GPS data all the important files used by the Bernes 5.0 software has been taken into account. The velocity vector of various PS has been computed and it has been noticed that the Indian Plate is moving in the North-East direction at a rate of about 5cm/year.

Introduction

The Global Positioning System (GPS), designed by the US Department of Defense for military and civilian navigation and positioning, has become the geodetic method of choice for studying a wide range of geophysical phenomena. GPS measurements are now in use to determine the motion of the Earth's tectonic plates, to study deformation around active faults and volcanoes, and to measure the adjustment of the Earth's surface due to past and present changes in the mass of the world's ice sheets. GPS is used in combination with tide gauges to monitor global changes in sea level. As GPS signals are measurably delayed when they pass through the earth's atmosphere, GPS measurements are even able to contribute to atmospheric studies such as water content in clouds etc.

Several reasons contribute to the tremendous growth in GPS research. GPS provides three-dimensional relative positions with the precision of a few millimeters to approximately one centimeter over baseline separations of hundreds of meters to thousands of kilometers. The three-dimensional nature of GPS measurements allows one to determine vertical as well as horizontal displacement at the same time and place. Previously, horizontal measurements were often made by trilateration/triangulation and vertical measurements by spirit leveling. Furthermore, vertical and horizontal information together often place more robust constraints on physical processes than do either data type alone. GPS receivers and antennas are portable, operate under essentially all atmospheric conditions, and do not require inter-visibility between sites.

This paper emphasizes on the GPS data collection, dissemination and analysis collected from various Permanent Stations in India and two of our stations in Antarctica. The Permanent Stations are monitored by various Indian Universities and Research Organizations. The collected GPS data is stored, analysed at National GPS Data Centre (NGDC), Dehradun.

GPS Data Archival

The initiation to setup GPS Permanent Stations in India was started in 1998 with establishment of three GPS Permanent station in Survey of India premises at Bhubneswar, Pune and Trivendrum. Initially three Ashtech GPS receivers were installed at the above three locations. Since then 44 GPS permanent stations and 20 GPS stations collocated at tidal observatories have been established in the entire

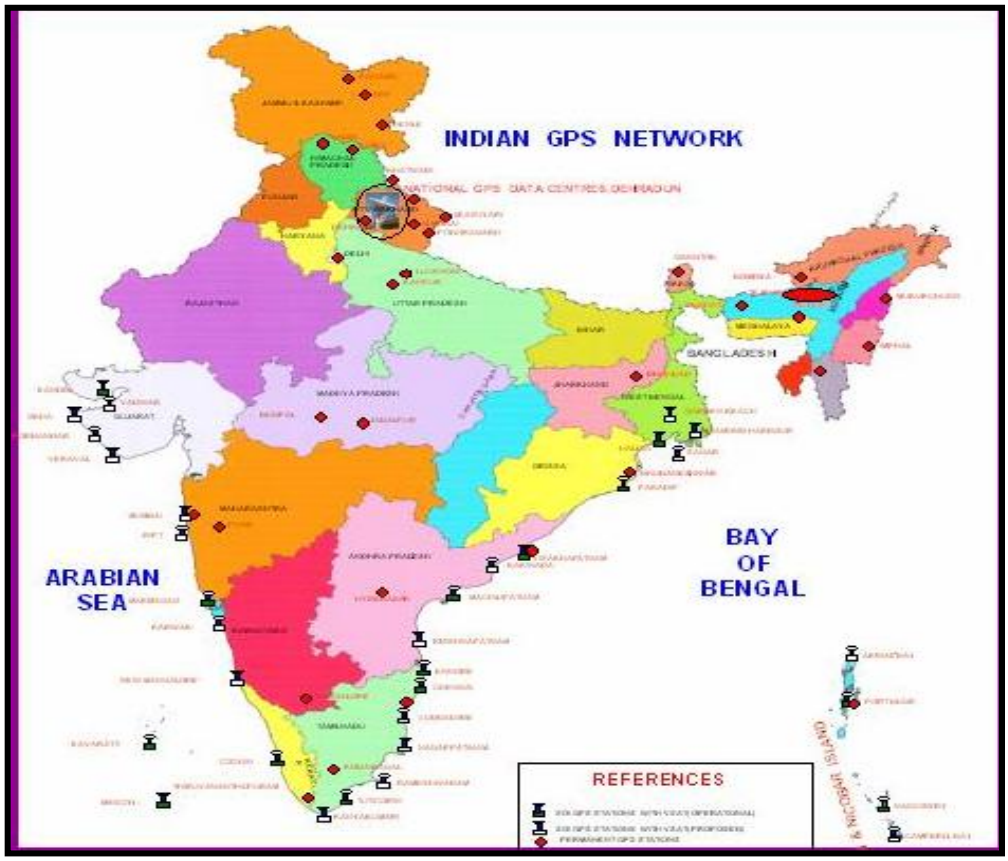
country. The 6 permanent stations namely Dehradun, Bhubaneswar, Pune, Trivendrum, Shillong and Port Blair and 20 GPS stations collocated at tidal observatories are monitored by Geodetic & Research Branch, Survey of India. The remaining 38 permanent stations are monitored by various research organization and universities. The GPS data in RINEX format of all 64 stations is archived at National GPS Data Centre, Geodetic & Research Branch Survey of India Dehradun. The location of GPS permanent stations is given below (**Map-1**).

estimate station velocity with ADDNEQ2 program in Bernese 5.0 software. The velocity of the permanent stations has been estimated using the Bernese 5.0 software by adjusting all epoch solutions (combination of all normal equations) in the ADDNEQ2 model.

Results and Analysis

GPS data of two to three years of various permanent stations has been processed using Bernese 5.0 software and reduced to a single epoch by combining

LOCATION OF PERMANENT GPS STATION IN INDIA



Map-1: Location of Permanent GPS Station in India.

GPS DATA PROCESSING AND ANALYSIS

The GPS data of permanent stations has been processed using Bernese 5.0 software. All required files like igs*.sp3, igs*.clk, igs*.erp, cod*.ion etc. downloaded from internet and used in processing to achieve the better accuracy. In order to compute combined coordinates of permanent stations at year wise campaign, the session's normal equations of the complete year are combined in the program ADDNEQ2. This procedure is repeated for several years.

If the multi-session solution cover a reasonable long time interval, e.g., one year or more, it is possible to

the normal equation using ADDNEQ2 program and velocities are computed. The comparative statement of three dimensional velocities of various permanent stations computed and estimated using Nuvel-1A model are given in the Table 1. In most of the Permanent stations it has been noticed that the actual computed velocity differ by about 1cm that of the estimated velocity using Nuvel-1A model.

The processed data also analysed for horizontal movement of the Indian Plate by converting the three dimensional x, y and z coordinates to latitude, longitude and ellipsoidal height and azimuth of each velocity vector has been computed. By inspecting the azimuth and velocities in terms of latitude and

longitude it can be concluded that the movement of the Indian plate is about 5cm per year in the NE direction. The results are shown in Table 2.

Only few permanent station data has been processed for several year and the variation in actual coordinates obtained and reduced by velocity are plotted in a graph form from Fig. 1 to Fig. 6. The graphs clearly show that the movement of the Indian plate is in the NE direction.

Table 1: Comparative Statement of Actual Computed Velocities and Velocities Computed Using Nuvela-1A Model

	STATION	NUVELA-1A			COMPUTED			DIFFERENCE		
		V_X	V_Y	V_Z	V_X	V_Y	V_Z	$\triangle V_X$	$\triangle V_Y$	$\triangle V_Z$
1	BOMDILA	-0.0384	-0.0210	0.0378	-0.0462	-0.0078	0.0220	0.0078	-0.0132	0.0158
2	LUCKNOW	-0.0380	-0.0130	0.0374	-0.0393	-0.0205	0.0292	0.0013	0.0075	0.0082
3	MUNSIYARI	-0.0368	-0.0148	0.0363	-0.0344	0.0107	0.0321	-0.0024	-0.0255	0.0042
4	TEZPUR	-0.0386	-0.0208	0.0380	-0.0445	-0.0115	0.0265	0.0059	-0.0093	0.0115
5	DEHRADUN	-0.0364	-0.0136	0.0359	-0.0333	-0.0035	0.0323	-0.0031	-0.0101	0.0036
6	BHUBANESHWAR	-0.0404	-0.0117	0.0398	-0.0384	-0.0073	0.0356	-0.0020	-0.0044	0.0042
7	COCHIN	-0.0414	0.0028	0.0406	-0.0451	-0.0013	0.0316	0.0037	0.0041	0.0090
8	ENNORE	-0.0415	-0.0026	0.0408	-0.0380	0.0208	0.0442	-0.0035	-0.0234	-0.0034
9	HALDIA	-0.0400	-0.0145	0.0394	-0.0464	-0.0321	0.0292	0.0064	0.0176	0.0102
10	KANDLA	-0.0374	-0.0030	0.0368	-0.0331	-0.0248	0.0193	-0.0043	0.0218	0.0175
11	KAVARATI	-0.0406	0.0049	0.0398	-0.0464	-0.0175	0.0256	0.0058	0.0224	0.0142
12	MACHHILIPATNAM	-0.0410	-0.0054	0.0403	-0.0342	0.0304	0.0413	-0.0068	-0.0358	-0.0010
13	PARADIP	-0.0405	-0.0123	0.0398	-0.0343	-0.0460	0.0315	-0.0062	0.0337	0.0083
14	VISAKHAPATNAM	-0.0409	-0.0080	0.0402	-0.0383	-0.0196	0.0211	-0.0026	0.0116	0.0191
15	KODIKANAL	-0.0415	0.0017	0.0408	-0.0598	0.0106	0.0391	0.0183	-0.0089	0.0017
16	RADHANPUR	-0.0375	-0.0046	0.0369	-0.0507	-0.0479	0.0216	0.0132	0.0433	0.0153
17	SHILLONG	-0.0389	-0.0195	0.0384	-0.0453	0.0151	0.0486	0.0064	-0.0346	-0.0102
18	SIKKIM	-0.0383	-0.0185	0.0378	-0.0421	-0.0040	0.0326	0.0038	-0.0145	0.0052
19	CAMP BELL	-0.0428	-0.0081	0.0421	0.0520	-0.0193	-0.0422	-0.0948	0.0112	0.0843
20	NANCOWRY	-0.0427	-0.0086	0.0420	0.0898	0.0538	-0.0324	-0.1325	-0.0624	0.0744
21	MAITRI	0.0086	0.0027	0.0032	-0.0023	0.0023	0.0294	0.0109	0.0004	-0.0262
22	LARSEMAN	0.0020	-0.0029	-0.0009	0.0627	0.1044	-0.1871	-0.0607	-0.1073	0.1862
23	LUMBANI	-0.0386	-0.0217	0.0381	-0.0442	-0.0167	0.0201	0.0056	-0.0050	0.0180

Table 2: Computed Velocities in Terms of Latitude and Longitude

	STATION	E.Height	LATITUDE	LONGITUDE	DIRECTION	Resultant Horizontal Movement
		V_h	V_{lat}	V_{long}		
1	BOMDILA	0.0049	0.0222	0.0465	64	0.052
2	LUCKNOW	-0.0104	0.0380	0.0356	43	0.052
3	MUNSIYARI	0.0202	0.0254	0.0357	55	0.044
4	TEZPUR	0.0035	0.0279	0.0451	58	0.053
5	DEHRADUN	0.0074	0.0331	0.0319	44	0.046
6	BHUBANESHWAR	0.0029	0.0369	0.0378	46	0.053
7	COCHIN	-0.0063	0.0332	0.0435	53	0.055
8	ENNORE	0.0239	0.0398	0.0409	46	0.057
9	HALDIA	-0.0202	0.0396	0.0453	49	0.060
10	KANDLA	-0.0242	0.0312	0.0228	36	0.039
11	KAVARATI	-0.0253	0.0308	0.0391	52	0.050
12	MACHHILIPATNAM	0.0353	0.0328	0.0384	49	0.051
13	PARADIP	-0.034	0.0462	0.0316	34	0.056
14	VISAKHAPATNAM	-0.0164	0.0273	0.0358	53	0.045
15	KODIKANAL	0.0044	0.0389	0.0606	57	0.072
16	RADHANPUR	-0.0475	0.0446	0.0330	36	0.055
17	SHILLONG	0.036	0.0367	0.0448	51	0.058
18	SIKKIM	0.0105	0.0313	0.0420	53	0.052
19	CAMP BELL	-0.0278	-0.0392	-0.0506	52	0.064
20	NANCOWRY	0.0431	-0.0388	-0.0930	67	0.101
21	MAITRI	-0.0283	0.0080	0.0028	19	0.008
22	LARSEMAN	0.2161	0.0431	-0.0360	-40	0.056
23	LUMBANI	-0.0029	0.0239	0.0454	62	0.051

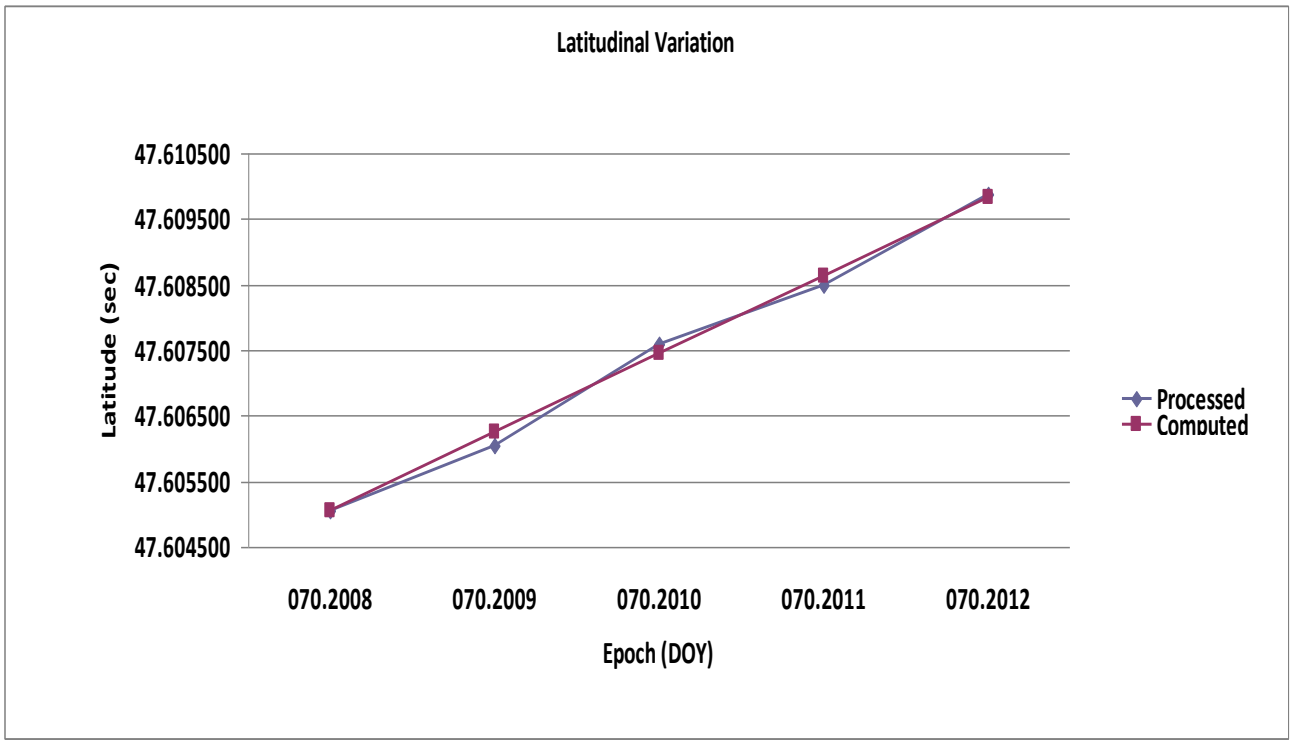


Fig. 1: Yearly Variation of Latitude of Bhubaneswar PS

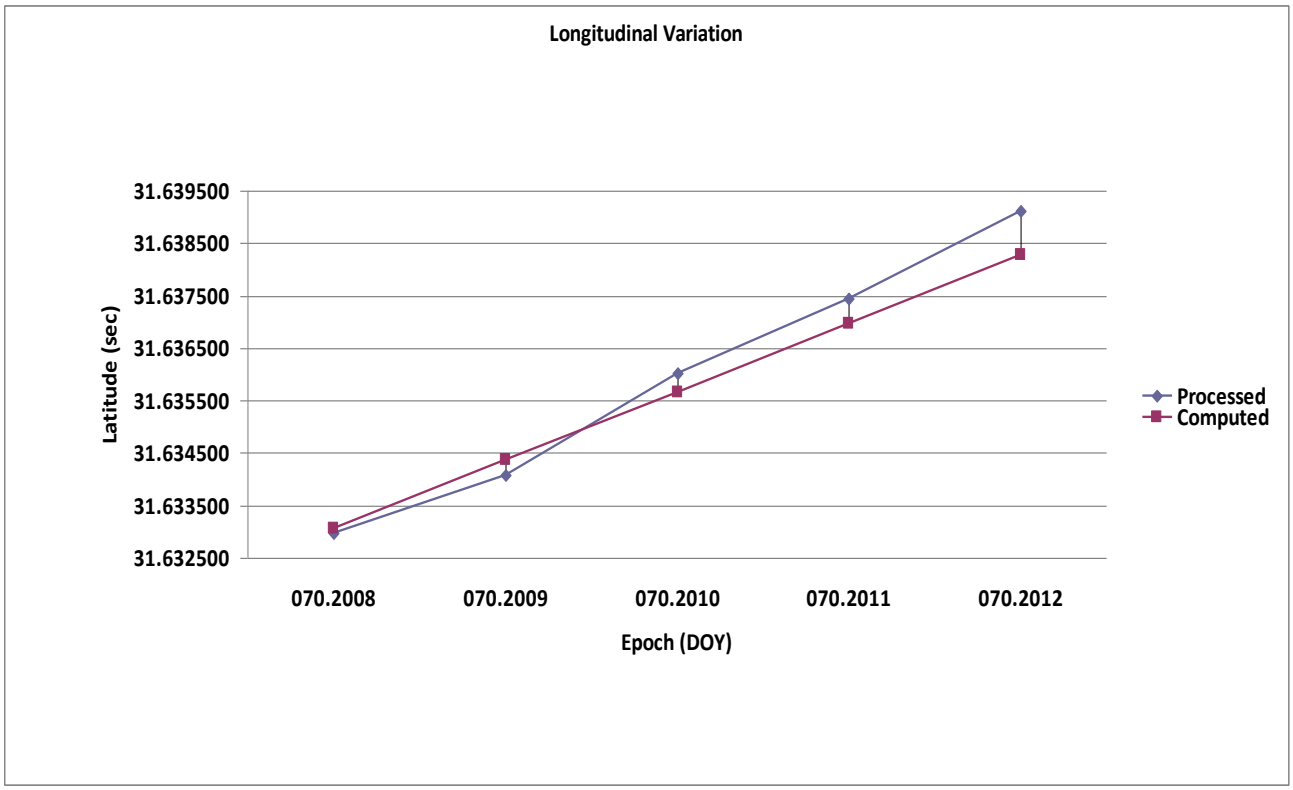


Fig. 2: Yearly Variation of Latitude of Bhubaneswar PS

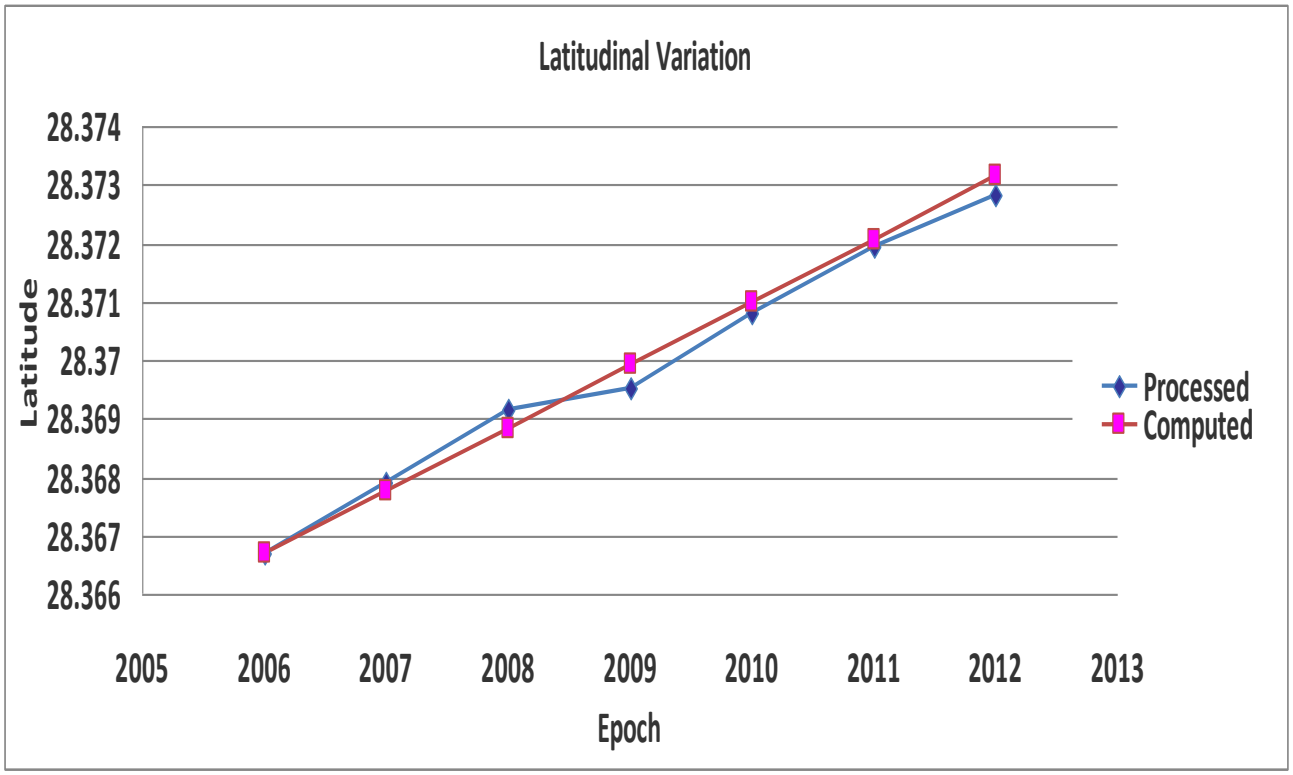


Fig. 3: Yearly Variation of Latitude and Longitude of Dehradun PS

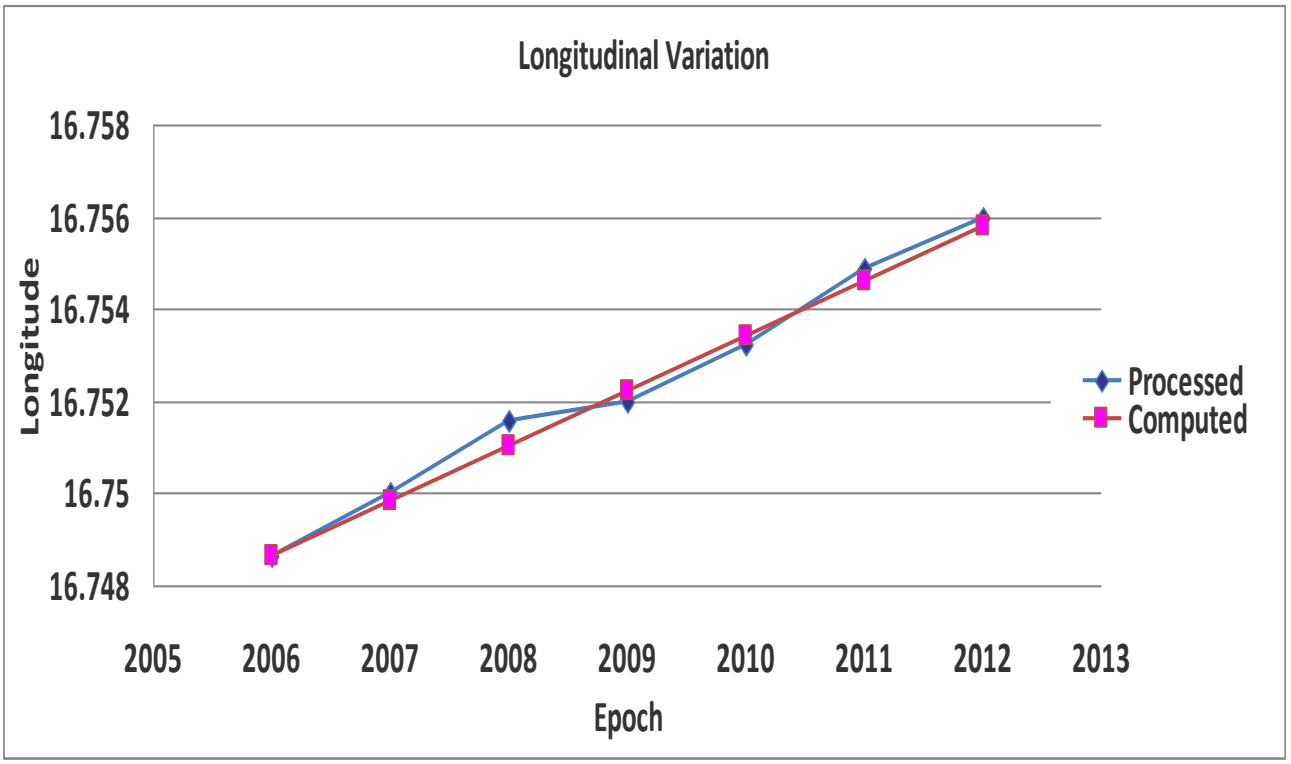


Fig. 4: Yearly Variation of Longitude of Dehradun PS

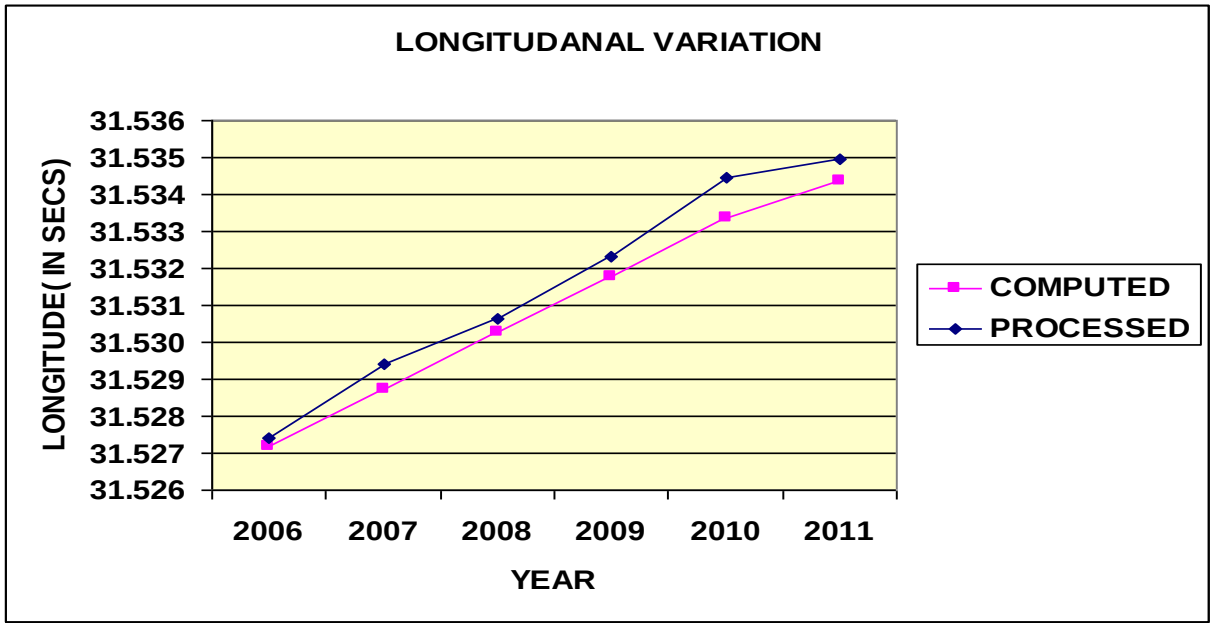


Fig. 5: Yearly Variation of Latitude and Longitude of LUMBANI PS

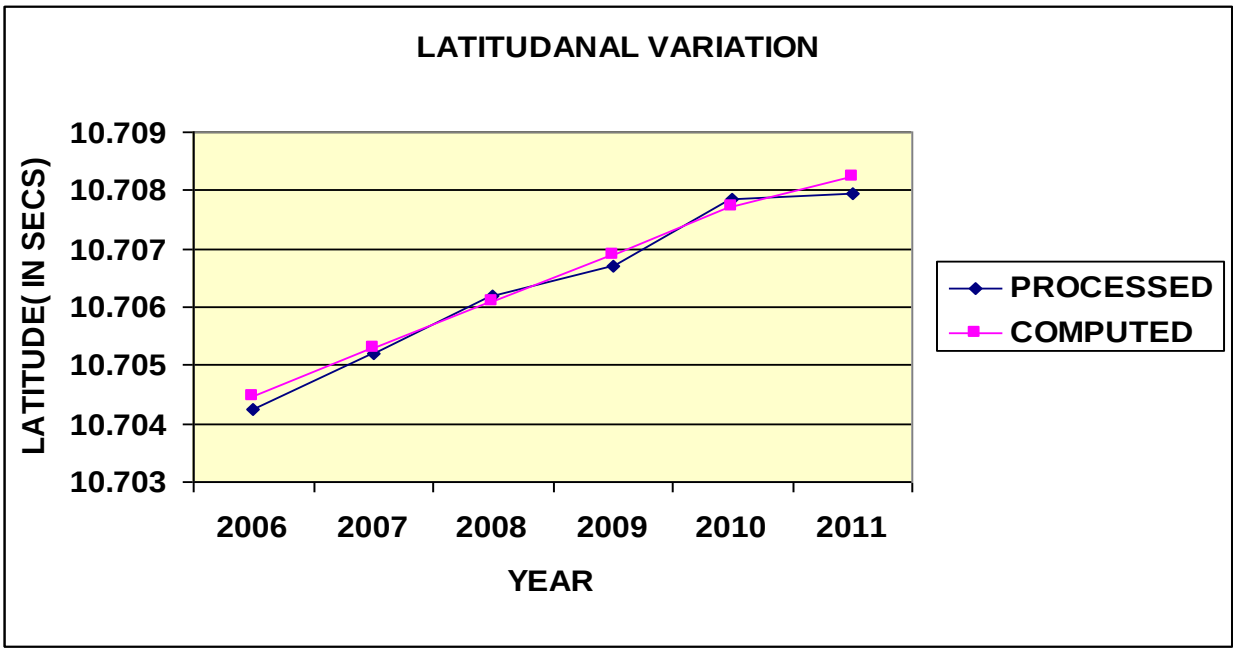


Fig. 6: Yearly Variation of Latitude and Longitude of LUMBANI PS

Conclusions

The analysis results shows that the movement of the Indian plate is about 5cm/year in the NE direction because of that the lofty Himalayas, which stretch 2900 km along the border between India and Tibet, are the visible creations of plate tectonic forces. The most dramatic effect of the moving Indian plate on its continental region is manifested at the Himalayan collision boundaries. The high elevations of the Himalaya and Tibet result from the continuing collision between India and Asia, which started more than 60 million years ago. Global plate models also predict that the velocity of Indian plate is approximately 5.0 cm/y in the north east direction.

Drainage Basin Analyses of Kaneri River Basin of Karnataka, India Using Visual Basic Programme bAd Calculator and GIS

A.C. Dinesh[1]* Vipin Joseph Markose[2] and K.S. Jayappa[2]
[1]Marine and Coastal Survey Division, Geological Survey of India, Mangalore,
[2] Dept. of Marine Geology Mangalore University, Mangalagangothri,
Karnataka, India - 574 199
**Email: acdinesh@rediffmail.com*

Abstract

Drainage basin analysis was carried out to describe the topography and drainage characteristics of Kaneri river basin of northern Karnataka, India. Linear basin parameters like stream number, stream order, stream length, stream length ratio, bifurcation ratio, length of overland flow, (b) aerial aspects like circulatory ratio, elongation ratio, drainage density and (c) relief aspects like basin relief, relief ratio, relative relief and ruggedness number were calculated for the 12 fourth order sub-basins of Kaneri river basin using visual basic programme bAd (bearing, azimuth and drainage) calculator. Spatial maps of areal and relief parameters were calculated in 1 sq.km. Grids and generated the spatial maps. The results show that bAd calculator can be used effectively for drainage basin analysis more accurately rather than conventional methods.

Introduction

Morphometric studies in the field of hydrology were first initiated by R.E. Horton and A.E. Strahler in the 1940s and 1950s. The drainage pattern characteristics of various basins and sub-basins have been studied using conventional methods in earlier times (Horton, 1945; Miller, 1953). Additionally, characteristics of stream networks can provide insight into various surface and subsurface processes (Horton, 1945; Strahler, 1957). Many studies have used various thematic layers such as geomorphology, drainage pattern, lineament, lithology, and soil for hydrological applications (Chowdhury et al., 2009; Saha et al., 2010) analyzed the relationships among morphometric and hydrologic parameters of seven basins in Southeastern Brazil using correlation and cluster analysis. Several software packages provide methods for analyzing watershed parameters in raster grids and remote sensing images. The use of GIS provides all of the additional advantages of using this type of software, such as many available data formats, geoprocessing tools, data editing and report possibilities. Shahzad and Gloaguen (2011a, b) developed TecDEM a MATLAB toolbox TecDEM includes a suite of algorithms to analyze topography, extracted drainage networks and sub-basins and it allows the extraction of parameters such as isobase, incision, drainage density and surface roughness maps. All these extensions and algorithms are used for extracting the drainage networks and watershed/sub-watersheds from DEM. The above review of commonly used programs is presented from the point of view of a computer scientist or a GIS specialist. However, it is more than evident that the need for software for measuring watershed morphometric parameters using a GIS approach is required.

Study Area

The Kaneri River extends from $14^0$59'49.46" to $15^0$12'58.85" N latitudes and $74^0$17'2.32" to $74^0$36'46.35" E longitudes in Uttara Kannada district of northern Karnataka, India forms the study area (Fig. 1). It is a 5^{th} order tributary of west flowing river Kali with a length of 62 km and covers a total drainage area of 425 km^2. The major part of the study area occupied by forest area of Dandeli and Anashi Wildlife Sanctuary. The land mass of the river basin is situated between 20 and 940 m above msl. The study area has a humid tropical climate along the coastal zone where the mean annual precipitation is around 3900 mm. The Kaneri river basin forms the western Dharwar craton of peninsular India and exhibits NNW-SSE trend. The basin is composed of various lithological units of Archean age of Dharwar Super-group of rocks. The major part of the study area is occupied by granitic gneiss and chlorite schist rocks. Minor occurrence of laterite and banded magnetite quartzite are also found as secondary formations. The rocks have been folded into a series of isoclinal antiforms and synforms. The major part of the Kaneri river basin is found in hilly regions of the Western Ghat.

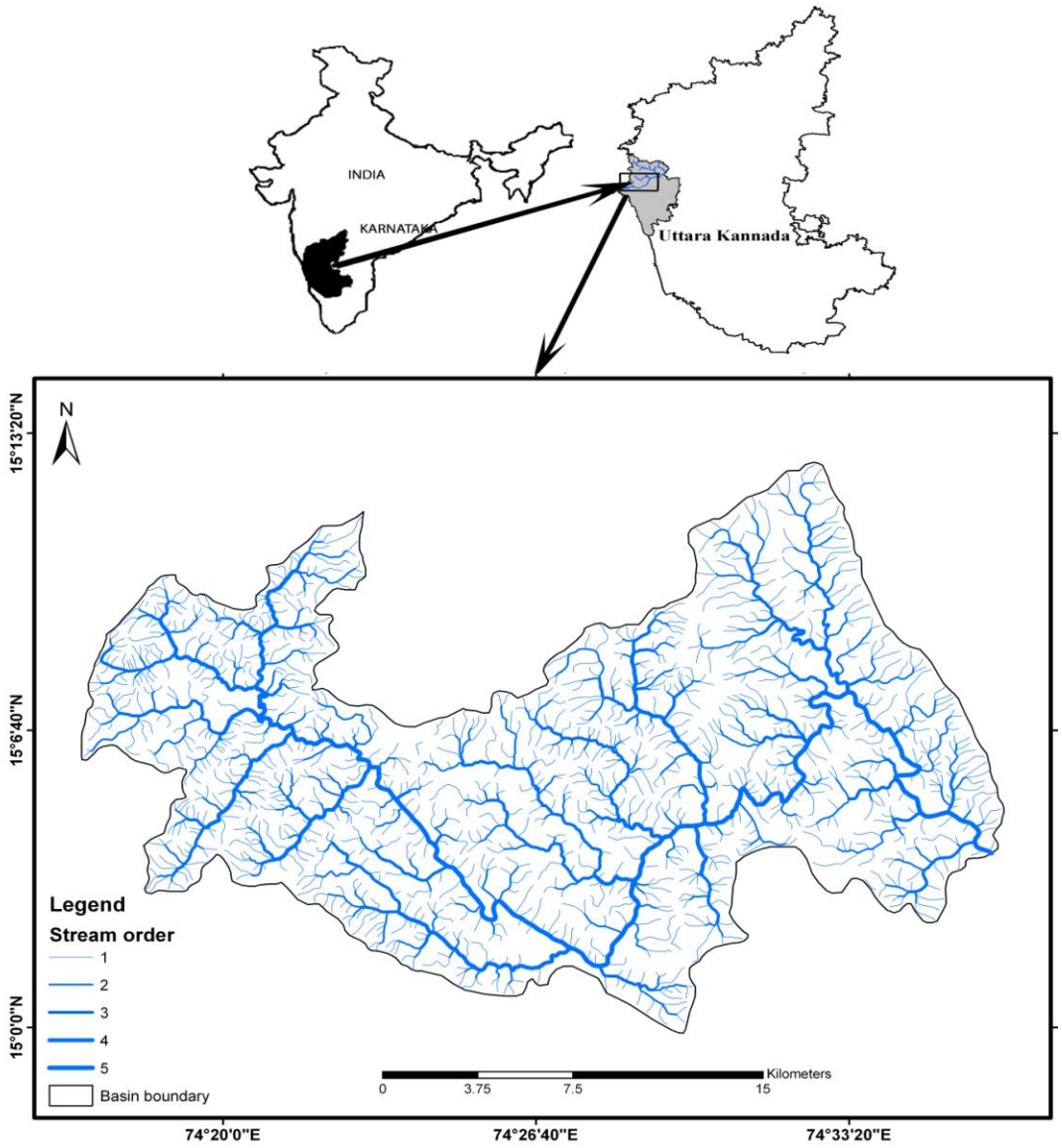


Fig. 1: Location and drainge map of Kaneri river basin.

Materials and Methods

Topographic maps (1:50,000 scale) of the study area published by the Survey of India were georeferenced with UTM projection (WGS 1984, Zone 43 N) using ArcGIS 9.3 software. The contour and drainage lines were digitized and stream ordering was done in accordance with Strahler's (1957) method. The entire area has been divided into 12 sub-basins with 4th orders and their boundaries were digitized using ArcGIS 9.3 software. The digitized data was converted into .txt format and imported to bAd calculator. The bAd calculator (Dinesh et al., 2012) is developed in Visual Basic 6 which supports widely used GIS software, ESRI's ArcGIS. The bearing/azimuth data of a large number of linear features such as drainage, faults and lineaments can be represented in the form of rose diagram using the software. The software calculates azimuth in two methods such as, end point azimuth and weighted average azimuth. For calculation of drainage basin parameters, two different methods are available in the software such as; calculate the values in user defined grids (e.g. 1 km^2) or in the sub-basin level. Fig. 2 shows the workflow diagram of the bAd calculator. The morphometric parameters were divided into four categories: linear parameters, areal, shape and relief parameters of the basin (Table 1). Spatial maps of morphometric parameters were calculated in 1 sq. km. grids and prepared the spatial maps using Inverse Distance Weighted interpolation methods.

Results and Discussion

Linear parameters: The calculated values of the linear parameters of the study area are shown in Table 1. Analyses of stream order length show that the length of first-order streams is much higher in sub-basin 3

and 7 than in other units. Sub-basin 5 and 8 has the lowest first-order stream length. Analysis of cumulative length of streams (L) shows that sub basins 2 and 6 have the highest L value, whereas, sub basins 7 and 10 have the lowest L value. The existence of high L value is due to structural complexity, high relief and impermeable bedrock. Bifurcation ratio, defined as ratio of number of streams in N^{th} order to N+1th order (Horton, 1945), is an important parameter describing stages of a river development. Spatial map of mean bifurcation ratio of the Kaneri basin is shown in Fig. 3 in which it is observed that Rbm values are distributed randomly with much variation in the values. But, in sub-basin level, the Rbm values ranges from 3.33 to 4.57 which is relatively a small variations. Strahler (1957) observed that Rb, characteristically ranges from 3 to 5 for watershed in which geologic structures do not distort the drainage pattern. Bifurcation ratio though varies from one order to the next order but tend to be constant for the entire basin which is the basis for Horton's law of stream number.

Areal parameters: The calculated values of the areal parameters and their spatial maps are shown in table 2 and figure 4 A, B, C & D). Drainage density is the ratio of the sum of lengths of streams to the grid area under consideration. When the drainage density of an area is high, it is indicative of high runoff and consequently low infiltration rate whereas low drainage density in an area implies low runoff and high infiltration (Prasad et al., 2008). Spatial distribution of Dd in the study area is shown in. Fig. 4A. High drainage density zones are present in the high relief areas of the Kaneri river basin. However, at the sub-basin level, sub-basin 2 has the highest value and sub-basins 4, 1, 5 and 7 follow it, respectively. About 80% area of the basin shows moderate to high drainage density values and low values are observed near to the basin boundary. Low Dd exists in 7, 6, and 12 and remaining sub-basins shows moderate Dd values (Table 1). High drainage density is the result of weak or impermeable sub-surface material, sparse vegetation and mountainous relief. The *stream frequency (Fs)* of a basin may be defined as the number of streams per unit area (Horton 1945). It is a measure of the closeness of the drainage. High drainage frequency means more surface runoff and low drainage frequency means more percolation and hence has groundwater potential (Sreedevi et al., 2009). At spatial scale, the Fs values of the study area ranges from low 1 to a higher Value of 14.93 respectively. As far as sub-basin is concerned, high Fs values are observed in sub-basin 1, 2,4,5 and 8 which indicate relatively higher relief; impermeable sub-surface material of the bed rock and high relief conditions prevails. Low values of Fs existing in sub basins 7 and 9, which are having high permeable geology and low relief (Table 1). The *length of overland flow (Lg)* is the length of stream flow paths, projected to the horizontal from the point of drainage divide to a point on the adjacent stream channel. The average length of overland flow is equal to half the reciprocal of the average drainage density. The length of overland flow value of the Kaneri basin ranges from 0.094 to 16 km^2/km whereas, Lg value for the forth order basins ranges from 0.14 to 0.22 (Figure 4 C, Table 2). The *drainage texture (T)* is an expression of the relative channel spacing in a fluvial dissected terrain. In simple terms T is the product of Dd and Fs. It depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development of a basin (Smith 1950). The drainage texture (T) of the Kaneri basin ranges from 0.094 to 16 km^2/km whereas, in forth order basin T values ranges from 5.22 to 18.70 (Fig. 4 D, Table 2).

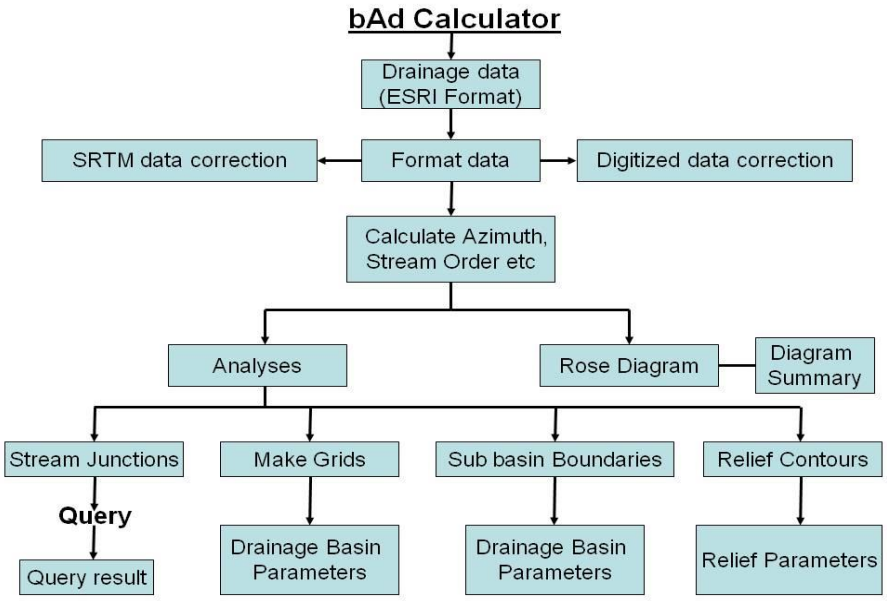


Fig. 2: Workflow diagram of bAd Calculator.

Table 1: Calculated values of linear parameters of 12 sub-basins.

No.	A	P	Lb	L_1	L_2	L_3	L_4	L	Rbm
1	20.64	27.51	8.26	43.67	11.82	3.50	5.89	64.86	4.36
2	18.14	20.43	6.37	42.35	7.86	5.16	6.21	61.58	3.59
3	19.10	20.41	6.93	30.96	10.01	5.41	2.01	48.39	4.25
4	16.14	20.70	8.35	35.05	6.89	3.43	5.45	50.82	4.03
5	17.12	19.12	6.68	33.12	8.72	2.79	5.83	50.47	3.93
6	26.47	28.68	11.24	40.49	10.61	6.66	8.06	65.83	4.31
7	34.68	30.39	9.78	44.12	13.20	17.17	1.70	76.19	4.32
8	19.21	20.97	7.58	37.98	7.42	8.02	2.26	55.68	4.47
9	9.26	14.54	5.74	16.87	2.01	2.94	2.02	23.83	3.42
10	32.81	28.31	9.33	55.44	14.96	5.01	10.65	86.06	3.74
11	8.80	12.22	3.93	14.83	4.66	3.82	0.20	23.52	3.33
12	51.19	32.95	10.33	70.06	26.38	12.04	5.80	114.28	4.58

Table 2: Calculated values of areal and relief parameters of 12 sub-basins.

No	Dd	Fsm	T	Lg	Rc	Re	Ff	HI	DI	R
1	3.14	4.36	13.70	0.16	0.34	0.62	0.30	0.46	0.39	400
2	3.39	5.51	18.71	0.15	0.55	0.75	0.45	0.46	0.33	300
3	2.53	3.30	8.35	0.20	0.58	0.71	0.40	0.37	0.28	240
4	3.15	4.96	15.62	0.16	0.47	0.54	0.23	0.56	0.31	280
5	2.95	4.38	12.91	0.17	0.59	0.70	0.38	0.41	0.33	280
6	2.49	3.59	8.92	0.20	0.40	0.52	0.21	0.41	0.34	260
7	2.20	2.71	5.96	0.23	0.47	0.68	0.36	0.49	0.38	280
8	2.90	4.16	12.07	0.17	0.55	0.65	0.33	0.52	0.41	300
9	2.58	4.00	10.29	0.19	0.55	0.60	0.28	0.54	0.39	280
10	2.62	3.81	9.99	0.19	0.51	0.69	0.38	0.49	0.48	380
11	2.67	3.53	9.43	0.19	0.74	0.85	0.57	0.42	0.53	420
12	2.23	2.34	5.23	0.22	0.59	0.78	0.48	0.62	0.61	440

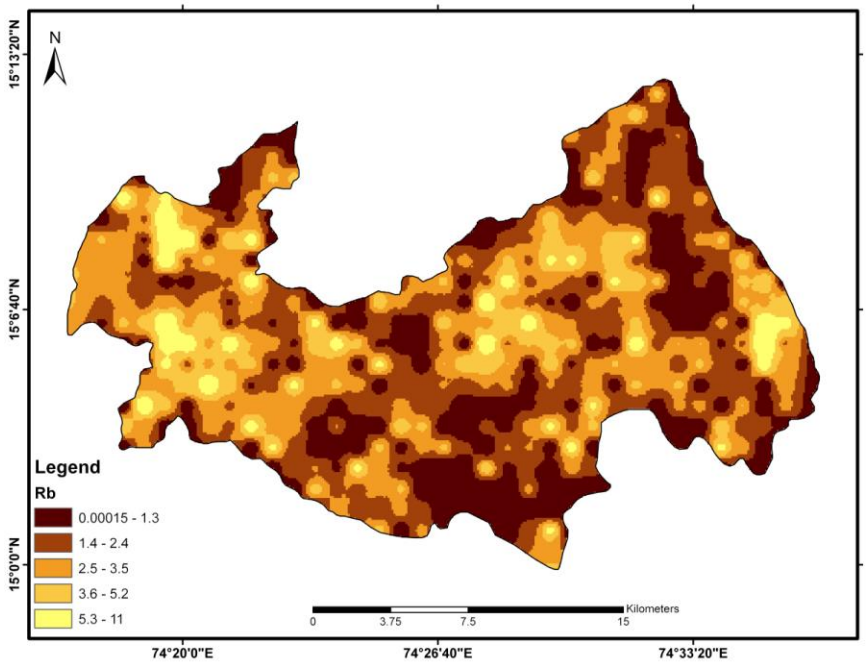


Fig. 3: Map showing mean bifurcation ratio of the Kaneri river basin.

Relief Parameters: The calculated values of relief parameters and their spatial maps are shown in Table 2 and figure 5 A, B & C. Relief is the elevation difference between the highest and lowest point on the valley floor of the region. The relief measurements like relief ratio, basin length and total relief have been carried out and the data are presented in Table 2. Relief aspect of the watersheds plays an important role in drainage development, surface and sub-surface water flow, permeability, landform development, and associated features of the terrain. *Basin relief (R)* is the difference in elevation between the highest and the lowest points of the basin. The R controls the stream gradient and therefore influences flood patterns and the amount of sediment that can be transported (Hadley & Schumm 1961).

Basin relief of the Kaneri basin ranges from 20 to 380 (Table 2). Compared to upper part of the basin, R shows high values in the river mouth part. In sub-basins, high R values is observed in sub-basin 12 followed by 1, 11 and 10. Lower R values are observed in sub-basin 2 to 9. The high relief value indicates the gravity of water flow, low infiltration and high runoff conditions. Relief ratio (Rh) is defined as the horizontal distance along the longest dimension of the basin parallel to the principal drainage line (Schumm 1956). In the study area, the values of relief ratio are ranging from 23.12 to 106.82. Relief ratio has direct relationship between the relief and channel gradient. The relatively higher Rh is an indicative of comparatively steeply sloping terrain and consequently higher the erosion processes operating along the hill slopes. Hypsometry has been historically used as an indicator of geomorphic forms of catchments and landforms. Hypsometry reflects landscape runoff and erosional process but also is strongly dependent on channel network and catchment geometry. Hypsometric integral for the sub-basins of Kaneri river basin ranges from 0.36 to 0.61 showing that the streams are in matured equilibrium stage as by the concept of Strahler (1952). Highest value of hypsometric integral is shown by the sub-basins 12 and 4 while sub-basin 3 has the lowest value. Dissection index (DI) is the ratio between the relative relief and absolute relief of the basin which always varies between zero (complete absence of dissection) and one (extreme case, vertical cliff at sea shore). According to the landform development cycle, higher dissection index value results due to differential cutting of once smooth land surface. It further implies that due to irregularity, more dissection occurs resulting in a plain surface. This implies that the higher the index value, the more is the dissection. The DI values of the study area range from 0.0014 to 0.82. High DI values exist in the lower part of the basin as compared to the upper part. Sub-basin 12 shows high DI value of 0.61 followed by 11,10 & 8 respectively.

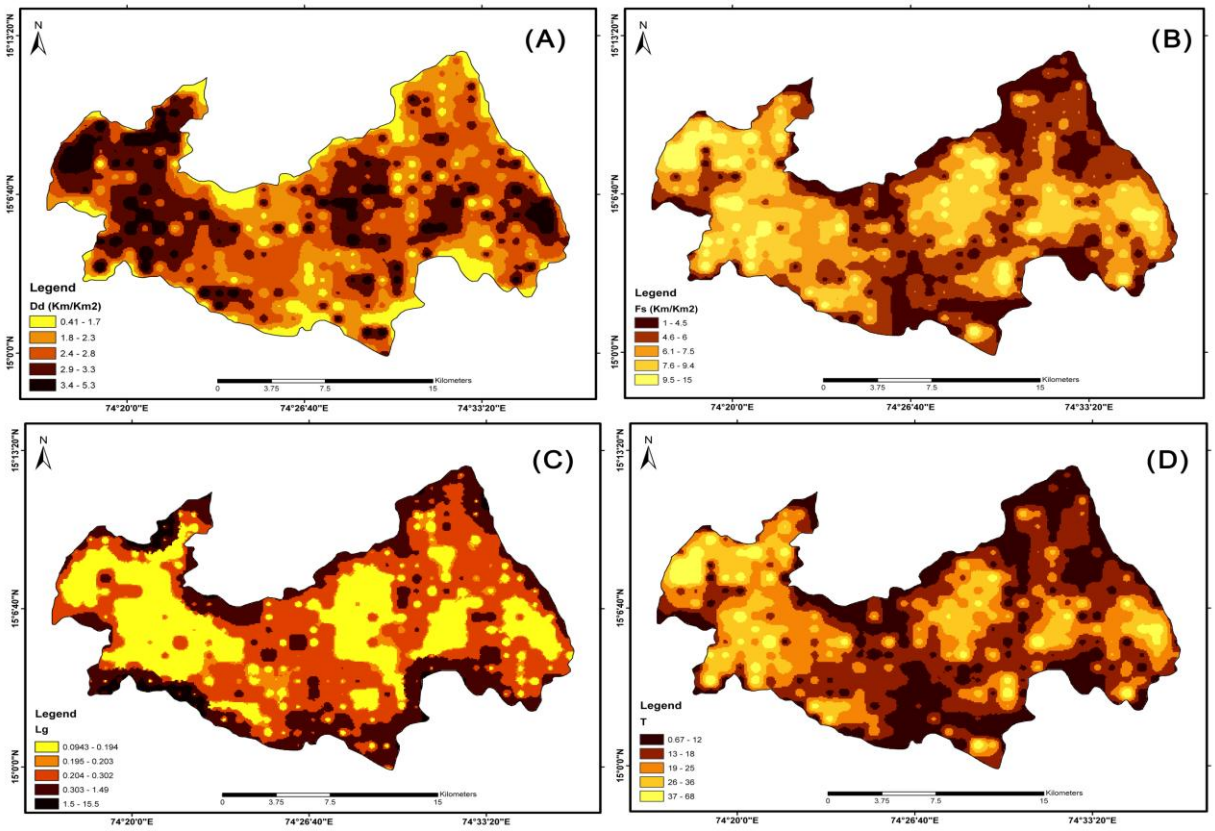


Fig. 4: Map showing spatial distribution of areal parameters. Drainage density (A); drainage frequency (B); length of overland flow (C) and drainage texture (D)

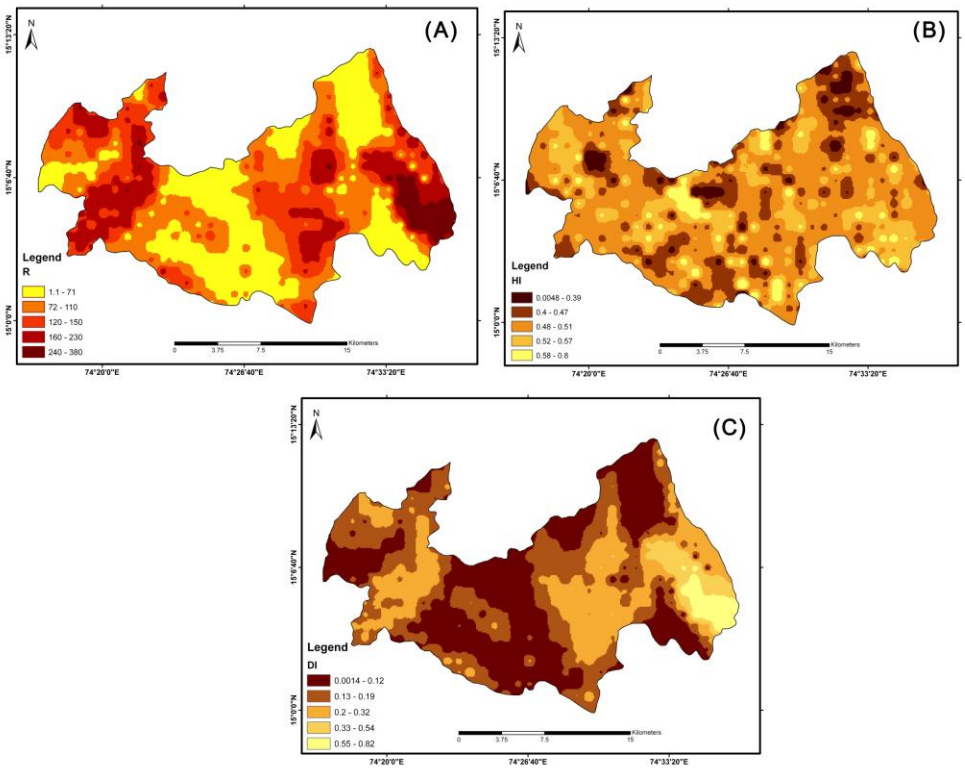


Fig. 5: Map showing spatial distribution of relief parameters. Basin relief (A); hypsometric integral (B) and dissection index(C).

Shape parameters: The calculated values of shape parameters are shown in table 2. In the study area, the Circularity ratio (Rc) values are ranging from 0.34 to 0.74. The basin has value of Rc less than 0.5 indicating that it is elongated, whereas the remaining sub-basins have greater than 0.5 values suggesting that they are more or less circular in shape and are characterized by the high to moderate relief and the drainage system were structurally controlled. The circularity ratio (Rc) is influenced by the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin. Rc 0.5 and above indicates that they are more or less circular and are characterized by high to moderate relief and drainage system is structurally controlled. Elongation ratio (Re) ranges from 0.52 to 0.85 (Table 3). High elongation ratio is observed in sub-basin 2, 11 and 12. Sub-basin located in the middle part of the basin shows moderate Re value. Values close to 1.0 are typical of regions of very low relief, whereas values in the range 0.6-0.8 are usually associated with high relief and moderate to steep ground slope (Strahler, 1964). Form factor (Ff) is defined as the ratio of the basin area to the square of the basin length. The smaller the value of the form factor, the more elongated will be the basin. Basins with high-form factors experience larger peak flows of shorter duration, whereas elongated watersheds with low-form factors experience lower peak flows of longer duration. The Ff value of the study area ranges from 0.29 to 0.56 which indicates that sub-basins are elongated in shape and lower peak flows of longer duration than the average. High Ff (>0.41) values are observed in sub-basin 2, 11 & 12 whereas; low values are observed in sub-basin 1, 4, 6 & 9.

Conclusion

Drainage basin analysis was carried out through measurement of linear, areal, relief and shape parameters of the 12 fourth order sub-basins of Kaneri river basin using visual basic programme bAd calculator. The existence of high L value is due to structural complexity, high relief and impermeable bedrock. About 80% area of the basin shows moderate to high drainage density values and low vales are observed near to the basin boundary. At spatial scale the Fs values of the study area ranges from low (1) to a higher Value of 14.93 respectively. As far as sub-basin is concerned, high Fs values are existed in sub-basin 1, 2,4,5 and 8 which indicate relatively higher relief; impermeable sub-surface material of the bed rock and high relief conditions prevails. Low values of Fs existing in sub basins 7 and 9, which are having high permeable geology and low relief. The length of overland flow value of the Kaneri basin ranges from 0.094 to 16 km^2/km whereas, Lg value for the forth order basins ranges from 0.14 to 0.22. Compared to upper part of the basin, R shows high values in the river mouth part. The high relief value indicates the gravity of water flow, low infiltration and high runoff conditions. Circularity ratio (Rc) values are ranging from 0.34 to 0.74. Sub-basin located in the middle part of the basin shows moderate Re value. The Ff value of the study area ranges from 0.29 to 0.56 which indicate that sub-basins are elongated in shape and lower peak flows of longer duration than the average.

Acknowledgement

The authors thankful to Shri. A. Sundaramoorthy, Director General, Geological Survey of India (GSI), Shri. S.C.Rath, Dy. Director General & HOD, Southern Region, GSI and Shri. G.P. Mohapatra, Dy. Director General, M&CSD, GSI, Mangalore for their support and giving permission to publish this paper.

References

1. Chowdhury, A., Jha, M. K., Chowdary, V.M., Mal, B.C., 2009. Integrated remote sensing and GIS-based approach for assessing groundwater potential in West Medinipur district, West Bengal, India. Int. J. Remote Sens. 30, 231–250.
2. Dinesh, A.C., Vipin Joseph Markose, Jayappa, K.S., 2012. Bearing, azimuth and drainage (bAd) calculator: A new GIS supported tool for quantitative analyses of drainage networks and watershed parameters. Computers and Geosciences, 48, 67-72.
3. Hadley, R. F., Schumm, S. A., 1961. Sediment sources and drainage basin characteristics in upper Cheyenne River basin. Washington DC: US Geological Survey Water-Supply Paper 1531-B, 198.
4. Horton, R. E. (1945) Erosional development of streams and their drainage basins. Hydrophysical approach to quantitative morphology. Geol Soc Am Bull 56(3):275–370.
5. Miller, V.C., 1953. A quantitative study of drainage basin characteristics in the mountain area. Virginia and Tennessee. Technical report. Office of Naval research, Department of Geology, Columbia University, New York.
6. Prasad, R.K., Mondal, N.C., Banerjee, P., Nandakumar, M.V., Singh, V.S., 2008.

Deciphering potential groundwater zone in hard rock through the application of GIS. Environ. Geol. 55, 467–475.

7. Saha, D., Dhar, Y.R., Vittala, S.S., (2010). Delineation of groundwater development potential zones in parts of marginal Ganga Alluvial Plain in South Bihar, Eastern India. Environ. Monit. Assess. 165, 179–191.
8. Schumm , S. A., 1956. Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geological Society of America Bulletin 67, 597 - 646.
9. Shahzad, F. and Gloaguen, R. TecDEM: A MATLAB based toolbox for tectonic geomorphology, part 2: Surface dynamics and basin analysis. Computers & Geosciences, 2010.
10. Smith, K.G., 1950. Standards for grading texture of erosional topography. American Journal of Science 248, 655 – 668.
11. Sreedevi, P.D., Owais, S., Khan, H.H., Ahmed, S., 2009. Morphometric analysis of a watershed of South India using SRTM data and GIS. Journal of Geological Society of India. 73, 543–552.
12. Strahler, A. N., 1957. Quantitative analysis of watershed geomorphology. Transactions of the American Geophysical Union 38, 913 - 920.
13. Strahler, A. N., 1964. Quantitative geomorphology of drainage basins and channel networks. In: Chow V.T. (ed.) Handbook of applied hydrology. McGraw Hill, New York, 4 - 76.

Study on GCP Configuration for Block Adjustment of Airborne Digital Data

E. Anantha Padmanabha, B. Narender, S. Muralikrishnan.
Aerial Services & Digital Mapping Area, National Remote Sensing Centre – ISRO.
E-mail: (anantha_p, naren_br, muralikrishnan_s)@nrsc.gov.in

Abstract

Airborne Large format digital cameras (LFDC) have almost replaced the conventional film based analogue cameras, as there are numerous advantages that save time, effort and money. An airborne Large Format Digital Camera equipped with Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) makes a valuable combination that can provide quick and effective solution. The block adjustment of LFDC data can be done by Directly Georeferencing (DG) or by block adjustment with the use of control points.

In the paper, optimum ground control point (GCP) requirement for the block adjustment of LFDC data is studied. The block adjustment result for various GCP configurations is studied. From the results it is observed that a minimum of 3 GCPs are required to achieve an accuracy of 1 pixel in planimetry and also for one and half pixels in height. In case of direct georeferencing the planimetric accuracy is 4 pixels and vertical accuracy is 2 pixels.

Introduction

The photogrammetry has gone fully digital with the inception of airborne digital cameras. Earlier with conventional film based cameras the acquisition is used to be in analog format. Presently with digital cameras, right from acquisition to the final product the process is completely digital. The digital cameras have various advantages that can significantly contribute to the quality of the products and better productivity (Anantha et al., 2009). Initially there was a limitation with the area of coverage, but with innovative use of multiple CCD arrays, the digital cameras can now match the coverage of analog cameras (Honkavaara et al., 2006). There are fairly good numbers of airborne digital cameras available commercially (Passini and Jacobsen, 2008). The choice of camera depends mainly upon the accuracy requirement, effective coverage, cost, ease of operation, compatibility with other ancillary sensors etc.

Ancillary sensors like Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) contributed to the acceptance of Large Format Digital Cameras as substitute to the aerial film cameras. These sensors are capable of providing the georeferencing information for each frame in the form of position (X,Y,Z) obtained from GNSS and attitude (ω, φ, κ) from IMU. Through simultaneous operation of these sensors along with the digital camera, the image data can be directly oriented by Direct Georeferencing (DG) i.e., without use of any ground control. The accuracy that can be achieved through DG still cannot match the accuracy achieved by Block adjustment using GCPs. But for special applications like Disaster Management Support, Search and Rescue and for mapping inaccessible areas the DG can be acceptable.

For cartographic and engineering applications block adjustment using GCPs looks to be inevitable at least in the near future. The accuracy that can be achieved through block adjustment depends primarily on the quality, distribution and the number of GCPs. There are other factors like size and shape of the block of images, quality of images, tie and pass point distribution, overlaps and sidelaps, the terrain type etc which also contribute to the final accuracy. If for a given block sufficient number of quality GCPs are there then the effect of all other factors can be kept under control. During last couple of decades there have been milestones in photogrammetry which contributed to the reduction in the requirement for ground control in block adjustment. These milestones include Aerotriangulation, Onboard GNSS for exposure station position and IMU for attitude of the platform. LFDC along with GNSS and IMU could significantly reduce the GCP requirement in block adjustment. All the systematic errors like LFDC and GNSS antenna offset, LFDC and IMU boresight misalignment should be precisely calibrated. Still the GCPs cannot be avoided completely due to non systematic errors in deriving the exposure station coordinates and platform attitude parameters. In the present scenario it is very important to know approximately the GCP requirement for a given block of images. This would ensure the required geometric accuracy for a project without unnecessary expenditure and manual effort.

In the present study an attempt has been made to study the optimum control point requirement for block adjustment of LFDC data, when used in combination with GNSS and IMU data. The results obtained in the study are applicable at block adjustment level only.

Study Area and Data Used

The study area is Bengaluru city of Karnataka state in India. Bengaluru city is one of the major metros in India with highrised buildings and can be classified as a dense urban area with undulating terrain. The total study area is 1245 sq.km and covered by 5057 images using LFDC at 20 cm GSD, with forward overlap of 80% and lateral overlap of 60%. The area falls under the 43rd zone of UTM projection.

Methodology

Digital images of the study area were acquired using Large Format Digital Camera (LFDC) onboard the aircraft. The data acquisition was carried out as per the flight plan with the aid of Computer Controlled Navigation System (CCNS) fitted in the aircraft. The aircraft also carried a GNSS antenna and an IMU unit onboard for simultaneous acquisition of data related to the position and attitude of the platform for each exposure station. During the flying operation, a GNSS base station was operated within the study area to serve as reference during post processing.

In the present study Vexcel Ultracam-D Camera is used to acquire LFDC images. The sensor unit of Vexcel's UltraCamD consists of eight independent cameras, so-called cones. Four of them create the large format panchromatic image at a size of 11500 by 7500 pixels. The other set of four cones is responsible for the multispectral channels of the UltraCamD, i.e. red, green blue and near Infrared. The panchromatic part of the camera combines a set of 9 medium format CCD sensors into a large format panchromatic image. The multispectral channels are supported by four additional CCD sensors (Leberl 2003). The specifications of the camera is given in Table 1. The raw data from the sensors LFDC, GNSS and IMU was imported into the corresponding processing systems. Raw LFDC data was preprocessed through different levels to obtain the final pan sharpened images at the required resolution. GNSS and IMU data was processed with reference to the base station that was operated in the study area.

Ultra Cam-D Camera Specifications	
Panchromatic Image Size	11500 x 7500 pixels
Color Image Size	3680 x 2400 pixels
Pixel size of panchromatic camera	9 µm
Panchromatic lens focal distance	100 mm
Color lens focal distance	28 mm
Frame rate per second	>1 frame per second
Shutter speed options	1/500 to 1/32 seconds
Angle of View from vertical, cross-track (along-track)	55^0 (37^0)

Table 1: Specifications of Ultracam-D Camera

Processed data from different sensors was imported and integrated in a photogrammetry system for further processing. The project was created in the processing system with all the required parameters with corresponding datum and projection. First the LFDC data of the study area was imported into the photogrammetry system and pyramid layers were generated for ease in handling the image data. The EO parameters derived with reference to the base within study area were imported into the project and registered with the LFDC images.

Existing Ground control points (GCP) that were collected in the study area for a previous project with analogue camera were used. The points that were falling in the study area were selected and were carefully verified for any possible change using the field photos and latest LFDC data. A total of 59 points were finalized and imported into the project. Out of these points, 10 points which are well distributed all over the study area were kept as check points and the remaining 49 points were used for adjustment of the data. Normally in Photogrmmetric adjustments checkpoints of superior quality are used to evaluate the accuracy (Maune, 2007). Coordinates at these 10 check points were observed in stereo and compared with the ground coordinates. The distribution of control and check points in the block is shown in Fig. 1. All the 59 GCPs were measured precisely in the respective images. Tie points for all the images were generated through Automatic Point Matching (APM). The blunders in tie points were identified and eliminated. Connectivity between the images was ensured by manually measuring the points to fill up the gaps. Inpho 5.4 software is used for photogrammetric processing of data i.e DG and block adjustment of LFDC data.

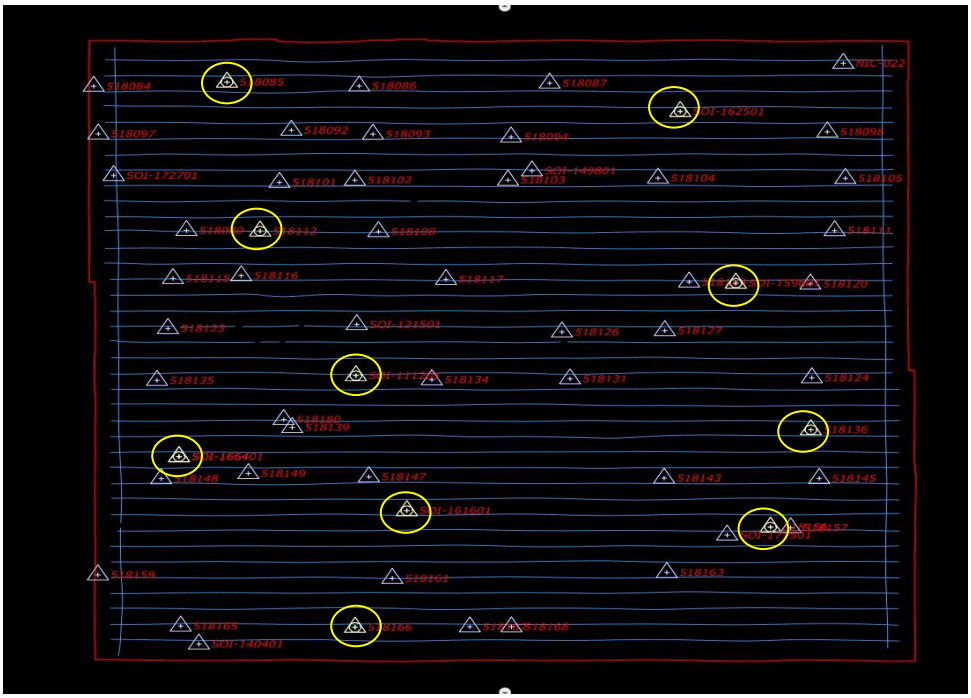


Fig. 1: Distribution of control and check points in the block

Block Adjustment of LFDC Data

The block adjustment of LFDC data is carried by two methods viz i) Direct Geo referencing method ii) With use of control points

Direct Geo referencing

In direct Geo referencing method, block adjustment is carried with use of EO parameters derived from GNSS and IMU, without use of GCPs. GNSS gives the X, Y, Z coordinates (space coordinates) for each frame, IMU gives orientation parameters of aircraft for each frame in terms of angles(omega, phi, kappa). After block adjustment the coordinates of 59 points are measured and compared with the actual ground coordinates. The Residuals in Easting, Northing and height is 0.77 m, 0.42 m, 0.41 m respectively. The graphical representation of DG results at 59 check points is shown in Fig. 2.

Block adjustment with control points

In this method the block adjustment is carried with EO parameters derived from GNSS and IMU and using GCPs., Control point configurations were planned starting with single point in the center of the block and ending with the use of all the 49 points. The increment in the number of GCPs is started with 1 initially and gradually increased up to maximum of 7. A total of 19 GCP configurations have been finalized for the analysis. Block adjustment process is repeated for all the 19 GCP configurations and residuals at the 10 checkpoints were noted for every adjustment. Root Mean Square Error (RMSE) of the check points for each adjustment process was computed and tabulated (Table 2). The plot between No. of GCPs and RMSE in X,Y,Z is shown in Fig. 3.

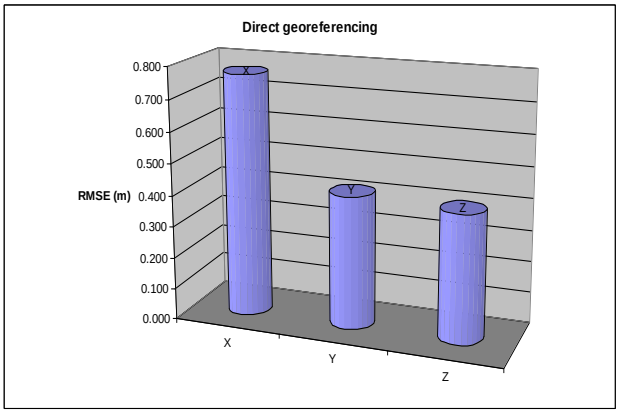


Fig. 2: RMSE in X,Y,Z at 59 check points using direct geo referencing

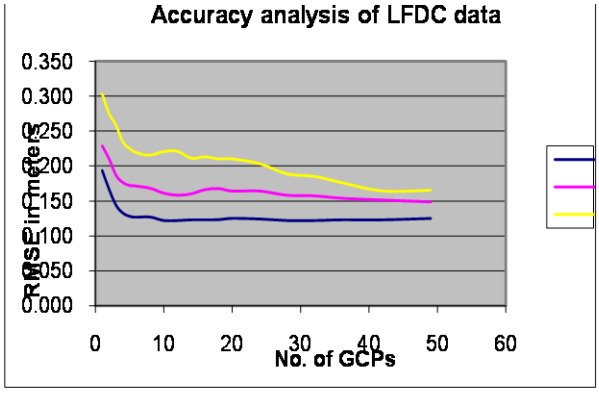


Fig. 3: Graph showing trend in RMSE for different control point configuration

S.NO	No. of GCPs	RMSE(X) (m)	RMSE (Y) (m)	RMSE (Z) (m)
1	1	0.194	0.228	0.303
2	2	0.167	0.210	0.275
3	3	0.144	0.187	0.259
4	4	0.133	0.176	0.235
5	5	0.128	0.172	0.225
6	6	0.127	0.171	0.219
7	8	0.127	0.168	0.215
8	10	0.122	0.161	0.221
9	12	0.122	0.158	0.221
10	14	0.123	0.160	0.211
11	16	0.123	0.166	0.213
12	18	0.123	0.168	0.210
13	20	0.125	0.164	0.210
14	24	0.124	0.164	0.203
15	28	0.122	0.158	0.189
16	32	0.122	0.157	0.185
17	36	0.123	0.154	0.176
18	42	0.123	0.151	0.164
19	49	0.125	0.149	0.165

Table 2: RMSE at 10 check points using different control point configuration

Results and Conclusion

From the results (Fig. 2), it is observed that, Direct Geo referencing gives accuracy of 0.87 m in planimetry and 0.47 m in height. The errors in planimetry are double, when compared to that of height.

Block adjustment of LFDC data (~ 5000 images) is done with different control point configuration, and the RMSE is computed at 10 check points. From Table 1 it can be inferred that RMSE in X (Easting) is better than 1 pixel for all configurations and RMSE in Y (Northing) is better than 1 pixel when 3 GCPs are used, and RMSE in height is of one and half pixel, when 3 GCPs are used.

From the results it can be seen that with DG the accuracy at X, Y and Z are 0.769m, 0.421m, 0.406m. When one GCP was used for adjustment the RMSE is 0.194m, 0.228m, 0.303m for X, Y and Z. When all the 49 GCPs were used the RMSE values are 0.125m, 0.149m, 0.165m respectively. The RMSE for X has been better than 1 pixel for all the configurations. The RMSE for Y was better than 1 pixel for GCPs 3 and more. Whereas, an accuracy of one and half pixel in height has been achieved with a configuration of 2 GCPs. It is always better to keep the fieldwork minimum due to obvious reasons of economy and comfort. But this optimization should be adopted without compromising with the required accuracy. The accuracy that can be achieved at block adjustment level for LFDC data depends upon various factors, but mainly on number, quality and distribution of GCPs.

In the present study an attempt was made to understand the effect on accuracy of LFDC data with number of GCPs and their distribution. From the results we can say that for this block a minimum of 3 GCPs are required to achieve an accuracy of 1 pixel in planimetry and also for one and half pixels in height. The RMSE with direct geo referencing (DG) is more in X, the reason for this could be the drift in flying direction. The block adjustment accuracy also depends upon many other factors such as the size and shape of the block, the GSD of LFDC data, the overlaps, the tie point network, LFDC internal geometry, accuracy of GCPs, measurement accuracy of control points in both planimetry and height etc.

Similar study needs to be carried for undulating terrain with high degree of terrain slope.

Acknowledgement

We express our sincere thanks to Dr. V.K. Dadhwal, Director NRSC for his support and encouragement during the study.

References

1. Ananatha Padmanabha E, Nalini J, Jayalakshmi I, Muralikrishnan S. and R aghuvenkataraman V, 2009. Direct georeferencing of LFDC imagery for disaster management support. ISPRS international workshop, at INCOIS Hyd, Nov. 2009.
2. Honkavaara, E., Ahokas, E., Hyyppä, J., Jaakkola, J., Kaartinen, H., Kuittinen R., Markelin, L., Nurminen, K., 2006. Geometric test field calibration of digital photogrammetric sensors, ISPRS Journal of Photogrammetry & Remote Sensing, 60, pp. 387-399.
3. Leberl F., R. Perko, M. Gruber, M. Ponticelli (2003). The UltraCam Large Format Aerial Digital Camera System, Proceedingsof the American Society for Photogrammetry& RemoteSensing, 5-9 May, 2003, Anchorage, Alaska.
4. Maune, D.F. (editor), 2007. Digital Elevation Model Technologies and Applications: The DEM User Manual, Second edition, ISBN1-57083-082-7, 655 p.
5. Passini, R., Jacobsen, K., 2008. Geometric analysis on digital photogrammetric cameras. ASPRS 2008 Annual Conference, Portland, Oregon, April 28- May2.

Hydrographic Services: A Must for Vast Resource Management to Ensure Sustainable Growth for Nation Building

Captain (IN) Lochan Singh Pathania[1], Lt Cdr Raja Abdul Rahiman[2]

INS Sandhayak, C/o Fleet Mail Office,
Visakhapatnam, India.
[1] lochanpathania@gmail.com
[2] rarahiman76@gmail.com

Abstract

Hydrography plays an integral role for the management and sustainable development of marine resources. Hydrographic data and information is required to produce nautical charts as well as to contribute to the decision making process on many other different activities that take place in and on the sea. This paper discusses the inherent value of hydrographic services and bathymetric surveys beyond the obvious benefit of improved nautical charts. The influence hydrographic information has in the decision making process of different activities of national importance is also described thus justifying the requirement of a National Hydrographic Service for any maritime country.

Introduction

Brief History of Hydrography: From time immemorial seas have been associated with opportunity, wealth, adventure, bravery and abundant resources. Mere size and expanse of oceans inspired people to venture into it and see its limits and check what lies beyond. There were notions of eternity and this fuelled deep desire of humankind for adventure into the oceans. However most of the voyages made by man in ancient times ended up with unexpected results or were a complete failure for want of adequate knowledge of the seas. Thus the origin of the science of hydrography was a consequence of the need for reliable information of the ocean designed to meet the mariner's needs at sea. As early as 2000 BC Mediterranean Sea-powers were familiar with the effects of wind, tide, currents and ocean depths. For generations these seamen have navigated the seas with the help of oral as well as written directions handed down from their predecessors. These directions were basically personal accounts of experienced mariners compiled over a period of time and were guarded dearly, as the efficacy of the master mariner depended upon his ability to navigate safely at sea.

The oldest known navigational chart today is the Carte Pisane from the 13 C, known as Portolans which was drawn on animal skin and depicted interconnecting rhumblines representing 32 directions, coastlines, coastal names etc. This chart was probably drawn at a marine cartography school in Genoa. At about the same period similar schools were known to exist in Venice and Isle of Majorca [1].

The hand lead and line and the marine sextant became the most important instrument in the Hydrographers' inventory and remained practically



Fig 1: Carte Pisane, Source Wikipedia

unchanged till the previous century. During the last century with the invention of the Echo sounder and electronic positioning systems which could provide accurate positional information and distances, beyond visual range and over the horizon and finally Satellite based positioning systems, the science of hydrography has grown by leaps and bounds. More recent inventions like multi beam echo sounders, sound velocity profilers, automated tide gauges, GPS, ENCs etc. has helped in evolving hydrography into the specialized field of precision science that it is today.

Justification for the Study

The vastness of the oceans that fuelled our inspiration and curiosity, suggested that there could be few if any limits to its use or abuse. Our growing understanding of the oceans has fundamentally changed this perception. It has led to a growing appreciation not only of the importance of the oceans to social and economic progress but also of their vulnerability. We now know that abundance is giving way to scarcity

and in some cases at an alarming rate, and to conflicts arising from their use [2]. Therefore, it is of paramount importance that we take utmost interest and care in managing resources of the Oceans.

Importance of Management of Resources:
When nature is assigned with a value and used for human consumption and benefits it becomes a resource. In other words, resource is nature appropriated by humans. The intrinsic value of the resource leads to competition for ownership and is ultimately used to enhance the wealth and opportunity of the owner. In most cases there is no clear delineation of ownership as everyone assumes a right to use but no one accepts any responsibility to preserve. As a result in most cases nature is abused rather than used. Drastic changes occur in nature as a result of these human activities/ interactions. Though some of these activities have immediate impact, most have global consequence which becomes evident only much later. This complex chain of events interacts with nature directly and indirectly causing depletion, disturbance or contamination. As the results of these interactions are almost always negative it becomes extremely important to carefully monitor and manage these interactions [3].

All resource use bears a cost to nature. Management of resource is about determining whether this cost is worth bearing, recognizing limits and developing capabilities to prevent these limits from being exceeded. Natural resources are indeed a gift of nature, but their value must not be under estimated and the resources exploited for gaining a short time advantage. The natural resources should be viewed as assets of human kind and should be managed rather than spent [4].

Impact of Hydrography:
Although the principal objective of most hydrographic surveys is to obtain basic data for the compilation of nautical charts for ensuring safe navigation resulting in safety of life at sea, it also influences every other activity associated with the sea including maritime trade, resource exploitation, environment protection and management, marine boundary delineation, Coastal Zone Management etc. In brief, knowledge and practice of Hydrography is important to nation's progress on all maritime activities, is of great economic value and important for national development, employment generation and sustainable growth.

Hypothesis

To ensure sustainable growth and for nation building, Hydrographic services are a must for resource management.

What is Hydrography?

Hydrographic surveying deals with the configuration of the bottom and adjacent land areas of oceans, lakes, rivers, harbours, and other water forms on Earth. In strict sense, it is defined merely as the surveying of a water area; however, in modern usage it may include a wide variety of other objectives such as measurements of tides, current, gravity, earth magnetism, and determinations of the physical and chemical properties of water [5]. The definition of hydrography as adopted by the IHO says " Hydrography is that branch of applied science which deals with the measurement and description of the features of the seas and coastal areas for the primary purpose of navigation and all other marine purpose and activities including inter alia – Off shore activities, research, protection of the environment and prediction services".

The science of Hydrography has three major elements, Firstly, the collection of relevant and accurate hydrographic data. Secondly, compile these data into hydrographic information, in the form of nautical charts, ENCs and publication. Thirdly, regularly inform the mariner of the dynamic changes in his operating environment by constantly updating the hydrographic services.

Hydrography for Resource Management

Hydrographic Survey Efforts:
Requirements for hydrographic surveys arise as the result of policy decisions, product user reports or requests, national defence needs, and other demands. The inception of a specific hydrographic survey project follows an evaluation of all known requirements and the establishment of priorities. Among the many objective and subjective factors that influence the establishment of priorities are national and agency goal, quantitative and qualitative measures of shipping and boating, the adequacy of existing surveys, and the rate of change of the submarine topography in the area [5]. The purpose of hydrographic surveying is to collect geo-referenced data related to: -

(a) Shoreline configuration, including manmade infrastructure for maritime navigation i.e. all those features on shore that are of interest to mariners.
(b) Depths in the area of interest (including all potential hazards to navigation and other marine activities).
(c) Sea bottom composition.
(d) Tides and Currents.
(e) Physical properties of the water column.

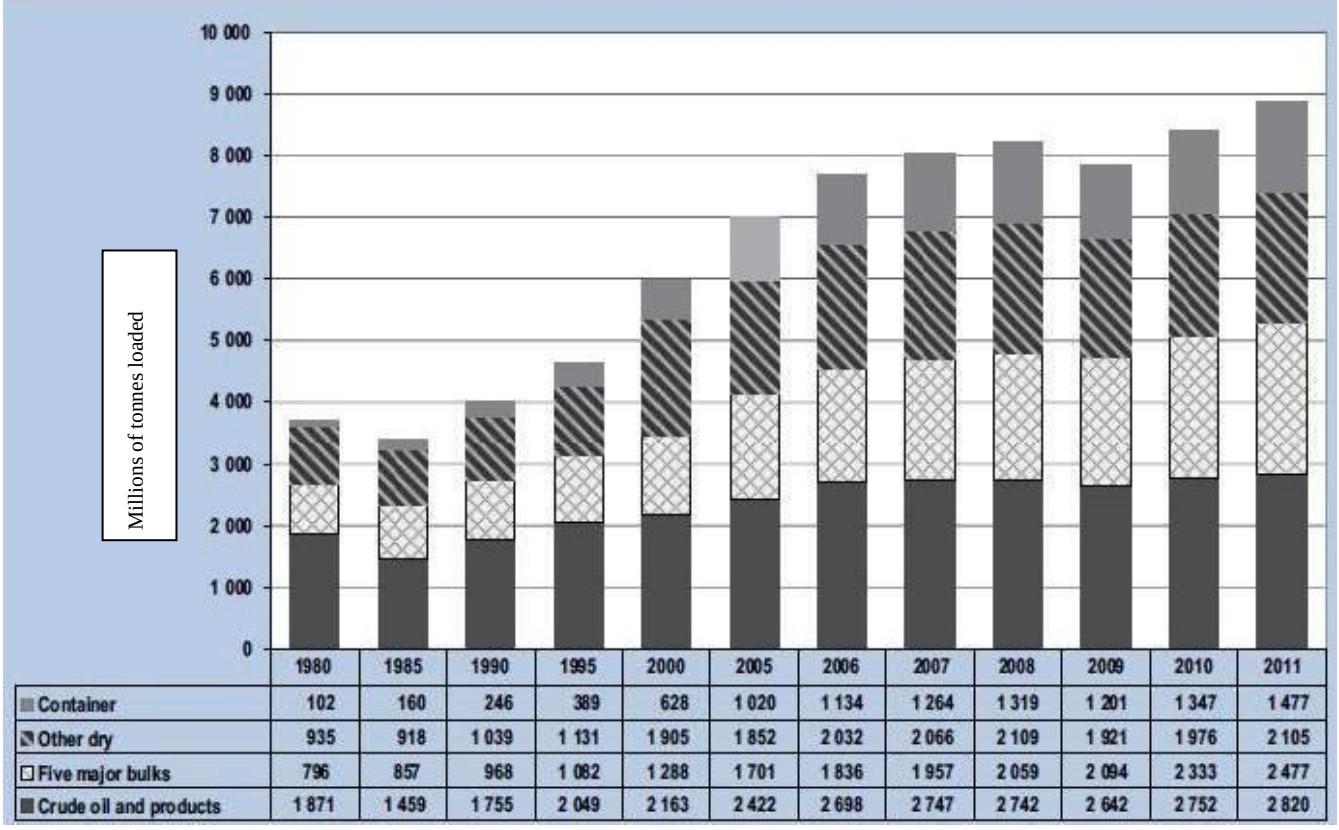
(f) To process the information collected in order to create organized databases capable of feeding the production of thematic maps, nautical charts, ENCs and other types of nautical publications which can be used for a variety of applications including but not limited to Maritime navigation and traffic management, Naval operations, Coastal zone management, Marine environment preservation, exploitation of marine resources and laying of submarine cables/pipelines, Maritime boundaries definition (Law of the Sea implementation, Scientific studies etc [6].

Nation Building Activities Related to Sea and Water Bodies

Safe Maritime Navigation.
India has a rich maritime tradition of over 4000 years. The ancient Indians had maritime activity with countries like Africa, Arabia, Mesopotamia and the Mediterranean which was a major contributor for the prosperity and flourishing of the ancient Indian civilizations. Even today India is predominantly a maritime trading nation with more than 90% of our trade by volume and 77% by value being transported by sea routes. Rise in International Seaborne Trade over last thirty years is shown in Fig. 2 below [7].

The prosperity and well being of our nation depends largely on the uninterrupted and efficient transportation of merchandise by sea routes. Needless to say the safety of vessels at sea is of prime concern for efficient trade. But what makes waters navigable and safe. Primarily it is the knowledge about water depths, dangers/hazards, tides and currents that facilitate safe navigation. For a successful business venture time is money. Therefore commercial shipping depend upon accurate and reliable charts to provide the most direct routes between ports, demarcate safe navigable channels to prevent accidents at sea and help carry more cargo by employing deeper draft vessels Hydrographic information primarily provides mariners with the necessary inputs to navigate safely and efficiently.

Environment Protection and Management:
An essential factor for the protection of the environment is safe and accurate navigation. Pollution caused by accidents at sea due to large oil spills are a major concern, the economic consequences of which are more devastating than is commonly imagined, but which, in some cases, have been estimated at US $ 3 billion for a single incident. The loss of revenue due to an accident can be directly measured from the loss of cargo. But there are a few indirect revenue losses in the form of settlements and cost of cleanup resulting from the devastating impact on environment and wild life habitat. Some of the damages caused by environment degradation due to marine accidents are irrevocable. Therefore the economic benefits and savings associated with preventing marine accidents



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Container	102	160	246	389	628	1 020	1 134	1 264	1 319	1 201	1 347	1 477
Other dry	935	918	1 039	1 131	1 905	1 852	2 032	2 066	2 109	1 921	1 976	2 105
Five major bulks	796	857	968	1 082	1 288	1 701	1 836	1 957	2 059	2 094	2 333	2 477
Crude oil and products	1 871	1 459	1 755	2 049	2 163	2 422	2 698	2 747	2 742	2 642	2 752	2 820

Fig 2: International Seaborne Trade.

through accurate and precise hydrographic information may not be quantifiable in exact terms but are enormous.

Exploration and exploitation of marine resources

A system for showing natural resources was started by US in 1942. The purpose was to provide information to the policy makers for better economic planning and analysis of the economic condition of the country. Proper accounting of natural assets is the first step towards its efficient management. It is through keeping accounts of natural assets that managers would be able to ensure its sustainability. Depreciation in accounts will indicate that unless the capital stock is maintained or replaced, the future consumption possibilities are bound to decrease [4]. Access to fisheries, sources of energy and other natural resources at sea depends on sound hydrographic information. Having access to resources is one thing but there is also a need to ensure that there are suitable people with appropriate competencies and qualifications.

Marine resource can be broadly classified as living and non living or the minerals. Marine living resources, such as those associated with fishing and aquaculture, are so vital to the economies of coastal nations, the information that hydrography can provide to ensure efficient use of these resources is equally as vital. In 2006, commercial and recreational fisheries supported over 2 million jobs and contributed over $73 billion to the United States gross national product. (NMFS, 2009) Commercial fisherman benefit from accurate charting through safe navigation, knowledge of preferred fish habitats, locating wrecks and other hazards that can interfere with nets, and improving the speed and efficiency of onload/offload operations. Bathymetry is a critical component of the characterization and delineation of fish habitats, as well as, the proper location and extent of aquaculture areas. Mineral resources include sand, gravel, oil, and other economically important resources found on, or below, the ocean bottom. Hydrography, by definition, characterizes the nature of the seafloor and thereby is a direct contributor to the discovery of areas of mineral resources available for exploitation. Side scan sonars, or acoustic backscatter from multi-beam echo sounders, are capable of bottom providing a technique that allows hydrographers to determine the type and extent of different bottom characteristics. This incidental activity can significantly reduce the cost of exploration by private businesses whilst at the same time continuing to improve navigation safety [8].

Coastal Zone Management:

The term "coastal regions" constitutes an area within 60 to 200 kilometres of the shoreline and may include coastal floodplains, coastal forests called mangroves, marshes, and tide flats (coastal areas affected by the rise and fall of the tide), as well as beaches, dunes, and coral reefs. It also covers marine fisheries because the bulk of the world's marine fish harvest is caught or reared in coastal waters. Coastal areas help prevent erosion; filter pollutants; and provide food, shelter, breeding areas, and nursery grounds for a wide variety of organisms. Coastal regions also provide critical inputs for industry, including water and space for shipping and ports; opportunities for recreational activities such as fishing and diving; and other raw materials, including salt and sand. Approximately 3 billion people, about half of the world's population, live within 200 kilometres of a coastline. By the year 2025, that figure is likely to double [9]. Most of India’s 7,500 km long coastal regions are densely populated, with nearly 250 million people living within 50 km of the coast, many of them in the 130 cities and towns that together form the engine of India’s economy. The high concentration of people in coastal regions has produced many economic benefits, including improved transportation links, industrial and urban development, revenue from tourism, and food production. But the combined effects of booming population growth and economic and technological development are threatening the ecosystems that provide these economic benefits. Adequate coastal zone management includes items such as construction of new ports and the maintenance and development of existing ones; dredging operations for the maintenance of charted depths and for the establishment, monitoring and improvement of channels; control of coastal erosion; land reclamation from the sea; establishment and monitoring of dumping grounds for industrial waste; extraction of mineral deposits; aquaculture activities; transportation and public works projects including construction of near shore infrastructure.

Precise large-scale surveys provide the primary data essential for projects involving all items mentioned above. Due to the rapid changes to which shorelines are subject, these surveys must be updated with the frequency dictated by the monitoring and analysis process. The information collected by Hydrographic Offices about the coastal zone provides essential input to coastal zone GIS (Geographic Information Systems) which are increasingly being used for better overall management and decision-making with regard to conflicting uses within the coastal region. Thus the users of hydrographic information go beyond the traditional user group, mariners, to include government agencies, coastal managers, engineers, and scientists [1].

Marine Science:

Marine science depends largely on bathymetric information. Global tide and circulation models, marine geology/geophysics, the deployment/placement of scientific instrumentation and many other aspects of

marine science depend on bathymetry provided by Hydrographic Services [1]. Hydrographic surveys provide the base layer for environmental monitoring, impact modelling and consequence management. Physical environmental characteristics, such as bathymetry, are required to support numerical modelling efforts in order to provide accurate representations of the impact from a variety of man-made and naturally occurring events. One of the aspects that call for special attention is the effect of natural hazards such as tsunamis and storm surges, which causes great loss of lives and damage to coastal communities with tremendous economic effect. The direction of the energy that approaches from the sea towards the shoreline is driven by the bathymetric characteristics of the place. Therefore if we know the bathymetry, we can run models to determine the expected run-up under certain conditions. The result will be the zonification of areas of greater or lesser risk. This represents, especially for coastal communities, important information required to support the decision on where a settlement should or should not be established [10].

International Maritime Boundary Delimitation:
For effective management of resources a coastal state should be aware of the limits of her economic jurisdiction. UNCLOS 1982 permitted the coastal state to establish a territorial sea of 12 nautical miles and a contiguous zone of 24 nautical miles from the baseline, which is defined as the low water line along the coast, as marked on large-scale charts of the coastal state [11]. In addition an exclusive economic zone (EEZ) of 200 nautical miles was also established where the coastal state has the exclusive right to utilize living and non-living resources. The first step for determining the baseline and establishing these boundaries is the accurate delineation of the Low tide line which forms the essential element of a hydrographic survey. UNCLOS also permits establishing the Continental shelf beyond the EEZ thereby extending the economic jurisdiction of coastal States to an area ranging from 200 to 350 nautical miles from the baseline (Article 76). Technically and in broad terms, the delimitation of the outer continental shelf is performed in two major steps: (1) determining the breadth of the continental margin based on seafloor morphology and the thickness of underlying sediment; (2) deriving constraint lines that are based on bathymetry and distance from the territorial sea baseline. Without accurate hydrographic information it is impossible to establish these maritime delimitations.

Maritime Defence:
As it is on land, each country needs also to establish, agree and set its international borders and boundaries. In the case of the delimitation with other countries, the limit must be drawn on the commonly accepted nautical chart and that chart must be the product of a hydrographic survey complying with international agreed standards. The maritime state must base such delimitations on standard procedures where depths, distances, characteristics of the sediments, cartographic projections and representations must be considered. Finally lines representing such limits must be represented on nautical charts to make users aware. The mariner, the fisherman, the security forces and others, must be aware whose area and jurisdiction they are in, as for each area, different regulatory measures frequently apply [10]. It is but obvious that accurate hydrographic information is critical not only for establishing maritime boundaries and delimitations but also for establishing jurisdiction and exercising authority in this area.

Tourism:
Coastal areas worldwide are major destinations for tourism, which represents the fastest growing sector of the global economy. Tourism dominates the economy of some regions and small island states; for example, tourism constitutes 95 percent of the economy of the Maldives and is the country's only source of hard currency [12]. Tourism can offer some environmental benefits, such as greater appreciation of the value of natural resources. In the Caribbean, for instance, diving tourism has helped raise awareness about the need for reef conservation. Good charts are particularly important to the development of the industry of tourism, especially involving cruise ships. Yet this important source of revenue cannot be properly developed if safe navigation to remote touristic landscapes is prevented or limited by a lack of adequate charts.

The economic impacts of hydrography and bathymetry on safety of navigation have been studied and reported for a number of years. However it is important to recognize that many aspects of hydrographic services fall into the category of ‘public goods’. A public good or service is that which is in the public interest but would not be supplied at optimal levels by market forces alone. There are three characteristics of a public good; non-rivalness in consumption, non-excludability and impossibility of rejection. The nautical chart is a noteworthy example of a public good. An individual using a chart does not impair another individual’s ability to use a chart to navigate safely, hence satisfying non-rivalness in consumption. It displays nonexcludability as it is impossible to prevent any member of the public from using the information the hydrographic service provides. Also, an individual cannot abstain from the benefits of the hydrographic service even if he or she wished to (impossibility of rejection). (Coochey, 1992) [8].

Way Ahead

Later part of twentieth century has made significant advances in technology that has transformed the way we conduct hydrographic surveys. Precise positioning

and complete coverage of seabed enable us to detect hazards and other bathymetric features with assurance that data thus collected can be used by the seafarers' scientific community with complete faith and confidence. However, data collected with these new methods and techniques forms a very small part. Electronic Chart Information and Display Systems (ECDIS) and Electronic Navigational Charts (ENC) has considerably enhanced the navigational safety thus having direct and positive impact on efficient and smooth conduct of maritime operations. But there are shortcomings, grey areas and issues which need attention, consideration and resolution. For sustained economic development authorities require significant assistance to provide the mariner with adequate nautical information while operating in adjacent waters. Full benefits of hydrographic information can only be realised to its potential when we take adequate measures and ensure that these issues are addressed.

Firstly, all efforts must be put to ensure that all our areas of interest have been adequately and efficiently surveyed. Secondly, hydrographic data must have a wide spread use by marine community. To ensure wide spread use it is the obligation of hydrographic office to ensure complete coverage of our areas (to ensure data availability of all areas). Lack of availability of data will not only delay developmental and economic activities but to a large degree will also impact accurate decision making. Thirdly, whatever data we accumulate, must be consistent. We need to have a robust mechanism to ensure proper amalgamation of data received from different sources. In this regard Quality Assurance Cell (mechanism) and Repository plays a very important role. Fourthly, there is a need to afford an easy access to hydrographic information and data. Complex and intricate access will deter data users and decision makers from accessing the data and thus prevent them from making full use of hydrographic information for developmental activities as well as decision making process. Initiatives like National Spatial Data Infrastructure (NSDI) are a step in right direction in this regards. We must fully support such initiatives and involve actively and ensure that our data is tailored to meet the structural requirements of NSDI. Conversely, we may involve in such a manner that the NSDI data structure is tailored to our data structure. Such steps will ensure greater and wider use of hydrographic information. We will also be contributor in decision process of all data users and decision makers actively or passively.

We have specifications and standards for the use of hydrographic data in nautical charts. Fifthly, we must ensure that we standardize the format, content and structure of these data to facilitate its broad use in coastal engineering, coastal zone management (CZM), environmental applications and scientific research. The Future holds many challenges for National Hydrographic Office. Much needs to be achieved in hydrography to support supplementary maritime requirements and with its expanding uses beyond the safety of navigation applications. The National Hydrographic Office in its pursuit to be the national authority on hydrographic affairs is posturing to meet these challenges. It is imperative that we must ensure a more representative and responsive National Hydrographic Office to ensure sustainable growth and efficient resource management, which is essential for nation building.

References

1. IHO Manual of Hydrography, M-13.
2. The Oceans Our Future, *The Report of the Independent World Commission on Oceans*. Cambridge University Press; 1998.
3. Ivan Goodbody, Elizabeth M. Thomas Hope*; Natural Resource Management for Sustainable Development in the Caribbean, 2002*.
4. Suleman Aziz Lodhi & Muhammad Abdul MajidMakki; *A Natural Resource Management Framework for Sustainable Development, Pak. J. Commer. Soc. Sci. 2010 Vol. 4 (1)pp. 56-68.*
5. NOAA Hydrographic Manual Part-1, Edition Jul 4, 1976.
6. National Maritime Policies and Hydrographic Services (M-2; *International Hydrographic Organisation, Monaco p. 13.*
7. UNCTAD-*Review of Maritime Trade 2011.*
8. Brian Douglas Connon, USA, Rod Nairn, Australia; *Economic Impact of Hydrographic, FIG Commission 4, WG 4.4* - Capacity Building and the Economic Benefits of Hydrography.
9. Liz Creel,PRB*; Ripple Effects: Population and Coastal Regions.*
10. Hugo M Gorziglia, IHO, Gordon Johnston, United Kingdom; *Why a National Hydrographic Service?*
11. IHO- Special Publication No. 51, 4th Edition - March 2006(Ch 4-3)
12. Making Waves, *Libby Brown*
13. Barbor K, Rear Adm, USA: The International Hydrographic Organisation, *Posturing for the Future.*

Forest, Resource Bonanza and Cultural Biological Diversities in the Andaman & Nicobar Islands

Dr. S.C. Chaturvedi
Jawaharlal Nehru Rajkeeya Mahavidyalaya
Port Blair, Andaman & Nicobar Islands – 744104
Email: SC1Chaturvedi@gmail.com

Abstract

The tropical climate of the Andaman & Nicobar Islands has nurtured a good forest cover over practically all the islands making a total forest area of about 7171 sq. km. A recent check of vascular plants in the Islands names over 2400 species out of which 292 are endemic. These forests may be classified into evergreen, moist deciduous, littoral and mangrove forest. Bamboo and cane brakes form local variation. The forest area carries an average growing stock of 45 and 175 m^3/ ha of commercial and non-stock respectively. There are minor variations in species consortium and richness from north to south depending mainly upon rainfall, type of soil, and the topography. The saddle peak in North Andaman is unique in vegetation, several endemic species occur here which are not found elsewhere. Similarly the Great Nicobar a mountainous terrain culminating in a peak, Mount Thulier is rich in endemic flora. Islands such as Neil, Havelock, and Car Nicobar are plain and coral in origin. But majority of the others are hilly. The low elevation of the terrain and small variation in rainfall ensure an almost uniform vegetation and floristic composition in the Islands. The forests of the islands are home of many tribal as Great Andamanese, Onges, Jarawas, Sentinelese, Nicobarese, and Shompens.

The new settlers mainly Bengali refugees who come from East Pakistan (Now Bangladesh) are now settled and spread out in the forest area of North, Middle South and Little Andaman. Another group of Settlers are the Ranchi Tribals who originally hail from Chota Nagpur region of Jharkhand. They came as labourers and formed one of the largest settlements at Baratang Island in the Middle Andaman. They are culturally heterogeneous. These people represent heterogeneous cultural and linguistic background and hails from various ethnic stocks from east to west and north to south in the mainland India.

Sustainable resources use is that maintains an acceptable level of production and at the same time conserves the basic resources on which production depends, illicit encroachment is major threat to natural regeneration of vegetation and to forest as a whole. The forest on smaller islands will have to be left untouched for ecological safety. To save them from excessive commercial exploitation of the forest, mangroves are to be preserved to protect the coastline, wildlife and breeding grounds for wildlife, to play a role in primary food chain for marine fauna. The survival, amelioration or degradation of ecosystems depends largely on human activity.

Introduction

The Andaman & Nicobar Islands are situated latitudinally between 6º45' North to 13º 41' North and longitudinally between 90º 12' East to 93º 57' East. These Islands are the largest archipelago system in the Bay of Bengal, consisting of 306 islands and 206 rocks and rocky out craps. Total geographical areas are 8,249 square kilometers as forest is 7171 square kilometers, which constitute 86.93% of the geographical area of these islands. The Andaman & Nicobar Islands ecosystem are normally very fragile, though 86 percent of the land area is still covered by forest and trees, the ecosystems are under threat due to the developmental requirements.

Methodology and Data Sources

The present study is based on primary and secondary data collected from various sources on the basis of information and field survey. This research paper highlighted about tropical rain forest of Andaman and Nicobar Islands, high degree of endemic flora and fauna is an asset of the tract, besides, it has several species of animals not found anywhere in the world. It is said that about 35 percent of the flora is endemic and six aboriginal tribes.

Forest

Tropical rain forests of Andaman and Nicobar Islands are the pride of our country. The forest covers of the country as per 1999 assessment was 63.73 million hectares constituting 19.39 percent of the geographical area, out of which 37.71 million hectares (11.48 percent) was dense forest, 25.50 million hectares (7.76 percent) open forest and 0.49 million hectares (0.15percent) mangroves. Madhya Pradesh

had the largest forest area 20.68 percent of the country followed by Arunachal Pradesh (10.80 percent) Orissa (7.38 percent). The seven North Eastern states together comprised 25.70 percent of the total forest cover(A.B. Chaudhari, 2007). While Andaman & Nicobar Islands have total recorded forest 7171 square kilometers total recorded forest, which is 86.93 percent of the geographical area.

Trees are one of nature's most effective weapon of soil defence, conservation former use them to tie down steep hill sides, to check the growth of big gullies, to stabilize unstable stream banks, and to screen off cultivated field from harmful winds. The health and economic security of the human race depend on how well the forest of the world is managed. All the countries of the world are suffering the penalty resulting from man's neglect to plant where he has reaped. He has destroyed the gifts of a generous creator without realizing that they were a trust to be handed over on to future generations. The earth's green covering is Natural's capital.

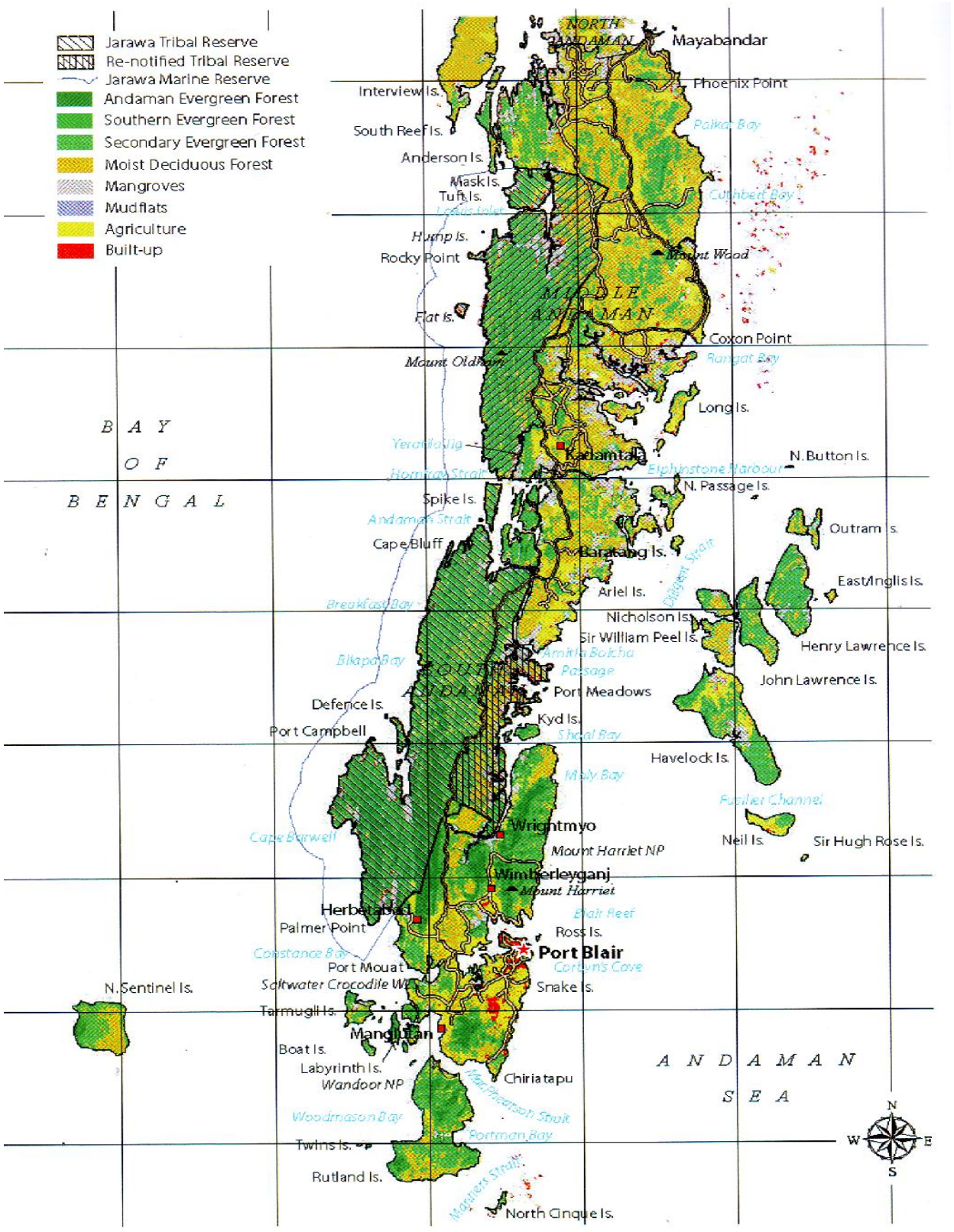
"The tree of the field is man's life"- Deut, 20:19.

Map 1: Land Cover Classification Map of Andaman & Nicobar Islands



Source: National Remote Sensing Agency 2003, Biodiversity Characterization at Landscape Level
NOT TO SCALE

Map 2: Vegetation Map of Andaman & Nicobar Islands



Source: LANDSAT ETM+Imagery dated 7th February 2000 (NOT TO SCALE)

Map 3: Andaman Trunk Road in the Reserve Forest Area

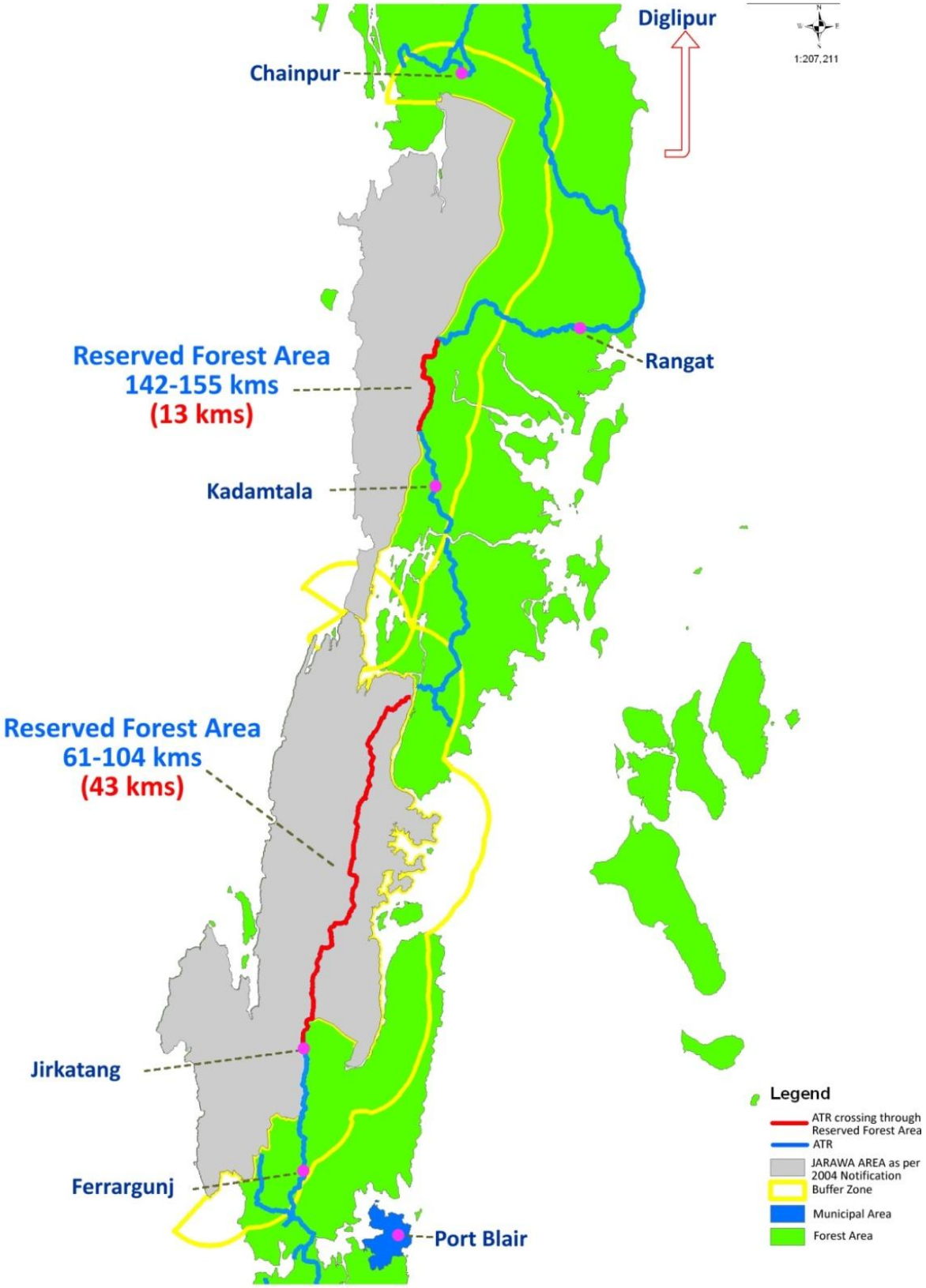


Table 1: Forest cover as per India State Forest report - 2009 (Forest Survey of India)

Andaman & Nicobar Islands	Forest cover (data of Jan – March 2007						
	Geographical Area	Very Dense	Moderately Dense	Open forest	Total	%	Scrub
	8249	3762	2405	495	6662	80.76	53

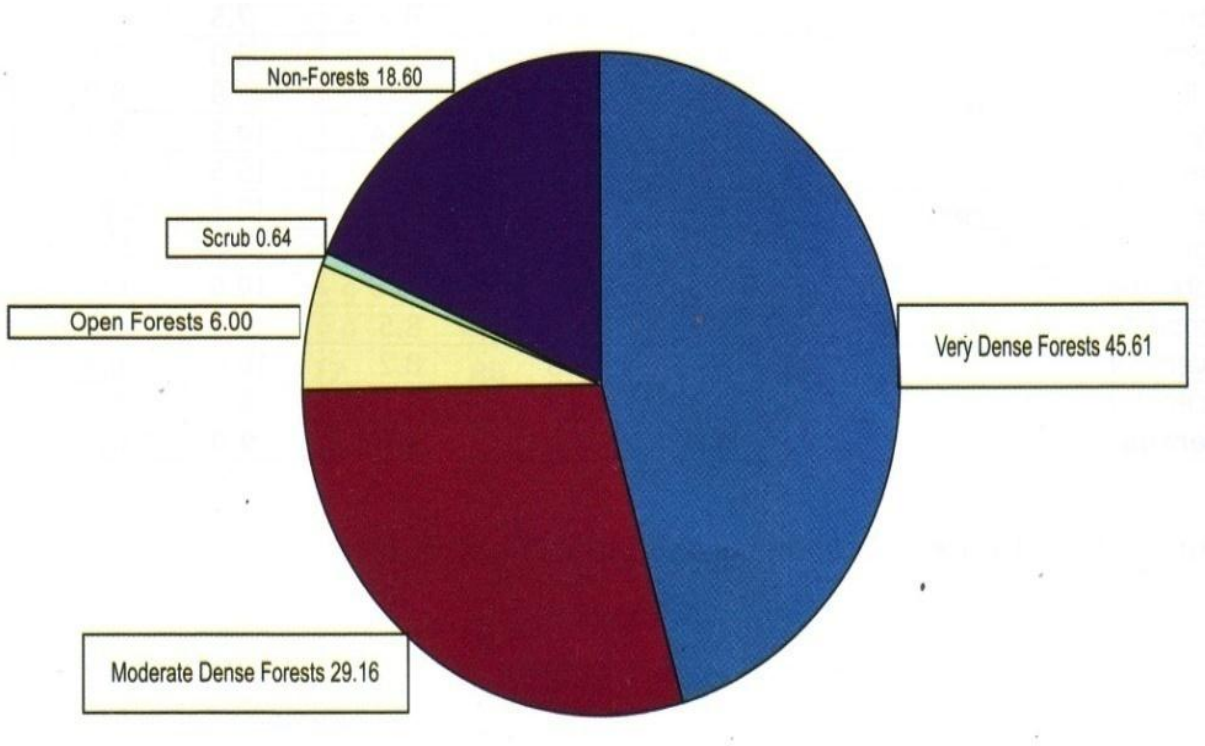


Table 2: Forest Cover assessment (1987 to 2007)

S.No.	Year	Area in sq.Km	Change (Sq km)
1.	1987	7601	-
2.	1989	7622	(+) 21
3.	1991	7622	0
4.	1993	7624	(+) 02
5.	1995	7615	(-) 09
6.	1997	7613	(-) 02
7.	1999	7606	(-) 07
8.	2001	6930	(-) 676 *
9.	2003	6807 Revised	(-) 123 *
10.	2005	6663 Revised	(-) 144 *
11.	2007	6662	(-) 1

Forest Statistics report (2009)

Recorded Forest

The total area recorded as forest is 7171 square kilometers, which constitute 86.93 percent of the geographical area of these Islands. Detail of recorded forests are given in the following table.

Table 3: Recorded forests of Andaman & Nicobar Islands

Union Territory	Reserved Forest	Area in sqKm		
		Protected Forest	Total recorded Forest	Percent of recorded forest out of geographical area
Andaman & Nicobar Islands	2929	4242	7171	86.93%

Mangrove Cover

Mangroves are salt tolerant forest ecosystems found in the tropical and sub tropical inter tidal region of the world. Forest Survey of India is assessing the vegetation cover of the country including mangroves using remote sensing since 1983. The Mangrove cover as assessed by FSI in their assessment is given below:-

Table 4

Sl.No.	Year of Assessment	Area under Mangrove cover in A & N Islands (in Sq. Km)
1.	1987	686
2.	1989	973
3.	1991	971
4.	1993	966
5.	1995	966
6.	1997	966
7.	1999	966
8.	2001	789*
9.	2003	658 (Revised) **
10.	2005	637***
11.	2007	615

Forest statistics report 2009

Table 5: District wise Mangrove Cover as per ISFR 2009.

(Area in Sq. km)

State/UT	Very Dense	Moderately Dense	Open	Total
Andaman	285	260	67	612
Nicobar		2	1	3
Total	285	262	68	615

Table 6: Island Wise Area Declared As Tribal Reserve

Sl.No.	Name of Island	Name of Tribes	Total Geographical Area (in sq.kms)	Tribal Reserve Area (in sq.kms)
1.	Battimalv	Nicobarese	2.072	2.072
2.	Bampoka	Nicobarese	13.468	13.468
3.	Bluff	Jarawa	1.14	1.14
4.	Car Nicobar*	Nicobarese	126.91	126.91
5.	Chowra	Nicobarese	8.288	8.288
6.	Great Nicobar	Shompen/ Nicobarese	1044.54	853.19
7.	Katchal	Nicobarese	174.307	174.307
8.	Kondul	Nicobarese	4.66	4.66
9.	Kabra	Nicobarese	0.518	0.518
10.	Kamorta*	Nicobarese	188.034	188.034
11.	Little Nicobar	Nicobarese	159.026	159.026
12.	Little Andaman	Onge	734.39	403.37
13.	Middle Andaman (Main Island)	Jarawa	1348.20	
14.	South Andaman (Main Islands)	Jarawa	1348.20	1028.00**
15.	Meroe	--	0.518	0.158
16.	Menchal	--	1.295	1.295
17.	North Sentinel	Sentinelese	59.67	59.67
18.	Nancowry	Nicobarese	66.822	66.822
19.	Pilo-Milo	Nicobarese	1.295	1.295
20.	Strait Island	Andamanese	6.01	6.01
21.	Spike	Jarawa	11.70	11.70
22.	Teressa	Nicobarese	101.269	101.269
23.	Tilangchong	Nicobarese	16.835	16.835
24.	Trinket	Nicobarese	36.26	36.26
25.	Trak	--	0.259	0.259
26.	Tries	--	0.259	0.259
27.	South Sentinel	--	1.61	1.61
28.	Brother	--	1.99	1.99
29.	Sister	--	0.36	0.36
30.	Passage	--	0.62	0.62
31.	Cinque	--	9.53	9.53
	Total		**5654.305**	**3279.285**

Source: Assistant Commissioner (Forest Settlement) Notification No.3 dt.2.4.1957.
Forest statistics report 2009

Note: * Includes de-reserved area of air field of Car Nicobar and Port area of Car Nicobar and Kamorta
** Tentative area arrived on the basis of boundary notified vide Notification No. 165 dated 15.09.04

Species of vegetation, animals and birds in Andaman & Nicobar Islands

There are seven reserved trees (ornamental wood) Padauk, Marble Wood, Chooi, Teak, Satinwood, Koko and Thitmin, superior hardwood, 21 standard hardwood, 12 softwood, 15 non commercial timber and 34 Mangrove species, 405 medicinal plant, 28 Bamboo species, 19 Cane species and more than species of 100 animals and insects and more than 242 birds species are found in the Andaman & Nicobar Islands (Harry V, Andrews et al, 2005).

Population Growth in Andaman & Nicobar Islands

Andaman & Nicobar Islands population has been grown from 2464 in 1901 to 356265 in 2001. The trend shown is due to the rate of increase in the settler population and mainly due to illegal and uncontrolled immigration from West Bengal, Bangladesh (East Bengal) and more recently from Tamil Nadu.

Table 7:

Year	Andaman District	Decadal Variation	Nicobar District	Decadal Variation	Total Population	Decadal variation
1901	18138	-	6511	-	24649	-
1911	17641	-2.74	8818	+ 35.43	26459	+7.34
1921	17814	0.98	9272	+5.15	27086	+2.37
1931	19223	7.91	10240	+10.44	29463	+8.78
1941	21316	10.89	12452	+21.60	33768	+14.61
1951	18962	-11.04	12009	-3.56	30971	-8.24
1961	48985	158.33	14563	21.27	63548	+105.19
1971	93468	90.81	21665	48.77	115133	+81.17
1981	158287	69.35	30454	40.57	188741	+63.93
1991	241453	52.54	39208	28.74	280661	+48.70
2001	314239	30.14	42026	7.19	356265	+26.94
2011*	S. Andaman - 237586, North Andaman - 105539 = 343125	6.68	36819	-12.48	379944	S.Andaman 13.97 & N & M Andaman -0.07 = 13.9

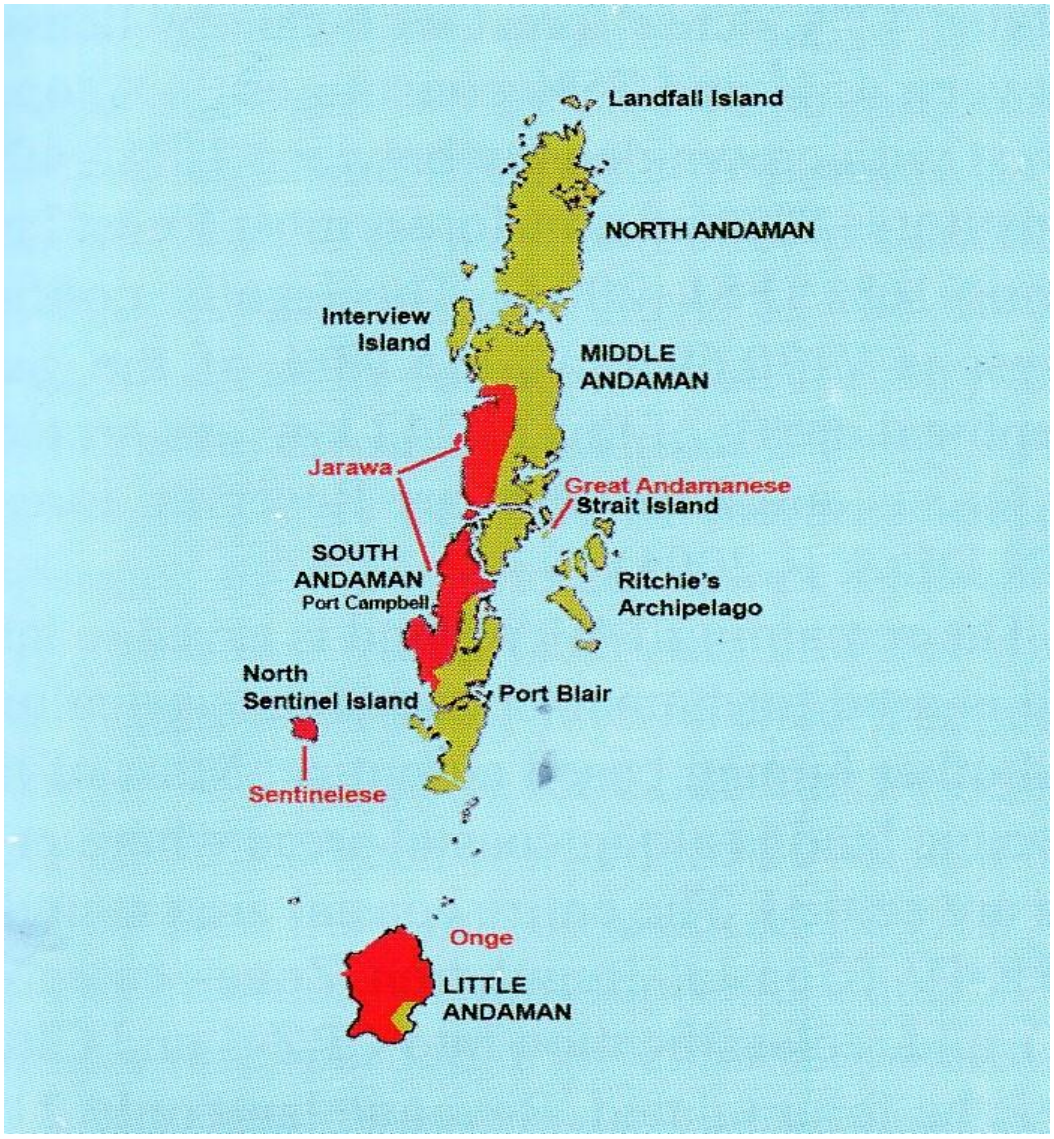
Source: Census 2011

Table 8: Indigenous Population in Andaman & Nicobar Islands

Scheduled Tribes	Island Group	1901	1931	1961	1911	1981	1991	2001
Great Andamanese	Strait Islands	1882	460	19	24	26	45	43
Onges	Little Andaman	672	250	129	112	97	95	96
Sentinelese	North Sentinel	NE	50	50	NE	NE	100	39
Jarwas	Western Coast of South and Middle Andamans	NE	70	500	NE	31	280	240
Nicobarese	12 Islands of Nicobar	5962	9589	13903	1787	421984	26000	28653
Shompen	Great Nicobar Island	348	200	71	92	223	250	398
Total		8864	10439	14672	18102	22361	26770	29469

Source: Directorate of Tribal Welfare A&N administration

Map - 4: Distribution of indigenous groups in the Andaman Islands.



Settled Population

The first settlers were the descendants of the convicts and freedom fighters who were jailed in these Islands. They brought with them a culture remarkably free of communal or caste bias, and they remains so till today. However, they constitute a very small proportion of the population, being outnumbered by recent immigrants. During independence in 1947, there were 3261 such families settle here and now they have multiplied. There are around 3000 Karens in the Islands now, with the main concentration just south of Mayabunder in Middle Andaman. To work the forests, 45 Karen families from Myanmar, were sent by the American Baptist Mission in Myanmar at the request of the British in 1925, and a number of them elected to return to Myanmar in the 1960's. These people are the descendants of the several Karen tribes in Myanmar. After independence the Karen people were settled as agriculturalist in Middle Andaman. The Karens have excellent knowledge of the forests and the seas of Andaman and their single keel, single log mechanized dugout canoe (Dungi), is the most popular in the islands used by all fishermen, settlers and most researchers.

The Ranchi people in the Andaman & Nicobar Islands were also brought by the British as labourers to work in the forests, during 1920s. These people from Chhota Nagpur have been settled on Baratang Island and have also spread themselves throughout the Andaman & Nicobar Islands. Refugees from the erstwhile East Pakistan were brought here in the 1950's. Settlement was opened up in South, Middle

and North Andaman for them, and the majority of settlements in the Diglipur are occurred during 1957-1959. Between 1953 to 1972, 4212 families of refugees from East Pakistan (Bangladesh) and landless persons Kerala from other states were settled here under various colonization and rehabilitation schemes. In the 1960's a group of 300 repatriates were brought from Sri Lanka under the Shastri Sirimavo Pact and settled on Katchal Island in the Nicobars and this population has increased to over 3000. There rehabilitation schemes the first group of ex-servicemen were settled on Great Nicobar island in 1969. A forest area of 1,499.65 hectares was cleared for 297 of these settler families, along the east coast, up to 35 km South of Campbell Bay. Each family was given 11 acres of land and schools, health centres and government offices were established for these people.

In the last three decades there has been a spurt of immigration from mainland India, mainly from West Bengal and Tamil Nadu. This immigration is enhanced by subsidized ship fares, subsidized food, and availability of job on daily wages. The obvious consequence has been encroachment on a large scale leading to degradation of the forests and increased pressure on natural resources. Currently there are 503 inhabited census villages in the Andaman & Nicobar Islands. Out of which 334 are in the South Andaman, North & Middle Andaman District, 26 Island and the remaining 170 villages, hamlets, small seasonal camps and individual family units are all on 12 islands in the Nicobar District (Census of India 2001).

The Andaman Islands were home to several groups of Negrito, hunter-gatherer indigenous tribes. The most important in the last century were the Great Andamanese people, consisting of 12 tribes that included different sects (Portmary, 1899; Cooper 2002). These groups of people numbered around 6000 in the 1850's when the islands were colonized by the British for a penal colony. The British attempted to 'civilise' the Andamanese people, teaching them to eat exotic food, to wear clothes, live in houses, schools, and hospitals and to farm. These experiments failed, and led to the total decimation of the Great Andamanese (Portman 1899). The current number is 34 individuals, who have been marginalized to Strait Island on Southeast Coast of Middle Andaman. The Onge people, who inhabits little Andaman Island, were the next to be contracted in 1920, and a process similar to what happened to the Andamanese was initiated. Their numbers have drastically gone down from 500 in 1920 to 97 currently. The Onge are now confined to two areas, the mouth of Dugong Creek and South Bay.

The Sentinelese and the Jarwas, the other two tribes in the Andamans, have resisted contact until the 1960's. the Sentinelese, numbering 100-150 (estimated), have for long inhabited North Sentinel Island, an island 60 square kilometers south west of South Andaman Island. These people have been living in total isolation for over hundreds of years except for contact attempt made by the Andaman & Nicobar Administration in 1967, 1991, 2000 & 2004. However there is lot of disturbances around their island, due to intensive fishing lobster collection. The current status of the Sentenelese is about 39. The Jarawas are confined to the West Coast of South and Middle Andaman Islands. The contract process with some of the Jarawas people was begun in 1974 and they continued to remain hostile till 1999. But nowadays they are not so furious. The total numbers of Jarwas are 240.

The Nicobarese people of Mongoloid origin occupy 12 of the 23 Nicobar groups of islands. Some of them live in small villages but most live in smaller hamlets and in individual's family units in various locations and islands. A number of Nicobarese have been assimilated into the society brought from mainland India almost totally, but resent outsiders in their islands. Although until now, most Nicobar people are referred to, in general, as 'Nicobaris', it should be understood that these people are of several different groups with different customs, cultures and separate dialects.

These people are probably descendents of different hunter-gatherer from Indo-Malayan and Myanmar. They are 28653 in 2001. The Shompen numbering 380 and of Mongoloid origin, are confined to the inland forest and the east coast of Great Nicobar Island. These people numbered in thousand and inhabited the coastal areas of Great Nicobar Island. Their numbers probably, got reduced due to influenza 1918 and poliomyelitis in 1947. Currently their status still requires attention, as the male population is higher than the female, and as males outnumbers females there are few women and marriageable age. The Shompen are being subjected to forces of assimilation similar to those the tribal groups in the Andamans have already undergone.

Conclusion and Suggestions

The Andaman & Nicobar are one of the very few areas in India where much of the natural ecosystems are still intact. The tremendous biological and genetic adversity, and the high rate of endemism in fauna and flora, coupled with the sensitive nature of the native inhabitants who are completely dependent on the natural resources of the area. Out of nearly 3,80,000 peoples are residing in the Andaman & Nicobar Islands by the source of 2011 census records. The original inhabitants, the tribal, accounted for only around 09% of the total population. They are divided into 6 tribal groups.

The Andamanese, the Onge, the Sentinalese and the Jarawas in Andaman group of Islands and the Shompens and Nicobarese in the Nicobar group of Islands. Only the Nicobarese with a population of 28000 are numerically substantial. The rest of tribes together number only around 800, or about 0.21 percent of the total population of the islands.

The carrying capacity of the islands has already exceeded and population growth needs to be controlled. The immigration can be controlled by suitable legislative measure. All the protected areas to be demarcated and all proposed extensions and buffer zones notified. All encroachments in forest areas are to be removed on priority basis.

References

1. A.B. Chaudhari (2007), "*Forest, Environment and Men"* Daya Publish House Delhi – pp. 27.
2. Census of India (2001), Provisional population totals, Andaman and Nicobar Islands series 35.
3. *Forest Statistics (*2009) Department of Environment & Forests, Andaman & Nicobar Islands. pp.12, 13,21
4. Harry V, Andrews, RSC, Jayaraj and Seema Mundoli (2005), "*State of Environment 2005, Andaman & Nicobar Islands"*, Published Universities, pp 11-13,

Use of Geomatics and Inland Water Transport to Enhance Sustainable Development and Growth of North East Region (NER)

Capt.(IN) GS Inda
Senior Fellow, CENJOWS

Abstract

North-East Region (NER) has vast water resources in the form of rivers, which are the lifelines of the region. For time immemorial the mighty Brahmaputra and its tributaries have helped shape the life and sustainability of the people settled along the banks of the rivers. The origin for Brahmaputra and many other rivers are from China and it is believed that China is constructing six dams across the Yarlung Zangbu River. It is believed that when these dams are completed, they will grossly impact the availability and flow of water in Brahmaputra River, making it difficult for the people of NER, who are dependent on agriculture, fishing, and transportation to sustain their livelihood. The Brahmaputra is one of the largest rivers in Asia that traverses its first stretch of 1625 km in China's Tibet Region, second stretch of 918 km in India and the remaining stretch of 363 km in Bangladesh, before entering into the Bay of Bengal. The NER hosts the country's 37% of river waters, 20% of the hydrocarbon (oil & gas) potential, large quantities of minerals resources that are yet to be explored to their full potential. Endemic floods, landslides, cloud bursts and avalanches are common features of the region. The entire region comes under the highest risk zone in seismographic classification besides having poor infrastructure development, ethnic conflicts and ecological degradation. All these factors put the entire region into high volatile vulnerable region. However, favourable rainfall and strong network of rivers and streams have led to good water feeding particularly the valleys in the North-East. It has helped in development of fisheries and Inland Water Transport (IWT). Not withstanding the above, water resources could prove to be very helpful in development of the region.

Many rivers provide waterways for inland transportation and in many cases it is the only way for transportation. There is ample opportunity to develop water resources due to less carrying capacity of the rivers flood. In spite of water availability, irrigation facility is poor. The potential of the land in terms of irrigation system in the region is vital in the economic development of the area. The transportation techniques used in IWT sector is based on traditional navigation i.e. following the age old Thalweg principle (deep channel navigation) as known to the local people. This is due to absence of hydrographic data, river charts, and navigation techniques and above all use of non-mechanised boats. These all factors become stumbling blocks in the sustainable growth of the region. Keeping pace with the development and modernisation of IWT in other parts of the world, there is a need to identify various stretches of rivers, which have linkage to large population, mineral resources, forest region etc. to be surveyed for mapping and developed for promotion of IWT. These stretches can be studied and examined using GIS, remote sensing techniques and Geomatcis for geo morphological and hydrological data evaluation and thereafter, mapping the stretches on various scales to be developed for safe navigation and promotion of IWT for sustainable development and growth of NER

Introduction

North-East Region (NER) has vast water resources in the form of rivers, which are life lines of the region. From time immemorial, the mighty Brahmaputra and its tributaries have helped shape the life and sustainability of the people settled along the banks of these rivers. The origin for Brahmaputra and many other rivers are from China and it is believed that China is constructing six dams viz. Zangmu, Jiacha, Zhongda, Lengda, Jiexu and Langzhen, across the Yarlung Zangbu River, as it is called in China. It is feared that when these dams are completed, they may impact the availability and flow of water in Brahmaputra and its tributaries. The Brahmaputra is Asia's one of the largest river that traverses its first stretch of 1625 km in China's Tibet Region, second stretch of 918 km in India and the remaining stretch of 363 km in Bangladesh, before entering into the Bay of Bengal. In addition to the water resources, the NER has huge reserves of natural and mineral resources. It hosts the country's 37% of river waters, 20% of the hydrocarbon (oil & gas) potential, large quantities of low ash coal resources, limestone and dolomite deposits, as well as, a few other minerals that are yet to be explored to their full potential. Endemic floods, landslides, cloud bursts and avalanches are common features of the regions. The entire region comes under the highest risk zone under seismographic classification. Adding to the above factors are poor infrastructure development, ethnic conflicts and ecological degradation of forests. All these factors put the entire region into high volatile vulnerable region socially and economically. However, favorable rainfall and strong networks of rivers and streams have led to good water feeding particularly in valleys in the North-East. It has helped in

development of fisheries and Inland Water Transport. Notwithstanding the above, if potentials of available water resources are fully exploited, it could prove to be very helpful in development of the region.

Geomatics

Geomatics is a combination of the terms Geodesy and Geo-informatics. It includes the tools and techniques used in Land Surveying, Remote Sensing, Cartography, Geographic Information System (GIS), Global Positioning System (GPS), Photogrammetry, Geography and related forms of Earth Mapping. The term has been adopted by the International Organisation for Standardisation, the Royal Institution of Chartered Surveyors (RICS), and many other National and International authorities. Change of nomenclature from Surveying to Geomatics by Institution of Surveyors (IoS), New Delhi has also been under consideration. The related field of hydro-geomatics covers the area associated with surveying work carried out on, above or below the surface of the sea or other areas of water. The older term of hydrographics was considered too specific to the preparation of marine charts, and failed to include the broader concept of positioning or measurements in all marine environments. A number of university departments, which were once titled surveying, survey engineering or topographic science have re-titled themselves as geomatics or geomatic engineering.

Inland Water Transport (IWT) – An Environment Friendly & Economical Mode

Inland Water Transport has contributed to the development of mature economies over many centuries and created many bridges between nations. In 21st century IWT can help achieve Millennium Development Goals (MDG 1, 7 & 8). IWT provides a safe, environmentally sustainable form of transport, which is a key element of sustainable economic development. Such transports of goods and people can stimulate the development of regional economies and connect land-locked countries to the sea. It is important to highlight that ancient civilization came up along the rivers e.g. Indus civilisation, Pyramids along Nile river etc. IWT is the cheapest mode of transport compared to Rail/Road and there is zero transit loss in cargo and above all, it helps in sustainable growth and overall development of the region. IWT can be easily networked to Multimodal Transport (Road/Rail/Sea or vice versa). In case of NER, IWT can provide connectivity to National Waterways No.2 and proposed National Waterway No.6 (Barak River) to mainland and Sea through protocol route via Bangladesh. The IWT also helps in generating employment, facilitate education, encourage commerce/trade activities, provide communication, medical aid and generate hydro power etc. Navigation has the potential to offer a cleaner and more energy-efficient means of transportation than any other alternatives. Using IWT can connect people and contribute to the Millennium Development Goals i.e. Eradicate Extreme Poverty & Hunger (MDG-1), Achieve Universal Primary Education (MDG-2), Promote Gender Equality & Empower Women (MDG-3), Reduce Child Mortality (MDG-4), Improve Maternal Health (MDG-5), Combat HIV/AIDS, Malaria & other Diseases (MDG-6), Ensure Environmental Sustainability (MDG-7) & Develop a Global Partnership for Development (MDG-8).

Relatively Energy Efficient*

Inland vessels are relatively energy efficient e.g. a truck with one gallon of fuel can carry one ton of cargo to a distance of 59 miles, whereas a train can move it by 202 miles on rail and an inland vessels can move by 514 miles on waterways (1:3.4:8.7). Thus, inland transportation is by far the cheapest and most economical mode of transportation and needs to be developed. (*No. of miles One Ton can be carried per gallon of Fuel)

Emission Produced

A table below shows the Pollutants* (in pounds) produced in moving one Ton of cargo to a distance of 1,000 miles:

Mode	Hydrocarbon	Carbon Monoxide	Nox (Oxide of Nitrogen)
Tow Boat	0.09	0.20	0.53
Train	0.46	0.64	1.83
Truck	0.63	1.90	10.17

**Source : USDOT-Maritime Administration*

Major Waterways of the World

Some of the major waterways of the world are : Brahmaputra (India/Bangladesh), Colorado (USA), Congo(Congo), Danube (Germany, Austria, Slovakia, Hungary, Croatia, Siberia, Bulgaria, Moldova, Ukraine, Romania), Darling (Australia), Ganges (India/ Bangladesh), Indus (Pakistan), Mekong (China, Myanmar, Laos, Thailand, Vietnam), Mississippi (USA), Murray (Australia), Nile (Egypt, Sudan), Niger (Guinea, Mali, Niger, Benin, Nigeria),Rhine (Germany, Austria, Liechtenstein, Switzerland, France,

Netherlands, Luxembourg, Belgium, Italy), Rio Grande (USA), Tigris (Turkey, Syria, Iraq, Iran), Yangtze (China) and Yukon (Alaska, Yukon, British Territory, Colombia). These major waterways of the world are developed with modern IWT infrastructures and being exploited fully for sustainable growth of the region.

Important National Waterways of India

India has a vast coastline of 7516.6 km and more than 14,500 km of potential and identifiable waterways to be developed for inland navigation. By an Act of Parliament, Govt. of India has established Inland Waterways Authority of India (IWAI) on 27 Sep 1986 for development, maintenance and regulation of National Waterways. Accordingly, three National Waterways viz. National Waterway No. 1 (Allahabad-Varanasi-Patna-Bhagalpur-Farakka-Sagar Island: 1620 Km), National Waterways No.2 (Sadiya-Dhubri: 891 Km) and National Waterway No.3 (Kottapuram to Kollum including Champakara and Udyogmandal Canals: 205 Km) were declared in 1986, 1989 and 1993 respectively. In addition, National waterway No.4 (River Godavari (Bhadrachalam to Rajahmundry-157 km; River Krishna (Wazirabad to Vijayawada) - 171 km; Kakinada Canal (Kakinada to Rajahmundry) - 50 km; Eluru Canal (Rajahmundry to Vijayawada) - 139 km; Commamur Canal (Vijayawada to Pedaganjam) - 113 km; North Buckingham Canal (Pedaganjm to Chennai) – 315 km; South Buckingham Canal (Chennai to Merkanam) – 110 km and Kaluvelly Tank (Markanam to Puducherry) - 22 km. A total of 1077 km, of this, 888 km length of waterway falls in Andhra Pradesh, 187 km in Tamil Nadu and 2 km in Union Territory of Puducherry. In 50 km stretch of Buckingham Canal in Chennai area (Ennore to Muthukadu), there is no proposal for development of waterway due to the stretch being heavily encroached by MRTS and being urban area. Thus the effective length of waterway development is only 1027 km. National Waterway No.5 (Rivers Brahmani-Kharsua-Dhamra (Talcher- Dhamra) – 265 km; Matai River (Charbatia- Dhamra) - 39 km; Mahanadi delta rivers (Mangalgadi- Paradeep) - 67 km; East Coast Canal (Geonkhali- Charbatia) - 217 km. A total of 588 km, of this 91 km of waterway is in West Bengal and the rest is in Orissa. These waterways have been declared in 2008 and are being developed for Inland Water Transportation by IWAI.

State Waterways

Govt. of Assam, Goa, Orissa & West Bengal have well established State IWT department to develop, manage and regulate state waterways for transportation of men and materials for sustainable development of their states. Goa waterways plays vital role in transportation of Iron Ores and minerals from the mines to the Marmagao port for export. In addition, IWT is only the viable mode of transportation across the Goa state through the Mandvi and Zuari rivers. In these states IWT is also being used for promotion of trade, transport and tourism. The riverine states of UP and Bihar are keenly pursuing in establishment of state IWT departments and implement Inland Vessels Act 1907 for training, examination and certification of IWT crews, registration and survey of Inland Vessels.

Important Rivers and their Tributaries in NER

It is important to note that the total lengths of the rivers and their tributaries in the NER are 6258 km (approx.) and out of this length, suitable stretches can be identified, surveyed and developed for IWT, to help sustainable development of the area/region/state.

Old IWT Techniques and Lack of Modernization – A hindrance to development of the region

Many rivers all over the world provide waterways for safe inland transportation and, in many cases; it is the only way for transportation. The old transportation techniques used in IWT sector is based on traditional navigation i.e. following the age old Thalweg principle (deep channel navigation) as known to the local people. Due to absence of latest hydrological data, river charts and navigation techniques, local population is forced to rely upon traditional non-mechanized boats or country crafts for their movement and transportation of goods. Flow of heavy sediments during floods in the rivers and its deposits in the river beds also make it difficult for mechanized boats to navigate safely, carry more personnel and goods. Absence of safe, affordable and irregular transportation system, further deprive the local population to avail modern basic amenities like education, health and better job to make decent livelihood for their growth and survival. These factors are stumbling blocks in development & sustainable growth of the region and therefore identification & development of potential waterways, modernization of IWT infrastructure with safe navigable inland vessels along the viable stretches can ultimately help in sustainable development of the region.

World IWT Models for Sustainable Growth

Keeping pace with the development and modernization of IWT in other part of the world like USA, Netherlands, Germany, South America, China and South East Asia, there is a need to identify various stretches of rivers in the NER, which have linkage to large population, mineral resources and forest region. These identified viable stretches can be planned to be surveyed for mapping and development of IWT. These stretches can be studied and examined using Satellite Imageries and Remote Sensing techniques. Further, GIS can establish data base for geomorphological and hydrological data and thereafter, mapping the stretches on various scales to be developed for safe navigation

and creating necessary infrastructures for IWT in the region, which will aid in sustainable development and growth of NER.

Development of IWT in pre & post-Independence and Road Ahead

Since Establishment of Tea garden in 1835 and first export of Tea to London in 1838 and later discovery of oil in Makum and setting up of refinery at Digboi in 1890, laid the foundation for development of Assam. The British ruler found significant potential for the exploitation of natural resources and invested in infrastructure. The region was at the forefront of development in the mid 19th century till India's independence on 15 Aug 1947. The proximity to Chittagong port through inland waterways and land transportation through road and railways network provided the support for the transportation of goods and people. The railway link between Dibrugarh and Chittagong was one of the earliest projects implemented by the British. The partition of the country in 1947 changed the landscape of the region by virtually cutting it from the mainland. Inadequate transportation network hampered progress in development of the NER compare to mainland and pushed the region to the bottom of GDP national Index. Now, for NER to keep pace with the mainland there is a need to increase infrastructure development in the region, which can be executed, if sound transport network is available. The viable mode is IWT through which each and every remote corner of the region can be joined and thereafter networked to existing Rail/Road (Multimodal Transport) system to the mainland. For establishing Inland Waterway system, there is a need to study and identify river stretches for mapping and development of IWT using latest state of the art hydrographic surveying technique like GIS, GPS, Remote Sensing and Automated Hydrographic Survey System for data collection, analysis, and planning.

Conclusion

North Eastern Region (NER) has 37% of water resources and 20% of Hydrocarbons (Oil & Potential). In addition to Flora & Fauna and Tourism, there are reports that Arunachal Pradesh has huge reserve of Shale Gas and could be explored to meet India's future energy requirement. The rivers of NER also provide potential to generate Hydropower. By 2020, the Govt. has planned to generate 64,000 Megawatt of power through Hydro projects in the region. There are also reports that 30% of NER population is Below Poverty Line (BPL), the reason could be assigned to poor infrastructure, inadequate/nil transportation network, poor connectivity to main land etc. Having water resources in abundance the viable means is Inland Water Transportation but except the National Waterway No.2 (Sadiya to Dhubri-891 km), there is no developed waterway in the NER. In addition, proposal to declare Barak River as new NW is under consideration by the Govt. Even existing NW-2 is utilised by very few selected IWT operators for goods transport and not promoted for passenger/local transportation. Using Geomatics to identify, survey and map the potential stretches viable for development of IWT will go long way in sustainable growth and development of the NER and help in improving the social status and well being of the people of NER. It is well known all over the world that IWT is one of the most economical and environmental friendly transportation and need to be promoted and developed for improving the livelihood of the people of the NER.

Types and Distribution of Domestic Water Sources in Jorhat Town, Assam

Mayurakshi Bhuyan* and Zahid Husain**
**Research Scholar and **Professor,*
Department of Geography, North-Eastern Hill University, Shillong – 793 022
E-mail: mayurakshibhuyanjrt@gmail.com, husainzahid1@rediffmail.com

Abstract

Water is the most vital and foremost requirement for life. There are various uses of water, but the basic use is for domestic purpose. The demand for water has been increasing in urban areas as a consequence of rapid population growth and increase in per capita consumption. Due to the insufficient water from the public water services in most of the cities and towns, people mostly depend on other sources such as river, stream, ponds, tube well, hand pump, dug well etc. Most of the urban centres, despite having domestic water supply, face the problem of water scarcity and poor quality, which invite attention of the scientists to study the types, distribution and status of sources of domestic water in a human settlement, especially in an urban centre to analyse the availability of domestic water. It is not only interesting but also relevant from various points of view. Therefore, an attempt has been made in the present paper to study the availability of water sources for domestic consumption in Jorhat Town, Assam. This study is based on both primary and secondary data. The mapping of water sources has been done with the help of geospatial technology. The analysis based on primary data supplemented by GIS maps reveals lack of planning, poor engineering design, and absence of lack of policing of the water distribution system, leading to shortage of domestic water and possible contamination of domestic water from sewage at multiple sites.

Introduction

Water is the most vital and foremost requirement for life and it is generally considered as a natural resource available everywhere. There are various uses of water, but the basic use is for domestic purpose like drinking, bathing, watering lawns and gardens, air conditioning, flushing of toilets, livestock etc. The survival and growth of mankind depend on the availability of water in sufficient quantity and safe quality. Demand for water has been increasing over the years in the urban centres of the world as a consequence of rapid population growth and increase in per capita consumption due to various reasons. On the other hand, the water resource potential of urban areas is being adversely affected in terms of both quantity and quality due to expansion of concrete structures, shrinking open spaces required for percolation of water and reduced recharge of ground water. At the same time use of water bodies as dumping grounds for all sorts of waste has been polluting both the surface and ground water, thus aggravating the problem of scarcity. Most of the urban centres, despite having domestic water supply infrastructure, face the problem of inadequate quantity and poor quality of water. Whatever may be the reasons, it is a fact that there is a severe problem of quantity of water in many human settlements of the world, which invite attention of the scientists to study the types, distribution and status of domestic water sources, which is not only interesting but also relevant from various points of view. Due to insufficient water from the public water services in cities and towns, people mostly depend on other sources of water for domestic purpose such as rivers, streams, ponds, tube wells, hand pumps, dug wells etc. Therefore, an attempt has been made in the present paper to study the availability of water sources for domestic consumption in Jorhat Town of Assam. The main aim of the study is to highlight the types and distribution pattern of sources of domestic water. This study is based on both primary and secondary data.

Study Area

Jorhat town is situated between 94°11´0´´-94°14´0´´East Longitudes and 26°44´30´´-26°46´30´´ North Latitudes. The town is bounded by *Sarbaibandha* in the north, *Barpool, A.T. Road* in the east, *Kansaikia Jan* in the west and *Bongal Pukhuri* in the south. Administratively, Jorhat town is divided into 19 (nineteen) municipal wards altogether covering an area of 9.20 sq km. *Bhogdoi* is the main river that passes through the town along with other streams like *Tocklai, Tarajan, Jahkharijan* etc. as the town stretches from the piedmont zone of the Karbi Anglong Hills to the banks of the Brahmaputra river. Besides, the town is dotted with number of ponds (locally known as *pukhuri*). The average annual rainfall is 2045 mm.

Data Base: The present study is based on both primary and secondary data. The primary data has been collected in the field survey (2010) of each ward of the entire town. Handheld GPS Garmin 72 was used to acquire the geographical location of domestic water sources. The secondary data was collected from Jorhat Municipal Board, Assam Urban Water Supply and Sewerage Board, Public Health Engineering Department, Swajaldhara Scheme, Marwari Thakurbari Committee, Town and Country Planning

Department, Jorhat. Besides, data has also been collected from various published and unpublished literature including journals, books, reports etc.

Methodology

Both primary and secondary data were compiled, tabulated and analyzed in Excel and depicted through diagrams and maps. The mapping of different water sources and distribution pattern has been done with the help of geospatial technology such as Garmin 72 GPS, Google earth open source software and Arc GIS 9.3 software.

Results and Discussion

All the above helped to identify the different sources of water for domestic consumption and its distribution pattern in Jorhat Town, which has been discussed in following lines.

Types of Domestic Water Sources

Water is not only vital to all forms of life but it also has a great role to play in socio-economic development of human population. According to Park (1997), water sources for domestic consumption must conform to two criteria: (a) the quantity must be sufficient to meet present and future requirements; and (b) the quality of water must be acceptable. There are three main sources of water in Jorhat Town:

1. Rainfall
2. Surface Water
(i) River *Bhogdoi*
(ii) Pond
3. Ground Water
(i) Shallow Well
(ii) Deep Well
(iii) Dug Well
(iv) Hand Pump, Mark Series Tube Well

Rainfall: Jorhat experiences the predominant influence of the south-west monsoon which reigns from May to July with occasional winter showers. The approach of the monsoon is marked by strong winds, overcast skies and occasional thunder showers, hailstorm and cyclones during April and May and it starts heavy showers from June (Anonymous, 2002).

Table 1: Water balance of Jorhat District (based on average rainfall of 50 years)

Months	P	PET	AET	WD	WS
January	23.50	53.30	39.61	13.69	0.00
February	29.40	70.90	47.12	23.78	0.00
March	61.20	116.50	78.34	38.16	0.00
April	194.80	133.40	133.40	0.00	38.45
May	260.90	125.20	125.20	0.00	47.10
June	363.60	113.60	113.60	0.00	250.00
July	385.80	116.50	116.50	0.00	269.30
August	356.80	114.50	114.50	0.00	242.00
September	238.80	104.60	104.60	0.00	134.20
October	119.80	97.50	97.50	0.00	22.30
November	30.40	69.00	64.43	4.57	0.00
December	12.10	51.10	38.65	12.45	0.00
Total	2076.8	1166.10	1073.45	92.65	1003.35

P = Precipitation, PET = Potential Evapotranspiration, AET = Actual Evapotranspiration,
WD = Water Deficit, WS = Water Surplus
Source: Soil Resource Atlas, Jorhat District, Assam, 2004

Theoretical method given by Thornwaite (1948) and Thornwaite and Mather (1957) is used to calculate the climatic water balance. It is based on the precipitation (water supply) and the evapotranspiration (water need). When precipitation exceeds the water need, there is surplus water for storage, leading to deep percolation, but when the water supply falls short of water need; it is deficit (Table1) (Anonymous, 2004).

Surface Water: River *Bhogdoi* is the main source of surface water in Jorhat town, which passes through Ward numbers I, II, III and XIX (Fig. 1), while other streams like *Tocklai*, *Tarajan*, *and Jahkharijan* also exist but the quality of water of these smaller streams is not potable. These streams and rivers cannot satisfy the water need of the town due to causes varying from distance and inadequacy of discharge to quality of water (Paul, 1997). The municipal wastewater, the rain water run-off and the industrial effluent is carried by these three mutually independent open drains to *Bhogdoi* River directly (Bordoloi, 2003).

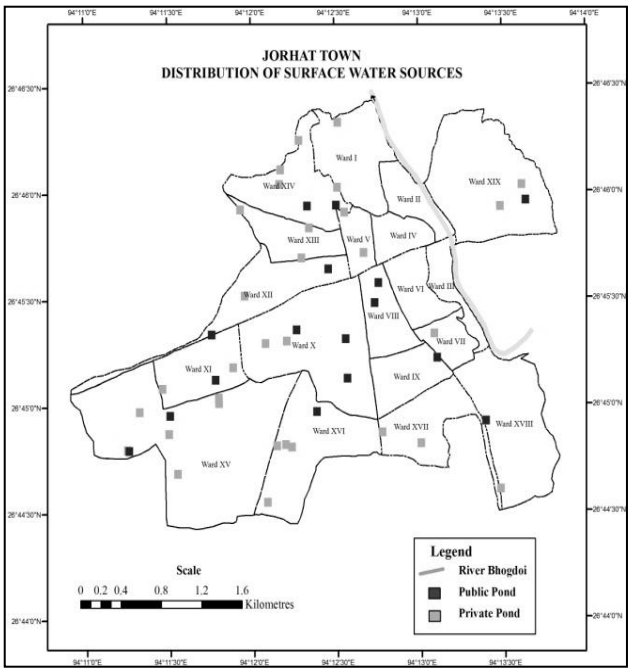


Fig. 1

Ponds: Ponds are large excavations in which surface water is stored. They are an important source of water supply in most of areas (Park, 1997). The people use about more than 10 public ponds and 28 private ponds (Fig.1) as another important source of domestic water in Jorhat town. Some of the ponds are of historical importance, for example, Rajmao Pukhuri, Mitha Pukhuri, Tarajan Buhagohain Pukhuri, Padum Pukhuri, Rajamaidam Pukhuri and Sonari Gaon Pukhuri, as these were constructed by rulers of different times. Almost all the wards of the Town are having both public and private ponds and ponds are well distributed. It may be noted that ponds provide bathing and washing places for the poor people who do not have tap connections in their houses. On the other hand, some of the ponds have disappeared from the landscape due to dumping of solid wastes in them, and some have shrunken in area because of encroachment (Bhuyan and Husain, 2012).

Ground Water: The usual ground water sources are wells and springs. Wells have been classified into shallow and deep wells, dug wells and tube wells (Park, 1997).

Shallow Well: Shallow wells tap subsoil water, i.e., the water from above the first impervious layer in the ground. In Jorhat town, most of the shallow wells are found in northern, south-western and southern parts at household level as a private water source (Fig. 2). People have constructed shallow wells in the premises on their own and 60.96 m bgl (below ground level) water can easily be withdrawn for domestic purposes. The highest numbers of shallow wells are confined in ward number XV.

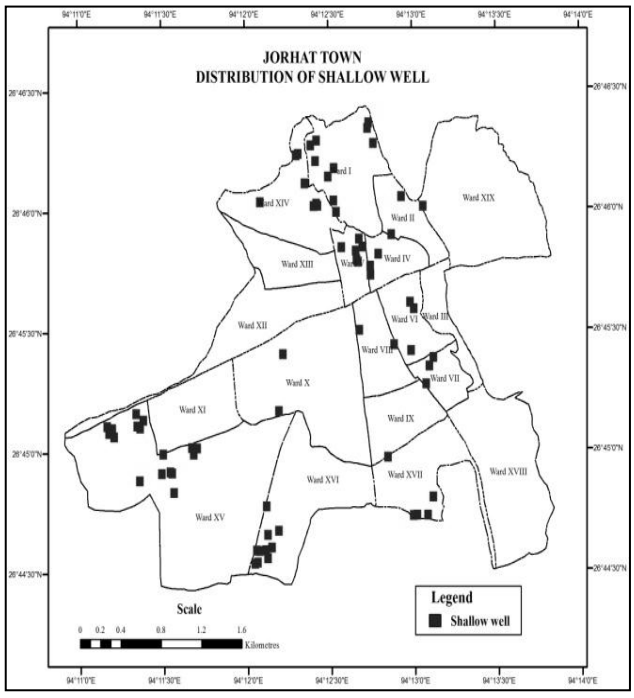


Fig. 2

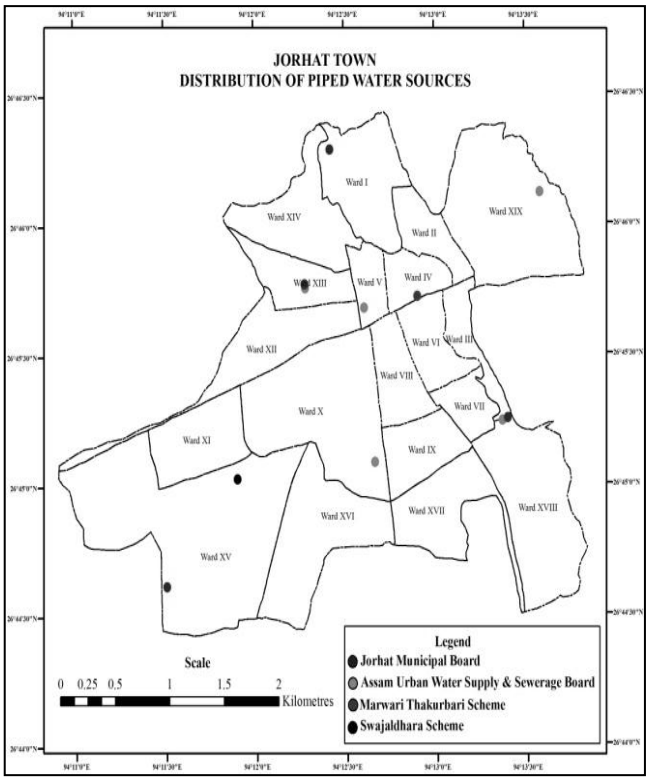


Fig. 3

Deep Well: A deep well is one which taps water from the water-bearing stratum below the first impervious layer in the ground and in entire town deep wells are identified as public piped water supply provided by four organizations such as Jorhat Municipal Board, Assam Urban Water Supply & Sewerage Board, Swajaldhara Scheme and Marwari Thakurbari Scheme (Fig. 3). Jorhat Municipal Board provides water to a section of the people residing in almost all the municipal wards except ward number 19. This water supply scheme is divided into four zones. All the water supply projects depend on ground water except the Bhogdoi Water Supply Project whose intake is from the *Bhogdoi* River. The other water supply projects are situated far from the river as they depend on ground water. Under the scheme of Assam Urban Water Supply and Sewerage Board, the whole town has been divided into seven water supply zones, but only five zones have been covered until now. The combined Bhogdoi and Na-Ali zone use water from the *Bhogdoi* River. The Swajaldhara Water Supply Scheme serves above 3000 people living in 250 (4.43%) households spread over the ward numbers X, XI and XV. Marwari Thakurbari Scheme is a community based water project maintained by the Marwari people. The main source of this project is ground water and it has two deep tube wells at a depth of 121.921 m and 60.96 m. Besides these water supply projects, there are another 250 number of street hydrants located in different wards (Fig. 4).

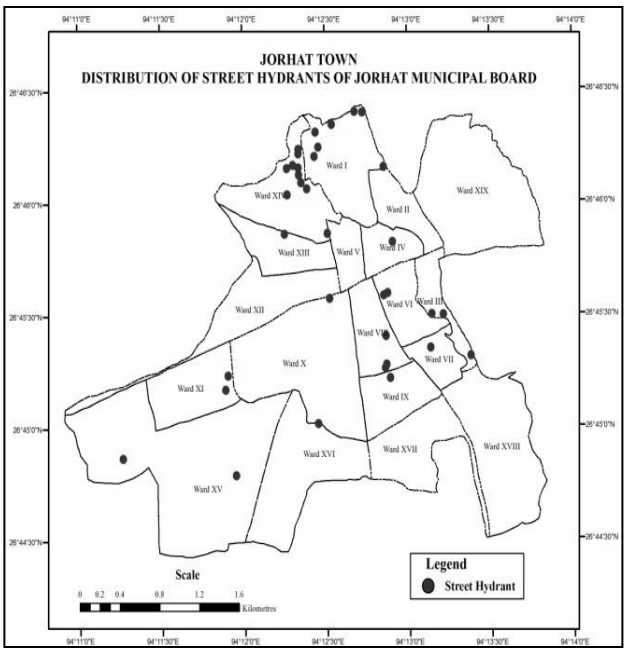


Fig. 4

Dug Well: Dug wells are of two types: (a) the unlined kutcha well, and (b) the masonry or pucca well. The kutcha well is a hole dug into the water bearing stratum. The pucca well is an open well, built of bricks or stones (Park, 1997). Moreover, mostly people are depending on piped water supply but in water deficiency period they use water from kutcha well and masonry pucca well on private basis in both pre-monsoon and post-monsoon seasons. The water table of the dug well is mostly found from 0.50-1.5 m in both the seasons and high concentration of this type of well is mostly confined to northern part of the town (Fig.5).

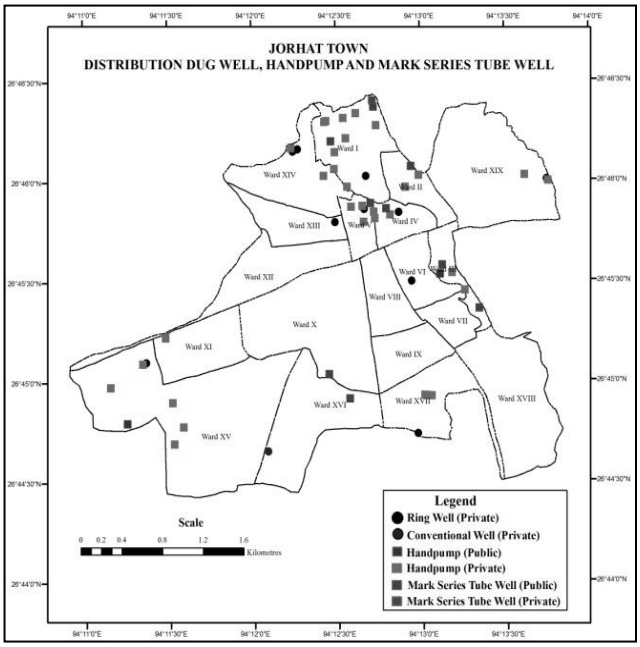


Fig. 5

Hand Pump and Mark Series Tube Well: Hand pump comes under sanitary well. The well should be equipped with a hand pump for lifting the water in a sanitary manner (Park, 1997). The hand pump is probably the most important contribution made by the government to the community in support of the wells program and there are both public and private had pumps in Jorhat town. The public hand pumps have been constructed in different wards by Jorhat Municipal Board, because all the households of the town are not capable of purchasing water from piped water connection due to various reasons.

Besides this, people have constructed themselves hand pumps in their premises and the depth of this water source mainly found in 15.24 m bgl. The public hand pumps are found in only ward number III and XV and high concentration of private hand pumps are confined to northern and south western parts of the town. The highest number of hand pumps is found in Ward number I (Fig. 5).

Mark series tube well is another source of water for domestic consumption in Jorhat town, which is constructed by Public Health Engineering Department in public areas. Public Mark series tube wells are found in Ward number I, II, III, IV, V, X and XVI and private Mark series Tube wells are found only in Ward number I (Fig.5).

The above discussion shows that the northern and south western parts of the town are very rich in water resource, whether it is public piped water source or private water source (Fig.6). The northern part of the town is very nearer to the main surface water source, i.e., the *Bhogdoi* River and it is nearly 8 km away from the River Brahmaputra. The low coverage and lack of infrastructure of piped water supply systems also has tremendous negative impact on family relations because fetching of water from other sources involves spending of valuable time and money as the sources are located at long distances. Moreover, these sources are not safe for health as *Escherichia coli* (*E. coli*) are found to be present in considerable proportion. Water from shallow surfaces as well as from the water schemes contains high proportion of *E. coli* as compared to the ground water sources (Thakur, et al., 2003).

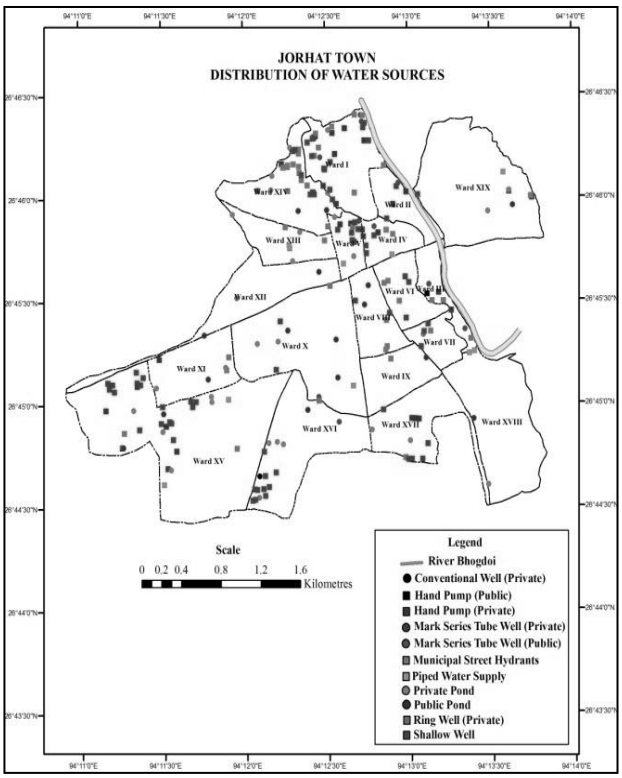


Fig. 6

Conclusion

Discussion on types and distribution of domestic water sources in Jorhat Town clearly shows low coverage of piped water supply; hence people fetch water from other sources such as ponds, dug wells, shallow wells, hand pumps etc. which always involve travelling long distances, and wasting of time and money. On the other hand, summer is the crucial period when a number of tube wells and bore wells go dry because of lowering of water table or even drying up of aquifers. In such a situation, people depend more on the ponds whose water is polluted and unsafe for drinking. All these problems related with domestic water in Jorhat town have put its citizen in severe trouble and people are really hard pressed. They just strive for collection of adequate water and safe water. The GIS mapping of different water sources reveals the critical areas and that can be used as a basis for policy planning in the development of water supply provision in Jorhat town and also for monitoring and evaluation purpose of water service performance in Jorhat town.

Reference

1. Anonymous, 2002. *State Water Policy of Assam*
2. *(Draft).* Assam Science Technology & Environment Council. Government of Assam. Guwahati. Pp-2.
3. Anonymous, 2004. *Soil Resource Atlas Jorhat District (Assam)*. National Bureau of Soil Survey and Land Use Planning, Indian Council of Agricultural Research. Nagpur.
4. Bhuyan, M. And Husain, Z., 2012. Water Resource Functioning in Jorhat town. *International Journal of Innovative Research and Development*. 1(4): 343-353.
5. Bordoloi, R., 2003. Environmental Geochemistry around Jorhat-A Case Study. Unpublished Ph. D Thesis, Department of Chemistry, Dibrugarh University. Dibrugarh.
6. Park, K., 1997. *Preventive and Social Medicine*. M/s Banarsidas Bhanot Publishers Jabalpur.
7. Paul, A.B., 1997. *Quest for Drinking Water from British Raj to Swaraj*. In Jorhat 200, Handique, B. (ed.), Jorhat Town 200 year's Celebration Committee, Jorhat, Assam.
8. Thakur, R.S., Bhuyan, K. & Burua, R., 2003. Potability of Water of Jorhat City in terms of Bacteriological Quality. *Indian J. Environ. & Ecoplan*. 7 (1): 83-86

e-Governance for Monitoring of Water Bodies in Urban Areas – A Case Study of Barasat Municipality, West Bengal

Sri Debdip Bhattacharjee and Dr. Sukla Hazra
East Calcutta Girl's College, Kolkatta
E-mail : debdip1983@gmail.com

Abstract

There is little doubt that human being has had a significant impact on the environment through population concentration. Electronic Governance is the way to maintain a bridge between government and citizens. In this study, Remote Sensing and G.I.S were used in order to delineate the impact of haphazard and unplanned urban growth on surface water bodies and small stream as well of Barasat Municipality, West Bengal. To show the spatial and temporal changes of water bodies, we used LANDSAT TM (1990), LANDSAT ETM+ (2000) and LANDSAT ETM+ (2011) satellite data. The whole analysis was carried out by image processing methods in ERDAS imagine 9.2 and TNT MIPS 2010 softwares. Several indices were prepared like Normalized Difference Built up Index (NDBI), Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), Land Surface Water Index (LSWI) and Normalized Difference Pond Index (NDPI) to have the real features of built up area and water bodies. Authors choose 14 differently situated water bodies and collected three water samples from each of them to measure the parameters like PH, Conductivity, Turbidity, Salinity, Total Dissolved Solid (TDS), and Dissolved Oxygen (DO) to delineate anthropogenic impacts on those water bodies. The result showed reduction of water bodies both in areas and number and help to monitor the status of the same.

Introduction to e-Governance

The e-Governance (Electronic Government or Electronic Governance) field[1] emerged in the late 1990's as a context within which one can share experiences among practitioners. Over the past few years e- Gov gave rise to several conferences with more and more scientific content. E- Gov represents the systematic use of modern information and communication technology by a government to improve the efficiency, transparency and accountability in its functioning and interface with citizens.

Benefits of e-Governance

E-Governance offers a new way forward, helping to improve government processes, connect citizens and build interactions with and within a civil society. E-Governance provides three changes potentials for good governance.

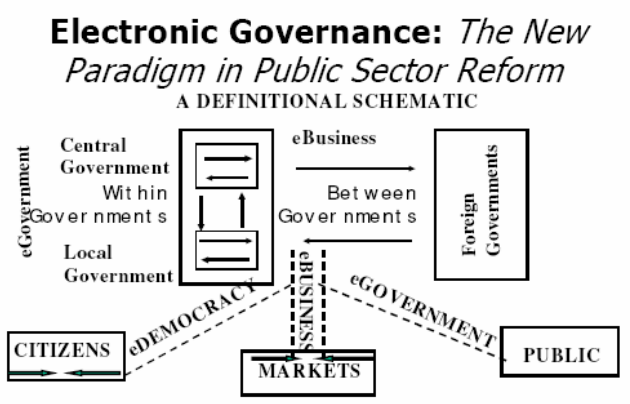
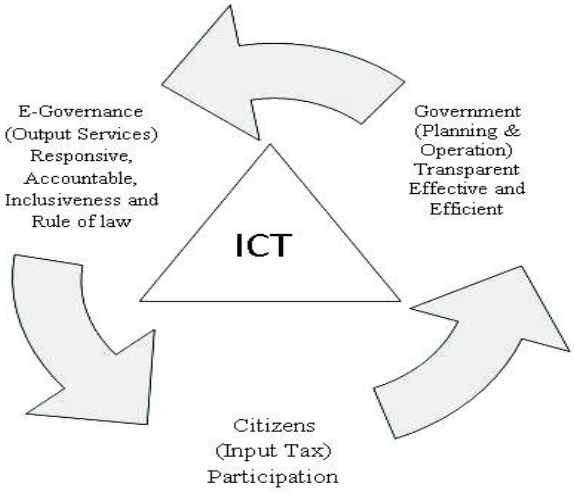


Fig. 1: Electronic Governance

Automation: Replacing current human executed processes, which involve accepting, storing, processing, outputting or transmitting information.

Informatisation: Supporting current human executed information processes, which include decision making, communication and decision implementation.

Transformation: Supporting new human executed transformation processes like creating new methods of public delivery. These change potentials may bring five main benefits to governance for development viz., Governance that is cheaper, Governance that does more, Governance that is quicker, Governance that works better and Governance that is innovative.



e-Governance Initiatives in India

More than 80% of the world population lives in developing countries, where socio-economic progress is slow. India is a developing country with a population of 1.2 billion spread over 29 geographically uneven states. In August 2002 the Government of India announced that it would implement a comprehensive programme to accelerate e-Governance at all levels of the government, including municipalities. The Government of India subsequently approved the National e- Governance Action Plan for implementation during 2003-2007. It aims to create the appropriate governance and Institutional mechanisms and set up the core infrastructure and policies. The National e-Governance Action Plan has identified the information of various Mission Mode Projects in e-Governance, including one for municipalities under the responsibility of the Ministry of Urban Development. So, e-Governance is the effective use of Information and Communication Technology (ICT) to improve the system of governance. In a country like India people are poor and infrastructures are not up to the mark, thus the present status of ICT is not good.

Study Area

Barista, a district headquarters lies within the jurisdiction of Kolkata Metropolitan Development Authority (KMDA) with an area of 31.41 sq.km. has been chosen as our area of interest (Fig. 2). This town is located between 88°27' east to 88°31' east longitude and 22°40'58" north to 22°44'44" north latitude. There are 32 wards in Barasat municipality town. As per the provisional reports of census of India, population of Barasat in 2011 is 283443 of which male and female population is 143732 and 139711 respectively. Barasat has a population density of 9023 persons per sq.km.

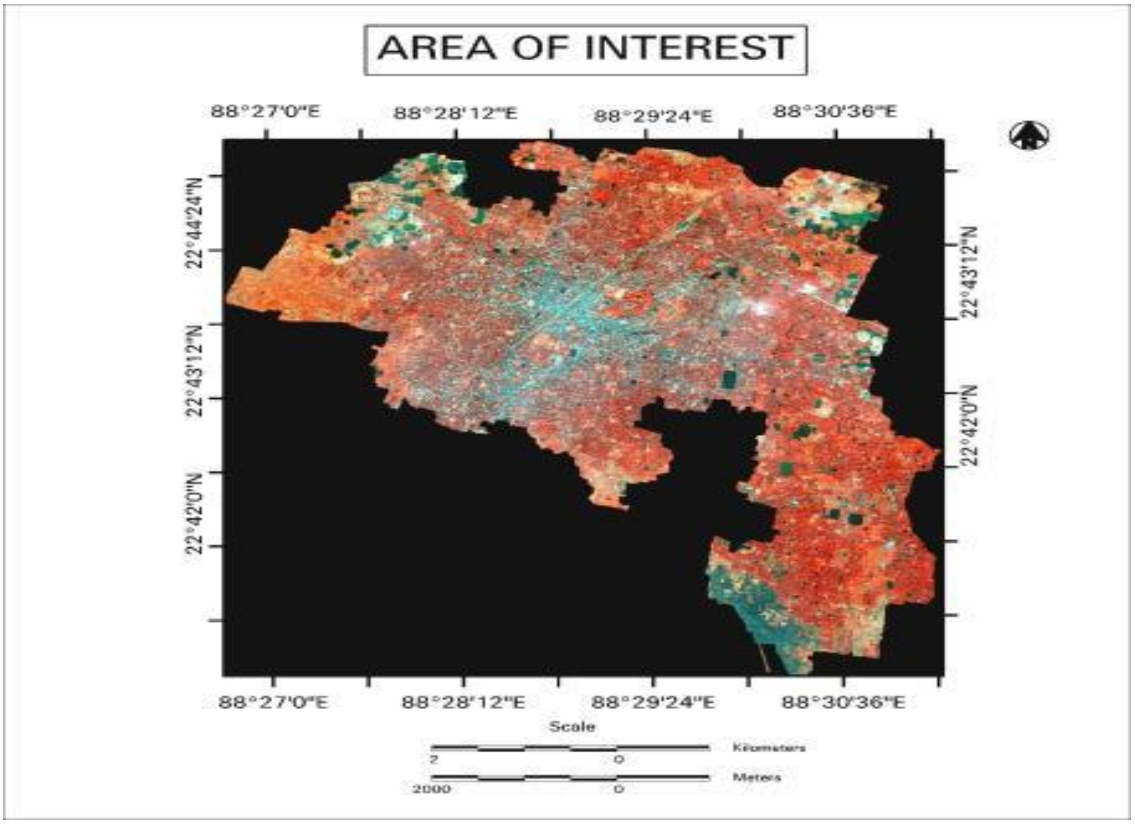


Fig. 2: Study Area

e-Governance in Barasat Municipality

- A Memorandum of Agreement (MOA) was signed on 28th June, 2006 by Barasat Municipality in which a spot light was given on the induction of e-Governance system.
- A few decisions were taken regarding e-Governance which are-
- Appointment of State-level Technology Consultant as State Technology Advisor.
- Preparation of Municipal E-Governance Design Document (MEDD) on the basis of National Design Document.
- Assessment of MEDD against National E-Governance Action Agenda (NEAA).
- Business Process Reengineering (BPR) for migration to e-Governance.
- Appointment of Software Consultants.

- Exploring PPP option for different e-Governance services.
- Defining monitorable time table for implementation of e-Governance initiative, against monitorable time table.
- Any other reform steps being undertaken.

So, various steps are taken and number of projects is going on regarding e-Governmental activities in Barasat Municipality. What we have suggested in this paper is about the using of Remote Sensing and Geographic Information System (GIS) techniques to monitor the natural resource of a region. Due to increase in population, these resources are over stretched often leading to resource depletion. Here an attempt has been made to delineate the impact of haphazard and unplanned urban growth on surface water bodies.

Materials and Data

Satellite Data: LANDSAT TM 1990, ETM+ 2000, ETM+ 2011;

Collected Data: Municipality map;

Census Data: Provisional reports of Census of India 2011; Primary Census Abstract 1901, 1911, 1921, 1931, 1941, 1951, 1961, 1971, 1981, 1991, 2001.

Field Data: Sample of water from 14 differently situated water bodies.

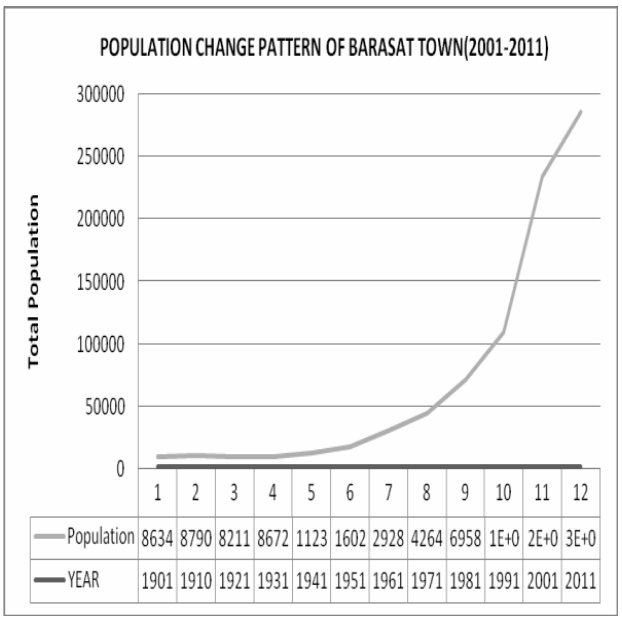
Methodology

Input Data: The satellite data of the study area are procured from LANDSAT TM (1990), ETM+ (2000), ETM+ (2011) and has been used for settlement and surface water resource study. A few collateral data, census data and laboratory based field data are also used.

Digital Indexing: To detect the changing status of surface water resource of Barasat town indices like Normalized Difference Water Index (NDWI), Moderate Normalized Difference Water Index (MNDWI), Land Surface Water Index (LSWI) and Normalized Difference Pond Index (NDPI) were prepared. To examine the change in spread of settlement Normalized Difference Built-up Index (NDBI) is also done. To understand the impact of urban sprawl on water bodies of Barasat town settlement extraction and pond extraction method were also applied.

Results and Discussion

According to the provisional census of 2011 population of Barasat town is 283443, which was 102660 in 1991 and 231521 in 2001 respectively. After partition of India volume of population is increasing. Migrated people from the erstwhile East Pakistan were added to the population of Barasat town. Since then onwards the rise of the town expanded from 6 wards to 32 wards. This town experienced 115.3% of population growth during 1991 to 2001 where as West Bengal (urban) had 19.88% which was much less than this town. Barasat also had higher growth rate in comparison to that of all India (urban) rate of 32.60%. The trend line shows the steep rise in population of Barasat town over time span. *Software used*: The whole analysis was carried out by image processing methods in ERDAS IMAGINE 9.2 and TNT MIPS 2010.



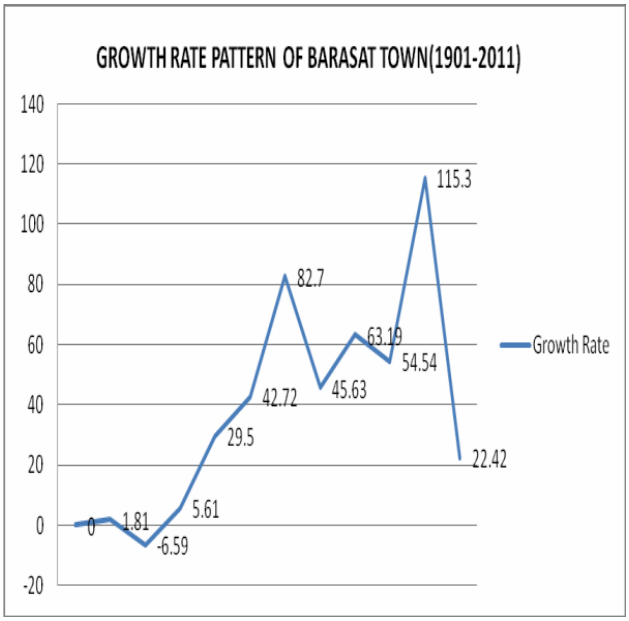


Fig. 3: The trend line shows the steep rise in population of Barasat town over time span.

Changing status of urban water bodies in Barasat town: Water bodies, the aquatic systems on land, like ponds, act as store house for variety of wild life. The ponds and other type of water bodies across the Barasat town are in varying degrees of environmental degradation due to various anthropogenic activities like haphazard urban growth.

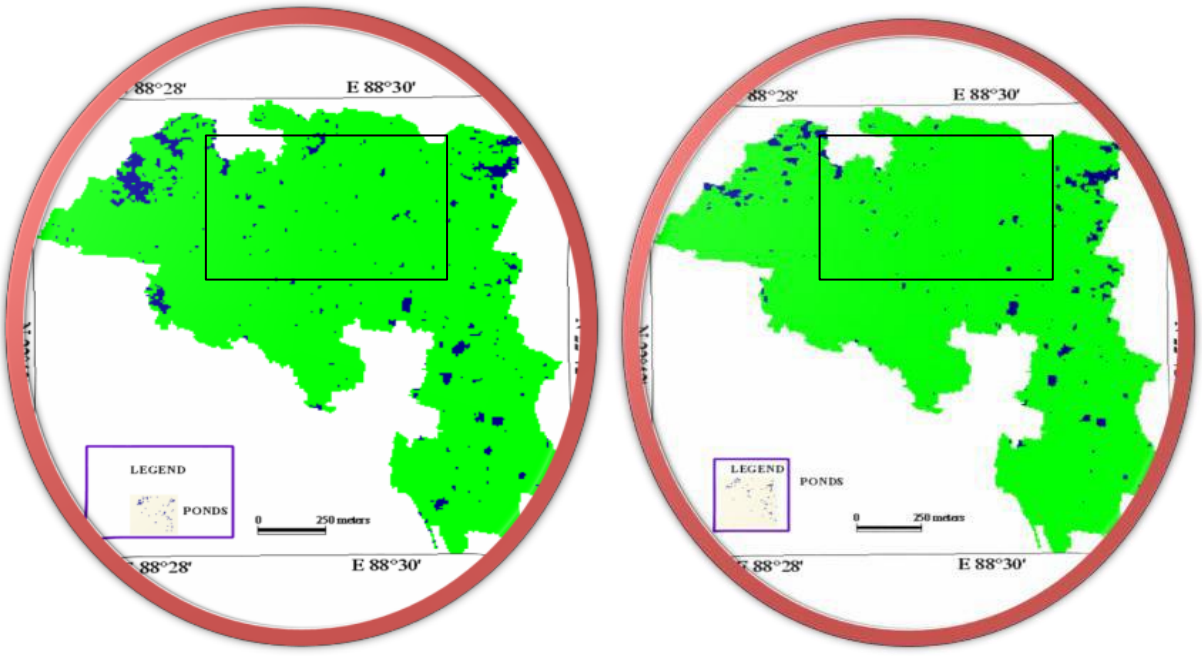
Urbanization is one of the main driving forces for large areas. The increasing urban sprawl in proportion to population growth posed severe pressure on urban water bodies, by making them non potable, impairing their absorption capacity, deteriorating water quality, disturbing aquatic bio diversity and finally resulting in the water body vanishing. In the other words, all the activities stated above can be grouped under encroachment phenomenon converted into land for construction, thereby increasing available urban areas.

Remote sensing techniques were applied to detect the changes in surface water resources like ponds. Several indices relating to water resource (NDWI, MNDWI, LSWI and NDPI) were prepared for each three years (1990, 2000 and 2011). Among those indices Normalized Difference Pond Index (NDPI) detected the change in number and area of ponds. As the negative value denotes water body for this particular pixel based classification, it shows the location of ponds for 1990, 2000 and 2011. The index value denotes ponds are given below.

Similarly, to detect the changes in area of urban settlement, Normalized Difference Built-up Index (NDBI) was prepared. As the positive value denotes built-up area for this particular pixel based classification, it shows the urban sprawl of 1990, 2000 and 2011. The index values denote built-up area given below.

Ponds extraction method was acted using the index values stated above in case of each year and changes both in number and areas were observed. Built-up area extraction method applied using the positive index values stated above in case of each year and urban sprawl mapping were done.

Year	1990	2000	2011
NDPI values	-0.021 to -0.935	-0.090 to -0.740	-0.018 to -0.395
NDBI values	0.012 to 0.556	0.052 to 0.281	0.021 to 0.485



1990 Number of Ponds: 241 **2011 Number of Ponds: 152**

Fig. 4: Diminishing number of ponds in Barasat town from 1990-2011.

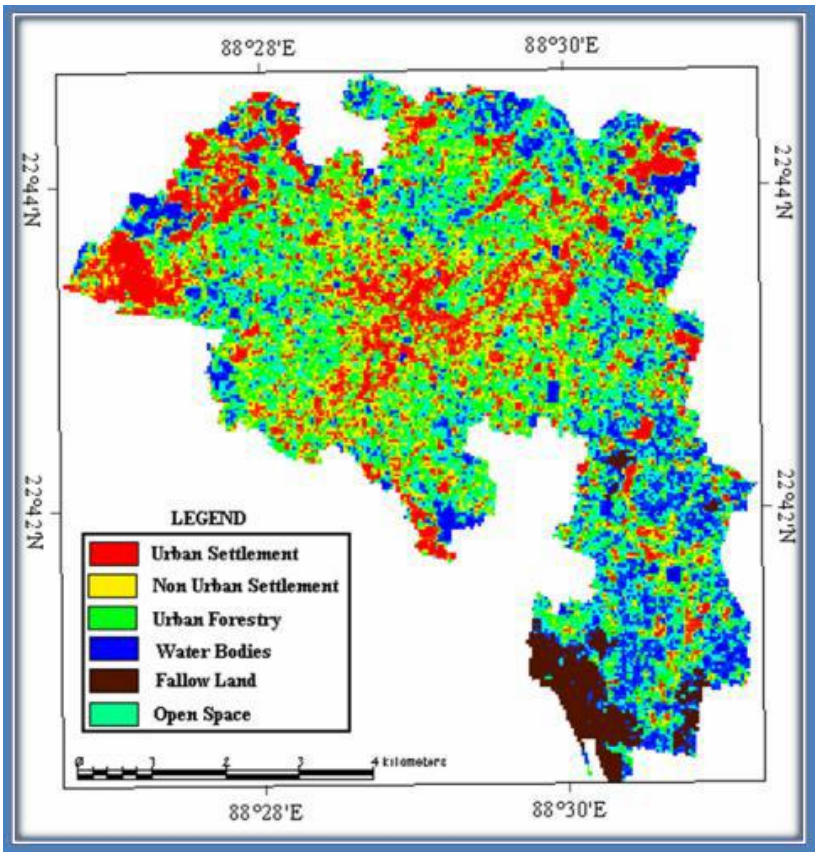


Fig. 5: Land Use Land Cover Map of Barasat Municipality, 2011

Name	T1	T2	T3	T4	T5	Total	User's Accuracy
Urban Settlement	1747	5	0	0	0	1752	99.71%
Non-Urban Settlement	18	697	26	0	0	741	94.06%
Water Bodies	0	11	708	9	0	728	97.25%
Fallow Land	0	0	8	924	6	938	98.51%
Urban Forestry	0	0	0	4	530	534	99.25%
Total	1765	713	742	937	536	4693	
Producer's Accuracy	98.98%	96.76%	95.42%	98.61%	98.88%		
Overall Accuracy = 98.15%				Khat Statistics = 97.55%			

Table 1: Accuracy Assessment on Supervised Land use/ Land cover classification of Barasat Municipality

On the basis of the prior knowledge and the field data collected with GPS of the study area a supervised classification of land use land cover was performed. In this classification some strategic training sets are assigned as some specific land use land cover types .Object oriented classifier was used for this classification. A landuse/ landcover map was derived with the following six classes: 1. Urban settlement 2. Non-Urban settlement 3. Urban forestry 4. Water bodies 5. Fallow land 6. Open space.

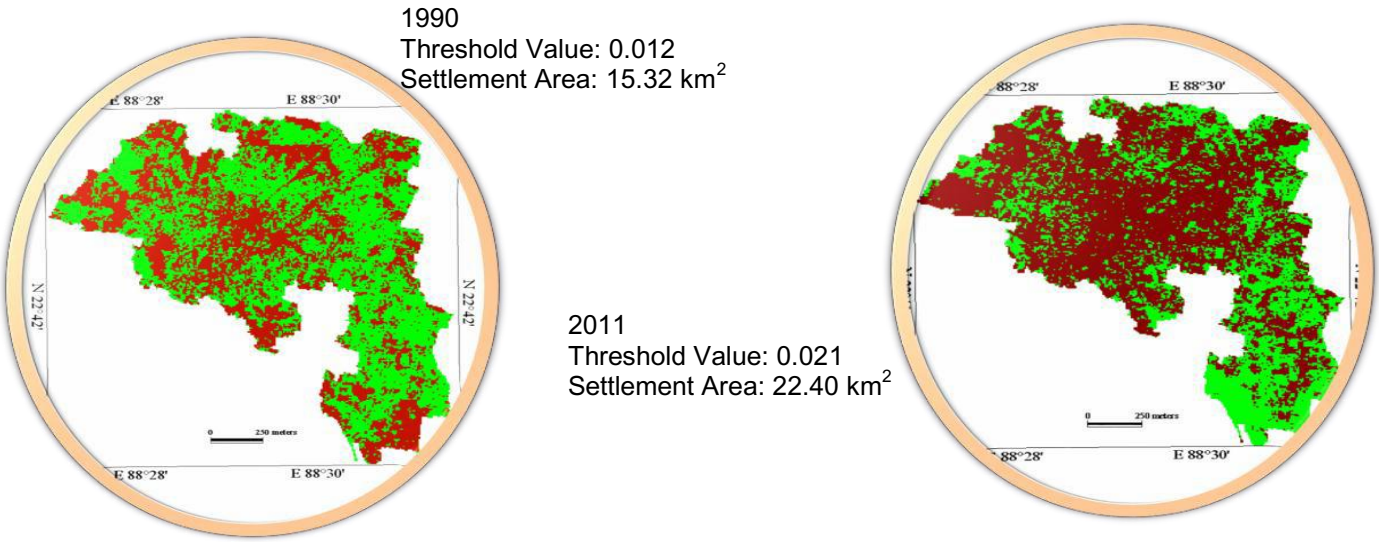


Fig. 6: URBAN SPRAWL- Extracted from Normalised Difference Built-up Index; Barasat Municipality, West Bengal

In the centre of the town a star like urban settlements grow at the crossing of Railway line and National Highways and State Highways. High density of settlement forms the CBD of the town. Since 1984 this town became the Head Quarter of North 24 Parganas District , the settlement grew at faster rate due to increasing administrative, business activities. Nearness to Kolkata is also important cause of increasing population in this neighbouring town.

Findings and e-governance

Now, what we have done that to show a way to maintain a bridge between the constantly changing surface water resources and human activities. We have tried that how remotely sensed data can help us to detect the changes over time span. It can help government to take necessary steps to have a sustainable environment.

References

1. Dwivedi, S & Bharti, K.A. (2005) "E-Governance in India- Problems and acceptability" Journal of Theoretical and Applied Information Technology.
2. Agrawal, V., Mittal, M & Rastogi, L. "Enabling E-Governance Integrated Citizen Relationship Management Framework- The Indian Perspective Indian".
3. Basu, S., Integration of ICT and E-Governance and Developing countries: An Overview" International Review of Law, Computers &Technology Vol 18 No,1 Pp 109-132.
4. Ahmad Hassan, Nusrath Asima 2010: Vegetation change detection of Neka River in Iran by using remote sensing and GIS. Int.Journal of Geography and Geology, vol. 2, No. 1; pp 58-67.
5. Baatz, M. and A. Schape. 2000. Multiresolution segmentation -an optimization approach for high quality multi-scale image segmentation. In *Angewandte Geographische Informations - Verarbeitung XII*,, eds. J. Strobl, T. Blaschke and G.Griesebner, 12–23. Karlsruhe: Wichmann Verlag.
6. Bisht, B.S. and Kothyari, B.P. (2001). LandCover Change Analysis of Garur Ganga Watershed Using GIS/Remote Sensing Technique. *,I. Indian Soc.Remote Sensing,* 29(3):165174.
7. Chitade.Z. Anil and Katiyar.S.K, classification techniques for landuse/landcover with special reference to Inland wetland mapping in parts of Nizamabad Districts, A.P. India- a case study, Department of Civil Engineering, MANIT Bhopal (M.P), India.
8. Congalton, R.G., Green, K., 1999. In: Lyon, J.G., Raton, B. (Eds.), Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Mapping Science Series, Durham.
9. Saravanan. P. and Iiangoval. P, 2010, Identification of urban sprawl pattern for Madurai region using GIS, International journal of Geomatics and Geosciences volume 1, No 2, 2010.
10. Walter, V. 2004. Object-based classification of remote sensing data for change detection. *ISPRS Journal of Photogrammetry and Remote Sensing* 58, (3-4): 225-238.
11. *Lei Jl, Li Zhang, and Bruce Wylle Analysis of Dynamic Thresholds for the Normalized Difference Water Index.* American Society for Photogrammetric Engineering & Remote Sensing November 2009.

Studies on Drought Prone Areas of Palakkad District, Kerala

Dani. V, Lekshmi G. S, Veena Surendran, and E Saravanan
Centre for Earth Science Studies,
Training and Extension Division, Akkulam, Thiruvananthapuram-695031
Email: danivarghes@gmail.com,

Abstract

Drought is defined as an extended period of abnormally dry weather that causes water shortages and crop damage. A drought starts when total rainfall is well below average for several months. Other signs of drought include unusually low river flows, low groundwater and reservoir levels, very dry soil, reduced crop yields or even crop failure. A reduction in crop productivity usually results in less income for farmers, increased prices for food, unemployment and migration. Water is integral to produce goods and provide certain services. Since severe drought is often slow in its development, several mitigation measures can be used to reduce the impacts felt by drought with the help of early warning system. Drought is related to the timing and the effectiveness of the rains. It can be defined and managed depending on the affected sector through proper monitoring.

Keeping this in view, an attempt is made to study the drought condition of Palakkad District. Drought is a recurrent phenomenon in Palakkad; its intensity is high in regional scale. Even though Palakkad has the maximum number of dams in the State, but the district is reeling under severe drought and acute drinking water shortage. The average temperature recorded in Palakkad around 42°C during summer. The incidences of droughts are more in Palakkad when compared to other districts of Kerala and hence it is prerequisite to study the intensity of drought in detail. Vegetation chlorophyll content, soil moisture, crop production and precipitations are the major parameters for the drought studies. For the present study, three indices (NDVI, NDWI, and NDYI) were used to predict the intensity of the drought. Apart from this NOAA based Drought Calculator and Standard Precipitation Index (SPI) are also used to depict the intensity of drought. The resultant indices, crop production data, Drought Calculator and the SPI, evaluated in the GIS platform will have a positive correlation. The LISS III and Landsat data is used for the present study. This study will be useful for the planners to workout strategies to mitigate the drought.

Introduction

A drought is defined as an extended period of abnormally dry weather that causes water shortages and crop damage. A drought starts when total rainfall is below average for several months. Other signs of drought include: unusually low river flows, low groundwater and reservoir levels, very dry soil, reduced crop yields or even crop failure, a reduction in crop productivity usually results in less income for farmers, increased prices for food, unemployment, and migration. Since severe drought is often slow in its development, several mitigation measures can be used to reduce the impacts felt by drought with the help of early warning system.

Problem of the Study

Kerala's climate is tropical monsoon and tropical savanna, according to Koppen's climatic classification. There is significant rainfall variation in North and South Kerala. In north Kerala, northeast monsoon rainfall shows a decreasing trend and contributes about 15% of the annual rainfall. In south Kerala, southwest and northeast monsoon rains have decreased by 5% and 8.3%. Mean annual rain fall is also decreasing in Kerala. This may adversely affect cultivation of the second rice crop in Kerala, especially in the north Kerala. During weak monsoons and droughts in Kerala, the orographic contribution is almost nil, but this is not attributed to a weaker westerly component during the dry spell. Kerala had a severe dry spells and drought in 1983, 1985, 1986 and 1987, even though the state has a Wet Climate. Damage due to drought was particularly significant in Kerala in 1987. About 1,500 villages in 14 districts were affected, and 9.82 lakh hectares of Cropland and 6 lakh cattle were also affected. During January–May 1987, the entire Kerala region was affected by drought. About 30% of the rabi season paddy crop was lost and cash crops like coconuts, arecanuts, cashews, and bananas were damaged, resulting in a loss of Rs. 1,000 crores. Compare to South, Northern Kerala experience severe drought. Palakkad district is located in the northern part of Kerala, and which has the largest cultivable area and highest production and records highest temperature in the state and ultimately drought prone.

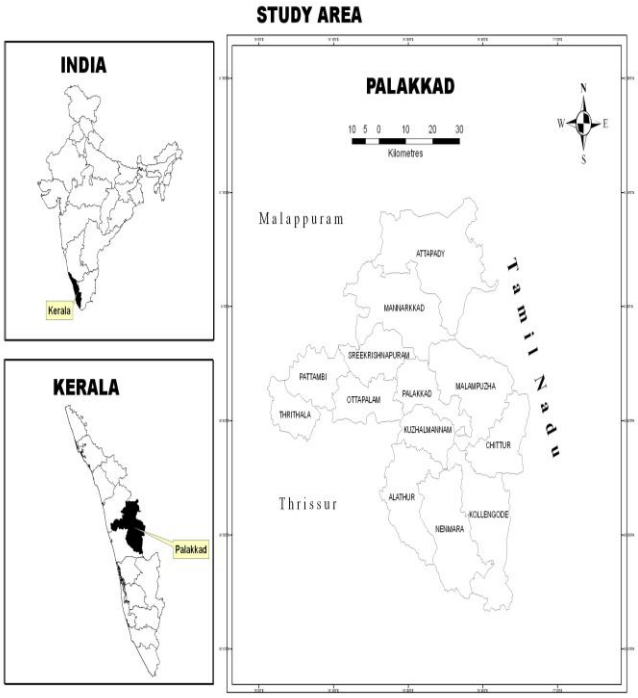


Fig. 1

Study Area

Palakkad is the gateway to Kerala due to the presence of the Palakkad Gap, in the Western Ghats. It lies in the 10.77°N 76.65°E The total area of the district is 4480 km² which is 11.5% of the state's area. Out of the total area of 4480 km², about 1360 km² of land is covered by forests. Most parts of the district fall in the midland region (elevation 75–250 m), The climate is hot and humid for most part of the year. Palakkad is one of the hottest places in Kerala. Study area shown in the Fig. 1.

Data Used in the Present Study

Digital images acquired by earth observing satellite sensors which can be used in several ways in order to nourish the basic data needed for the theme under study. The basic data are of various land use / land cover and other subtle information that are visible on the image in a varied manner. Even for the basic usage, it is necessary to carry out preliminary visual interpretation or image processing and image enhancement techniques that are essential in this regard. Like wise to obtain a readily understandable document, the image information has to be converted into maps – the geo spatial database, not only for the simple representation but also for complex representations. The validation of interpretation of satellite data have to be performed for final derivation of geo- spatial data base. As per government of India norm, certain criteria are given for declaring an area as drought affected one. They are as follows,

1. Decrease in rainfall subjected to previous years
2. Non-availability of surface and ground water
3. Decrease in agricultural production.

These are the three major parameters and there are several sub parameters also. Thirty years of rainfall data was collected and analyzed, it is found that there is a decreasing trend in rainfall pattern. Similarly it is found that water bodies are of non-perennial in nature and there is depletion in the ground water table. Twenty five years of agricultural data was analyzed it was found that there is decrease trend in the crop production.

Digital Image Data Products Used

The following satellite images are used for the present study to identify drought affected area

1. LANDSAT MSS (02-10-1973)
2. IRS P 6 LISS III (02-11- 2011)
3. Digital images of 14 scenes covering Palakkad district on scale 1:50000 is used Thirty years of rainfall data collected from various sources and analyzed for the study

Agricultural Data

The agricultural production or agricultural activities are affected by drought depending on its severity. Twenty five years (1986-2011) crop data of area and production were collected and analyzed.

Methodology

In the present study, the land use / land cover maps were prepared based on the rectified images using unsupervised classification algorithm. The rectified LANDSAT MSS satellite data acquired in 02-10-1973 data is used for creating the NDVI by using the ERDAS 10 software, which depicts the vegetation condition of the present study area. The agricultural data were collected from the secondary sources were used and analyzed. Thematic maps were prepared in GIS platform. The rainfall data is used to identify the drought, through drought index .based on the above drought prone areas are identified.

Software Used

1) ERDAS 10

ERDAS 10 is mainly used for the creation of NDVI. For creating the NDVI several spatial, spectral and radiometric correction has been done. The layer stack tool is used for combining the selected bands (namely Red and Infrared Band). Indices are created in the spatial enhancement tool and by using the reclassifying tool the pixel values can be recoded. The

NDVI is created and the value ranges between -1 to -1. Vegetation Index having the value -1 denotes water and +1 denotes healthy vegetation.

2) ARC GIS 9.3

The ARC GIS 9.3 is used for rectifying the top sheets and the satellite image. The base map is rectified using the top sheets as base and the study area is digitized by creating the shape file. The attribute tables are created and the spatial information on the agricultural data of the present study area is being entered. Finally the desired thematic maps are created and layout is prepared by giving grid, scale legend, north arrow, titles etc.

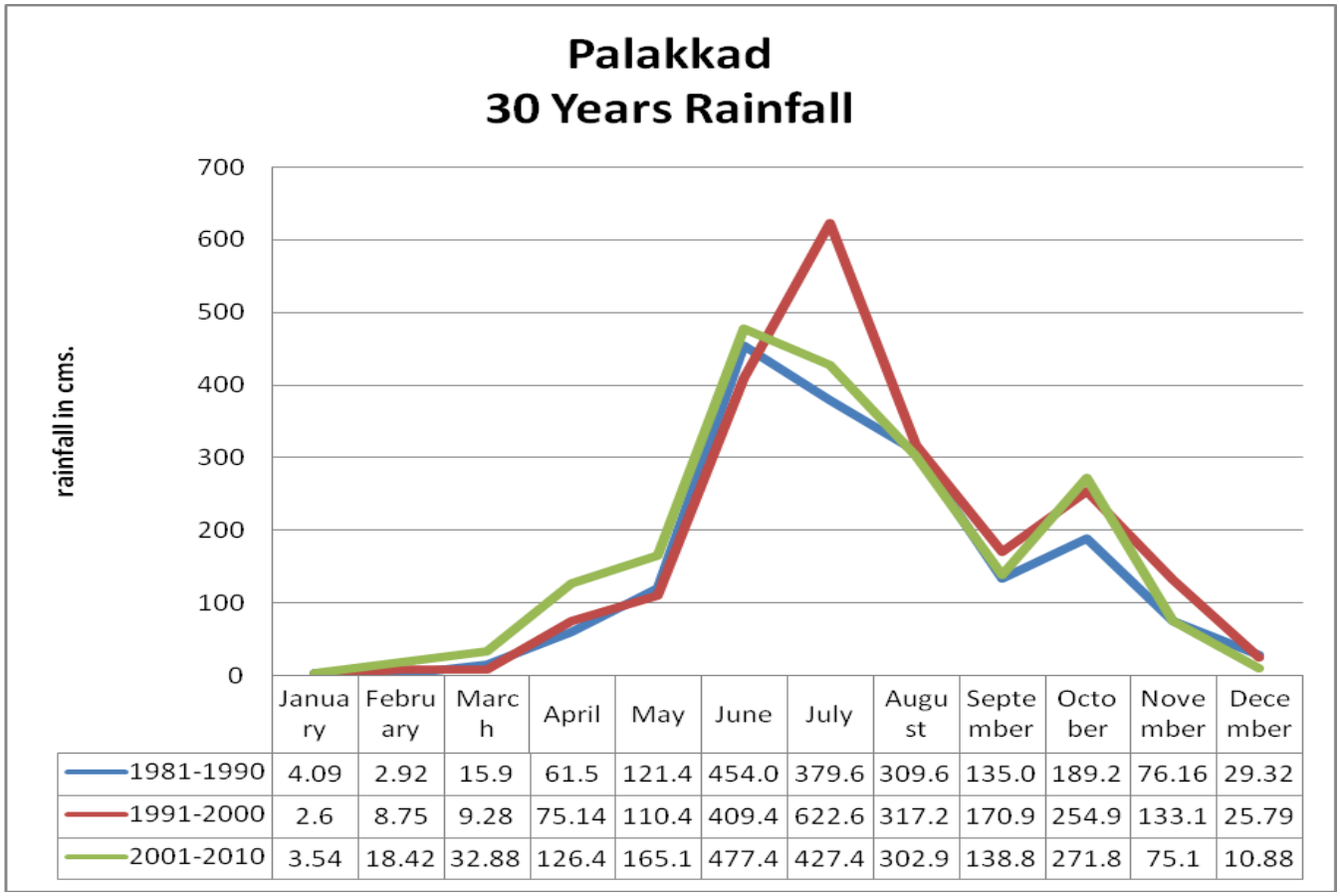
Spatio–temporal Analysis of Drought

Meteorological Data

The present study area is mainly affected by drought because of the incidents of less rainfall. During the month of January and February the rainfall is almost absent Fig. 2. Major River (Bharathapuzha) and other irrigation sources are mainly depending on the monsoon rainfall. The temperature of the study area ranges maximum of up to 42 °C in April and May, and 24 °C in the rest of the months. The average rainfall is below 238.9 cm. Palakkad receives more rainfall from the South-west monsoon and North- East Monsoon. The following graph shows that there is a declining trend in the rainfall. June and July recorded maximum rainfall due to South-west monsoon and remaining months are recorded with below average rainfall. Drought is more recurrent prior to monsoon period. The drought prone areas in Palakkad district are prominent in regional level. The above mentioned analysis is based on the incidence of thirty years of rain fall in Palakkad district.

Agricultural Data

Palakkad is known as the Granary of Kerala. Agriculture forms the major economy in the study area which is also affected by drought often. There are three types of crops cultivated in this region, namely Food Crops, Cash crops and Fiber crop (cotton). Palakkad is the only district in Kerala where fiber crop is cultivated. Agricultural crop production of Kerala from 1980 to 2010 were collected and analyzed. The graph shows there is a declining trend in the Agricultural production of crops with the reduction in rainfall over the year. Compare to major crops cultivated over the years it is seen that there is a decline in production especially after 1986. One of the factors in the declining trend of crop production is due to the prevalence of drought. The following graph (Fig. 3) shows the trend of agricultural production in Palakkad district.



	January	February	March	April	May	June	July	August	September	October	November	December
1981-1990	4.09	2.92	15.9	61.5	121.4	454.0	379.6	309.6	135.0	189.2	76.16	29.32
1991-2000	2.6	8.75	9.28	75.14	110.4	409.4	622.6	317.2	170.9	254.9	133.1	25.79
2001-2010	3.54	18.42	32.88	126.4	165.1	477.4	427.4	302.9	138.8	271.8	75.1	10.88

Fig. 2: Rainfall data for 3 decades in Palakkad

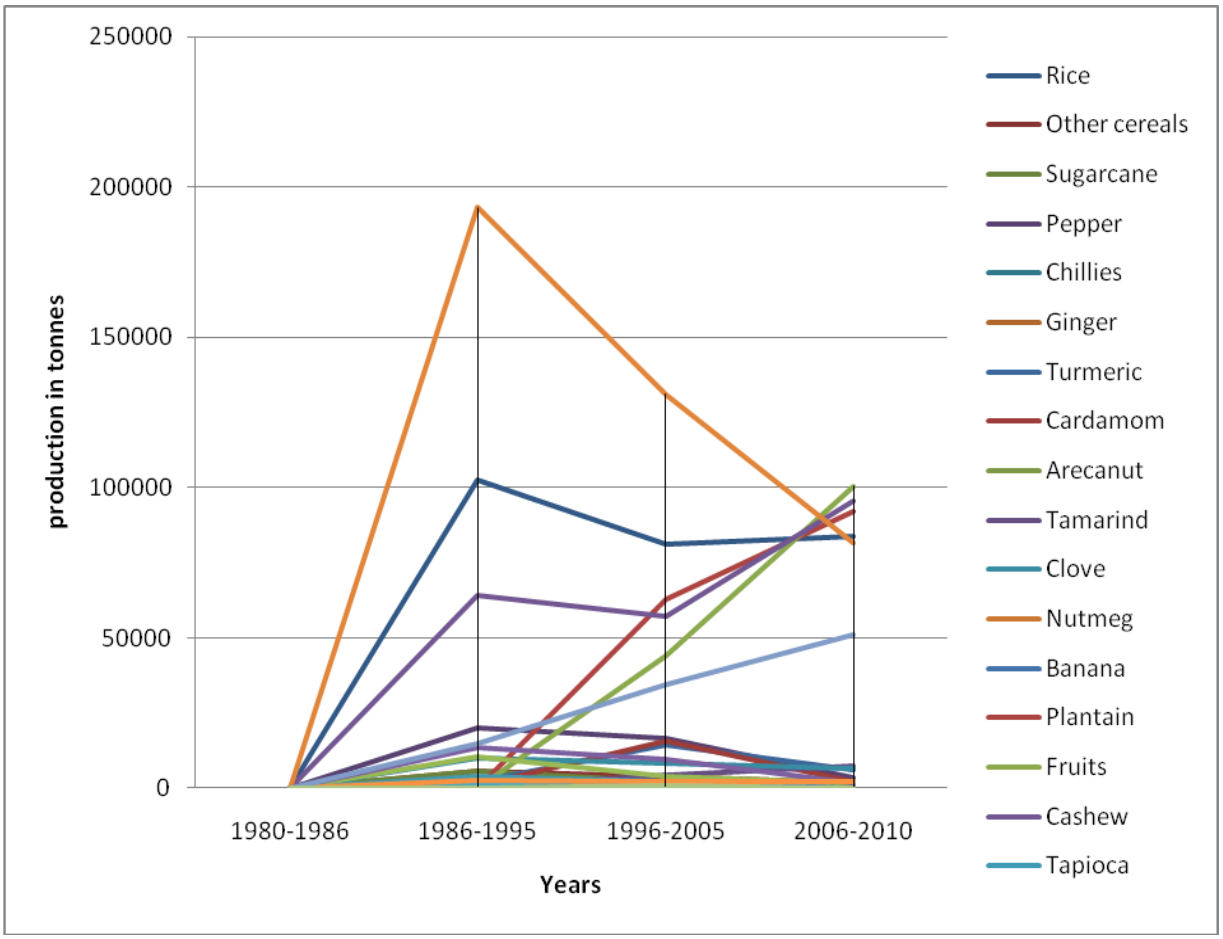


Fig. 3: Agricultural products of Palakkad

Agricultural Land Use/Land Cover Change – 1986 to 2010

Land use/ land cover map of Palakkad district was prepared by using Landsat MSS (02-10-1973) IRS P 6 LISS III (02-11-2011), using Erdas10 & Arc GIS 9.3 software. Land use / land cover of the present study shows that there is a sharp decline in the agricultural land and increase in Settlements along with waste lands. The agricultural Land use shown in the Fig. 4 & 5 shows the area under cultivation is decreasing over the years.

The Normalized Differential Vegetation Index (NDVI)

Many researchers have attempted to determine the condition of vegetation NDVI. The NDVI approach is based on the fact that healthy vegetation has a low reflection due to chlorophyll content and high reflectance in NIR because of the reflectance of mesophyll spongy tissue of green leaf (1).

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)}$$

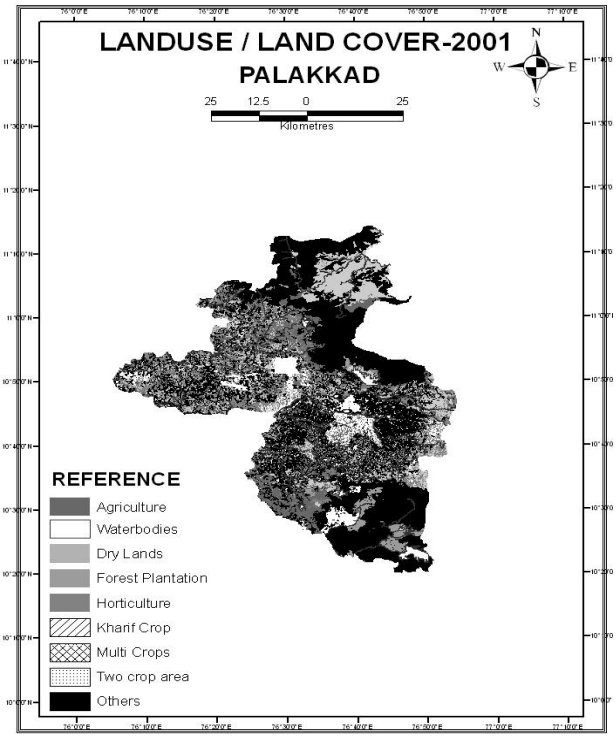


Fig. 4: Land Use/Land Cover in year 2001

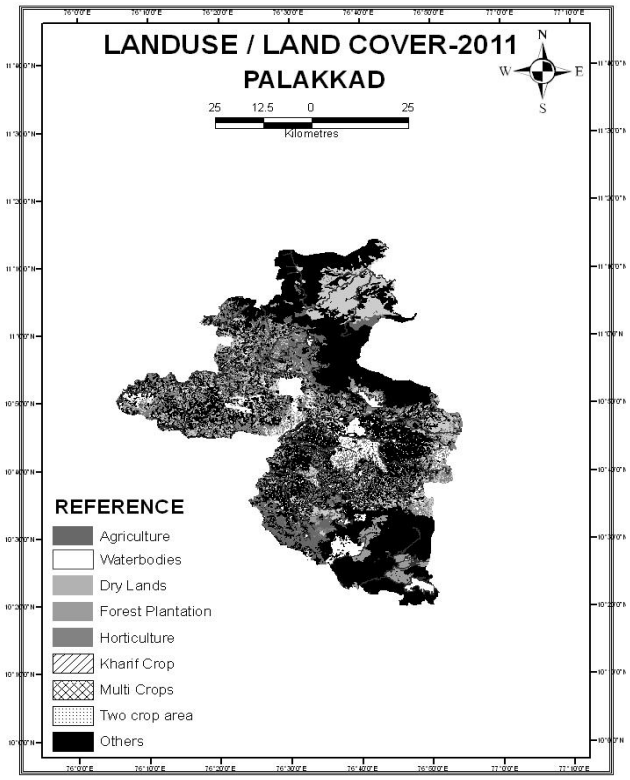


Fig. 5: Land Use/ Land Cover in year 2011

The NDVI is created for the present study area using ERDAS 10. NDVI is derived from the LANDSAT MSS (02-10-1973) and LISS III (02-11-2011). The NDVI output shows that there is a decreasing trend in poor vegetation condition and also the poor reflectance of water from 1973 to 2011, but there is high reflection on the bare soil.

The NDVI value of the study area ranges from (-1 to +1) and values were again minutely divided into (-0.577 to +0.65789). NDVI value of vegetation ranges from 0.04-0.7. The vegetation is further subdivided into different classes based on their health condition, by identifying its chlorophyll content (2). The poor vegetation reflection range from of 0.35-0.6 and the healthy vegetation range from 0.6-0.7. The present study proves that the amount of vegetation in Palakkad is scarcely distributed [LISS III 02-11-2011]. It is seen that the study area was not able to support the vegetation due to low rainfall and high temperature. The value of water present in the study area ranges from -0.1 to -0.257. The bare soil found in the study area ranges from 0.01 to 0.025. NDVI shows that the concentration of vegetation in Palakkad area is comparatively less in Kollengode, Malampuzha, Northern part of Chittor, Kuzhalmannam, North-Eastern part of Attapaddy and central part of Palakkad. The reflection of bare soil is very high and also the reflectance value of the water is very low in Palakkad. High vegetation concentration is found in Nenmara and North western part of Attapady and mild vegetation is found in Sreekrishnapuram. The NDVI shows decrease in trend of Vegetation and water in Palakkad District and there is significant increase of dry areas. The NDVI analysis map is prepared for Palakkad region is shown below (Fig. 6 & 7).

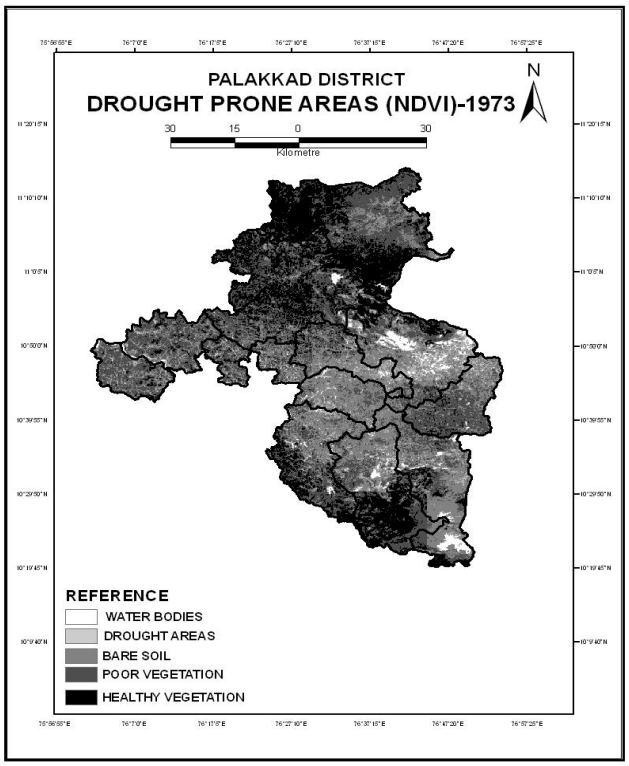


Fig. 6: Drought Prone area of Palakkad (1973)

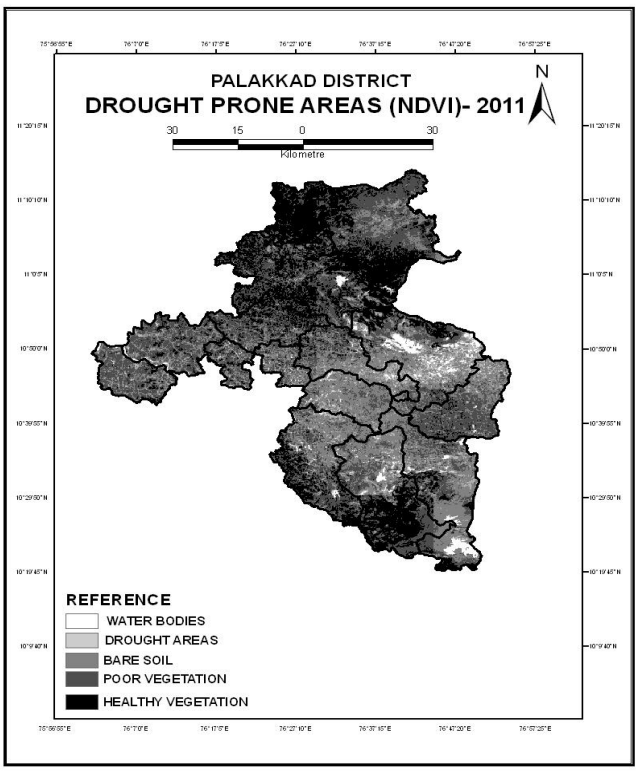


Fig. 7: Drought Prone area of Palakkad (2011)

Conclusion

The present study is an attempt to study the drought prone areas in Palakkad district. It is highly vulnerable due to its unique climatic and soil condition. Hence it is suggested that an intensive short term and long term study of drought condition is a prerequisite in order to achieve sustainable agricultural development of Palakkad. The assessment of available irrigation sources and conservation measures of increasing the groundwater potential is the need of the hour so as to increase the agricultural practices in this region.

The Geo-informatics techniques can contribute in the assessment of drought prone areas and there by a detailed data base in the form of thematic map will help the agricultural planners to apply appropriate measures to mitigate drought. The GIS tool will help to update the map periodically so that drought monitoring can be carried out accurately. The NDVI technique will be useful in the identification and assessment of the health of vegetation in the study area periodically so as to apply appropriate methods to improve the health of vegetation.

Application of Geoinformatics to Detect the Hotspot Regions where Human Responses against Bank Failure is Maximum – A Case Study of Malda District, West Bengal, India

Chhanda Dey and Dr. Jatisankar Bandyopadhyay
Department of Remote Sensing & GIS, Vidyasagar University, Midnapore, West Bengal, India
Email: dey.chhanda@gmail.com

Abstract

The word Hotspot Region generally indicates those areas where risk factor is maximum. Here the word is used in the context of zonation mapping where human response against bank failure shows at its peak in the Malda District, caused by the shifting channel of the Ganga. This study is focused on the analysis of the behavioral changes of the human response against the shifting channel of the Ganga for the identification of hotspot regions with the aide of Geoinformatics.

Landsat (Thematic Mapper) data is used for the river course Change Detection. Both the spatial and aspatial data are processed to categorize the district based on the risk factors and response patterns. Spatial Interpolation and Buffering techniques are successfully introduced to prepare Zonation Map and to find the hotspot regions. Mass displacement and land degradation (caused by flood, river bank erosion etc.) is higher in the Manikchak, Kaliyachak-I, Kaliyachak-II, Ratua blocks which are identified as a hotspot regions because 22 Mouzas have already been zoned into the river bed and about 4.5 lakh people have lost their shelter due to the encroaching Ganga.

From this study it can be concluded that the amount of erosion, neo-refugees and human displacement are increasing enormously in this district against which proper development is required.

Introduction

The Ganga is the main source for riverine natural disaster in the Malda District. The people of West Bengal and their behavioral response are largely affected due to the presence of the Ganga. Within West Bengal Malda is the most vulnerable district by means of the natural disasters or physical calamities. The Ganga enters near Ratua Block of Malda District in its lower course and has limited length of 76 km on its left bank before engrossing through the region and falling into another district. The goal of this study is to identify properly how the river Ganga changing its form after being affected by the natural as well as anthropogenic factors, and to assess the response magnitude of the affected demographics.

Background of the study

The Ganga in its lower course enters West Bengal, which is associated with flat alluvial plains and has nearly flat gradient. The formation of meander begins just below the Rajmahal hills because of very low gradient of the terrain and as a normal tendency of the alluvial river after losing sufficient stream velocity. The erosional activities of the Ganga is not static, it changes with changes in the volume of water and amount of mass movement caused by the fluvial action (Iqbal, 2010). It has been observed from the old maps and historical records that the position of the Ganga is static only at two particular points of Rajmahal and Farakka (Fig. 1).



Fig. 1: Satellite Image of the Study Area

The river Ganga normally has been changing its position since 1922-23. At that time the course of the river was nearly straight in between two particular points but the changing forms began to appear in between 1948-50 when it was observed that the Ganga has already been shifted towards the left from its actual position from just below the Rajmahal. Further, the bankline shifting became more prominent during 1967-68 and it was accepted that the position of the river Ganga swung to left below the Rajmahal and towards right below the Farakka. The shifting river provides considerable evidences on how human activity and human habitation are interlinked and influenced by the fluvial history.

Objectives

1) To study the shifting channel of the river near Malda District.
2) To identify the interaction between erosion potential zone and human response against it.
3) To investigate the changing pattern of landuse and landcover types caused by the natural disaster.

Study area

Malda District has been chosen for the present study. Malda District is located in the central part of the West Bengal. The study area lies between 25°32'08"N to 24°40'20"N latitude and 88°28'10" E to 87°45'50"E longitudes. The district covers an area of 3,733.66 square kilometers with 15 Blocks and 146 gram panchayats. Malda the gateway of North Bengal is surrounded by Murshidabad district to the south, North Dinajpur district and South Dinajpur district in the North, Santhal Parganas of Jharkhand and Purnea of Bihar to the west and Bangladesh in the east.

Rivers:

The Ganga is the main river of the Malda district. Apart from it other important rivers are Mahananda, Fulahar and Kalindri. They are prone to seasonal flooding and the entire district is markedly affected by the fluvial action of the rivers, with Ganga exerting the maximum impact.

Physiographic Divisions:

The district associated with a low-lying alluvial plain. The river Mahananda divides the region into three parts: the eastern part is known as 'Barind' and the western part is again subdivided by the Kalindri river among which the northern part is known as 'Tal' and the southern part is known as "Diara", which is very fertile and densely populated portion (DHRD, 2007).

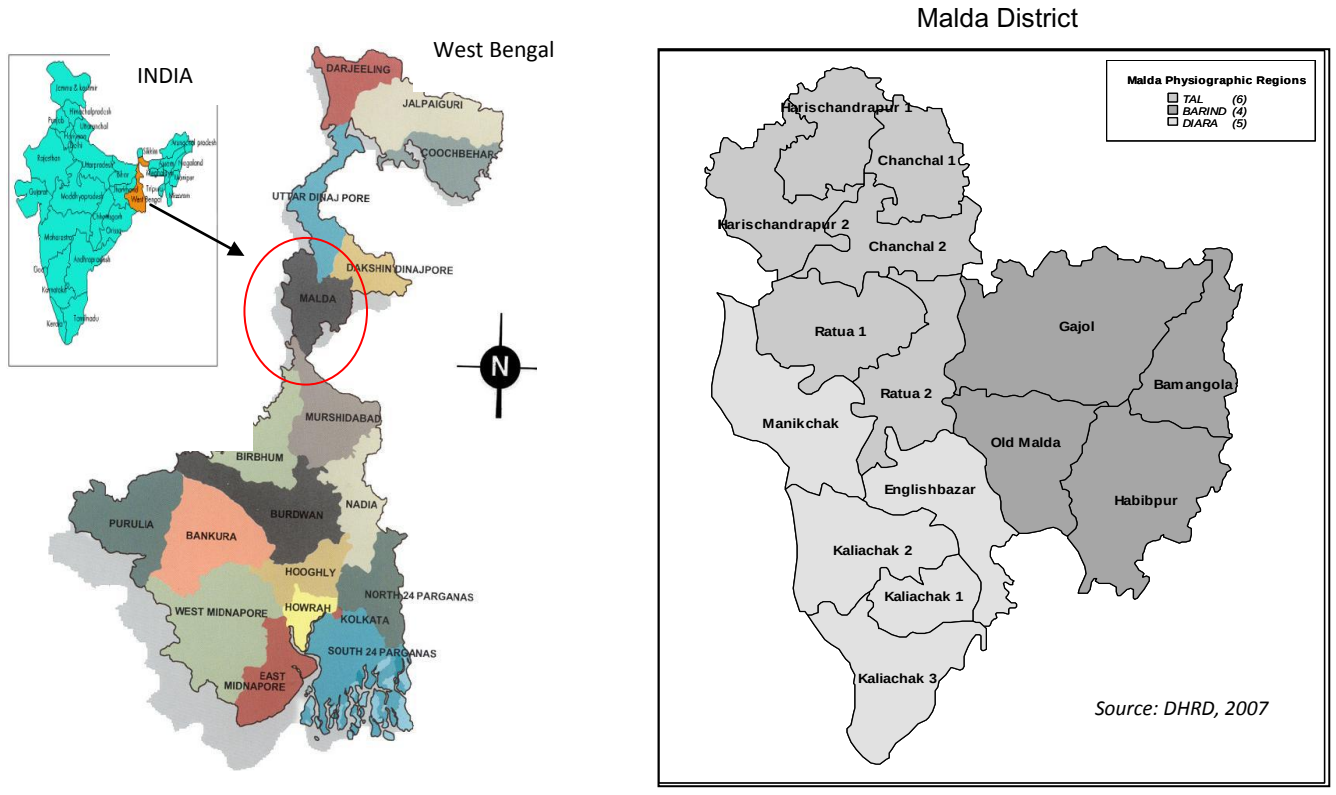
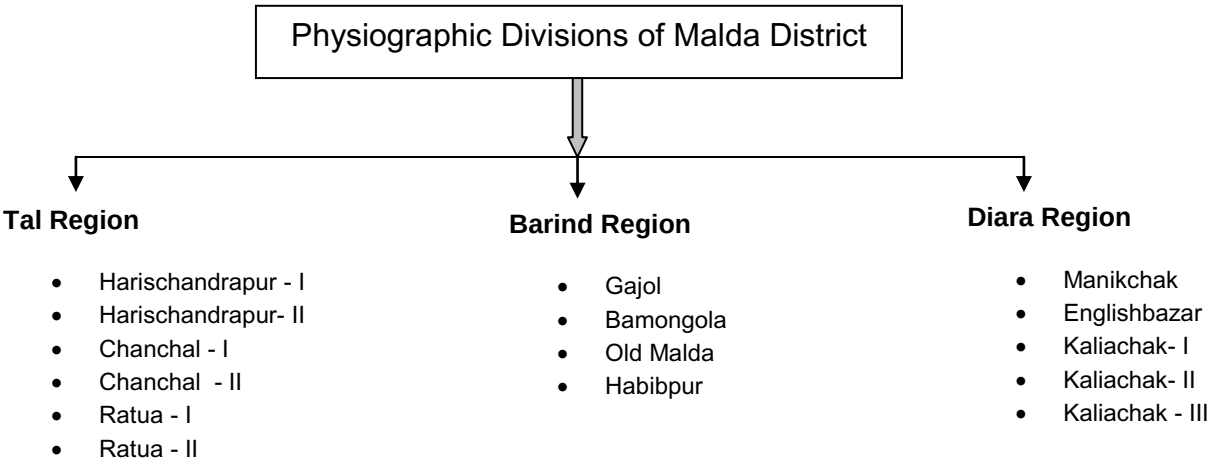


Fig. 2: Locational Map of the Study Area



Methodology

Multi-dated Landsat TM satellite data of different years from 1990-2006 are collected and rectified with the help of ERDAS IMAGINE v9.0. Then the images are registered with respect to Toposheet by using the same software. Then the study area was delineated through the subset technique. River channel from different images were overlaid on top of each other after going through the digitization process for the purpose of Change Detection and riverbank shifting. Census data and DHDR, 2007 report are used to study the demographic characteristics of local people and analyze the impact.

Analysis of bank failure and human response

The word 'Hot Spot' generally refers those areas where risk factor is the maximum. Here this term has used to detect that region where people are day by day suffering with the evil effect of riverbank shifting and trying to adjust with the changing phase of nature. This adjustment is dynamic and depends on both the social and economic factors.

1) <u>Bank Failure</u> is the principal cause of encroaching Ganga. Long term river oscillation in Malda district is a common feature between the two fixed points i.e. Rajmahal and Farakka where river is static by means of its position. The bankline changes can be identified after studying the historical data and multi-temporal satellite images. In terms of sheer magnitude of damage caused by the riverine erosion it can be said that the Diara is the most affected region. Due to the close proximity to the Ganga the blocks lying on Diara regions are mostly affected. The amount of land loss is rapidly increasing within the Diara region. The effect of Bankline Failure and riverine erosion is higher near Manikchak & Kaliyachak-II. Kaliyachak-III also shows a very high amount of land loss. Apart from the shifting channel of the Ganga the construction of Farakka Barrage should be mentioned as an important factor for the acceleration of the disaster. The Farakka Barrage blocked the natural movements of the Ganga and the leftward erosion increased at the time of high discharge of water (Parua, 1999). The amount of land loss increased enormously with the each passing year just after the construction of Farakka Barrage. The amount of land loss was recorded as 60 hectare in the year 1979 while the amount was 310 hectare for the year 1996. In 1998 the amount of land loss was recorded as high as 330 hectare due to the additional effect of flood.



Fig. 3: Bankline Shifting with the passing of time

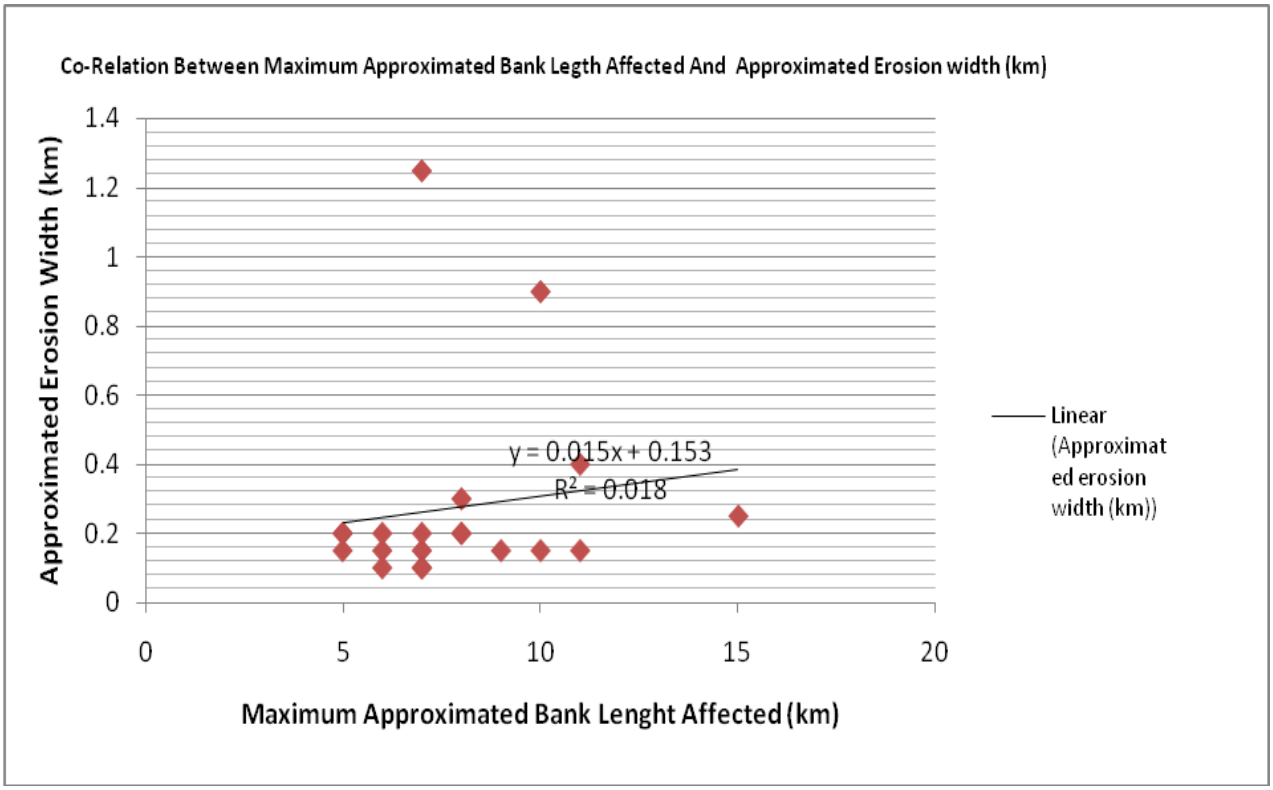


Fig. 4: Correlation Between Maximum Approximated Bank Length Affected And Approximated Erosion width (km)

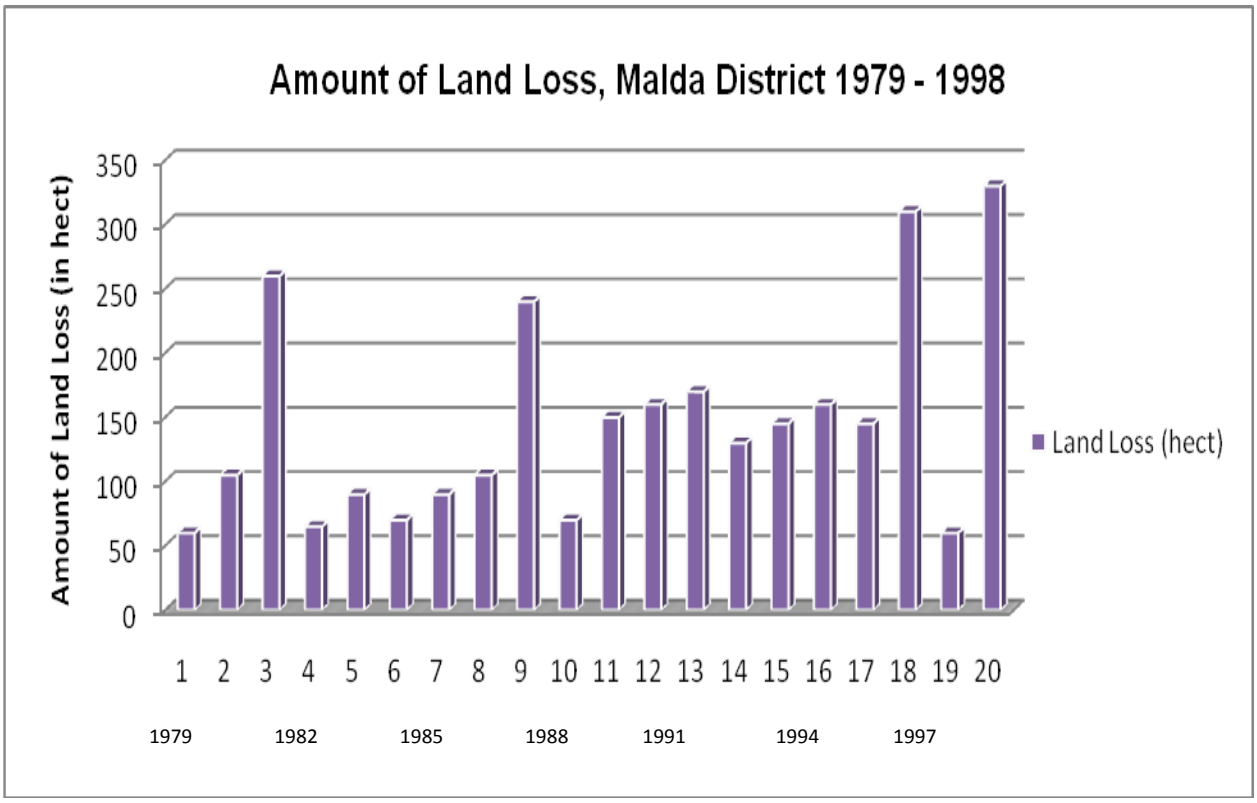


Fig. 5: Amount of Land Loss in Malda

2) Human Response

It is referred as the interaction between the changing of the nature and changes in demographic characteristics. Human response is reflected in the behavioral changes adopted by human being to survive with the changing of the nature for the purpose of better livelihood. The impact of riverine erosion is crucial for those villages, which are located near the bankline areas. The human livelihood is vulnerable near these areas due to the permanent and repeated loss of their land and settlement. Based on the Erosion related issues the settlement inherited by the local people can be categorized into few groups:

- Settlements located at erosional hotspot flood plain: Panchanandapur.
- Resettlement colonies: Dharampur, Gopalpur, Dakshin Chandipur.
- Land units wipe out due to the riverine erosion: Babupur, Jitnagar.
- Relocated settlement on *Char* land: Charbabupur
- No-man's land: Newly emerged *Char* without having any owner.

2. i) Effect on Rural Economy: Rural economy is primarily based on agriculture. However, after losing own lands most of the erosion-affected people are changing their occupation from cultivators to daily wage laborer. Huge number of Male population migrated from the Diara region in search of work. People displacement is a common phenomenon because of the limited option for their survival as purchasing new land demands huge financial resource. So the landless rural day laborers are migrating out of the area and sometimes out of the state for the sake of occupation.

2. ii) Conversion of Agricultural Land to Non-Agricultural land is very prominent. According to the Malda Distrct Human Development report, 2007 the conversion of Agricultural land to Bastu land has been recorded as 38.29 hect. with an annual rate of 7.66 hect/p.a. while the Agricultural conversion to commercial use has been recorded as 29.02 hect. with a rate of 5.80 hect/p.a.

2. iii) Land Conversion to Orchard is also very common in Malda district. From historical time Malda has been famous for *Mango* and *Litchi.* Mango cultivation is highly seasonal activities and it demands huge number of labors for the purpose of plucking and packing. The Barind region was famous for Mango cultivation but presently this trade is spreading all over the district and most of the erosion victims are choosing this as a secondary source of occupation or simply as a daily labor.

2. iv) Cultivation on *char* lands shows high demand. Due to the presence of fertile soil no or little fertilizers need to be used. Also, anyone can hold the char lands and claim as their own. The conflict over the possession of *Char* land is common feature in the social life on *Char* (Rudra, 2000).

Manikchak: Manikchak is the block most widely affected by the riverine erosion. In this block due to the higher amount of erosion the number of population is decreasing in Dharampur, Manikchak & Gopalpur areas. There are 15 mouzas within this Block, which are highly affected. The amount of Total eroded area is 13204.02 acres. The number of families losing their Land is 3330 among which the decline in Male population is more prominent compared to Female population because of the 'male outmigration'. The FMR ratio also shows a decline between 1991-2001 (DHDR, 2007). The decreasing number of cultivators and agricultural laborers provide the positive evidence against increasing livelihood pressure and high rate of migration.

Result & discussion

After analyzing previous studies and considering several factors i.e.- Bankline failure, Human Response, Effect on Rural Economy, Conversion of Agricultural land to Non-Agricultural land, Land conversion to orchard, Cultivation on Char lands the Hotspot regions can be identified. The Diara region is that region where Human response against bankline failure is the maximum. Among 15 blocks, Manikchak and Kaliyachak-II and Kaliyachak-III can be categorized as the hotspot regions.

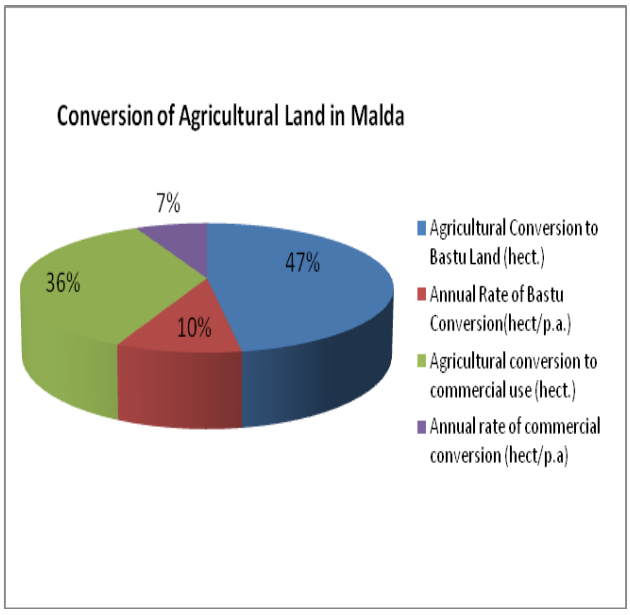


Fig. 6: Agricultural Land Conversion

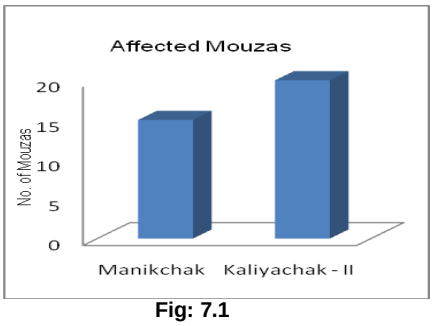


Fig: 7.1

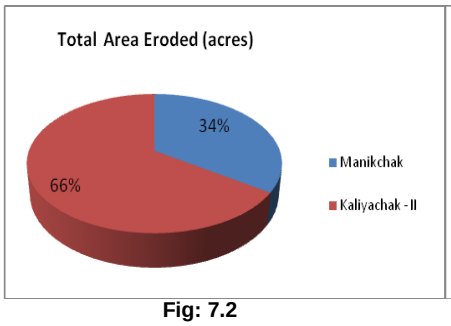


Fig: 7.2

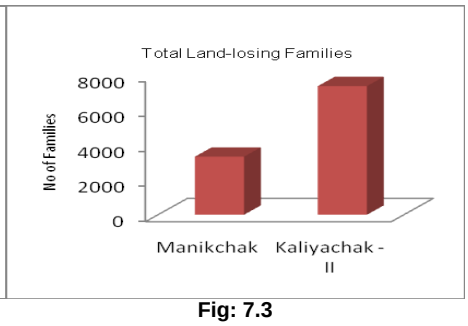


Fig: 7.3

Fig: 7.1/7.2/7.3. Comparative Loss Assessment between Manikchak and Kaliyachak-II Blocks

Kaliachak - II: The Ganga is now eroding its left bank by taking a concave shape and shifting its bankline. There are 20 mouzas highly affected by the erosional activities of the Ganga among which Jitnagar and Babupur are now depopulated while newly emerged *Char* land at Charbabupur has acquired new population. The amount of Total Area eroded is 25114.67 acres and the number of total Land- losing families is 7378.

Kaliachak - III: Near Kaliyachak-III the effect of river erosion somehow different compared to the previous ones. In Jagannathpur and Krishnapur villages the number of population is increasing rapidly. And on *Char* land the settlement is constantly increasing except Chainpara *Char* where people and their livelihood are facing serious problem.

Conclusion

The case study shows the successful use of Geoinformatics to detect the bankline changes and to identify the Hotspot regions where Human Response against this natural calamity is the most prominent. We believe that this study will facilitate more focused planning and elicit proportionate administrative counter-measures to effectively mitigate the destructive effect of the riverbank failures in the district of Malda.

References

1. Iqbal, S. (2010): Flood and Erosion Induced Population Displacements: A Socio-economic Case Study in the Gangetic Riverine Tract at Malda District, West Bengal, India. J.Hum Ecol 30(3).pp. 201-211.

2. Parua, P.K (2002): Fluvial Geomorphology of the River Ganga around Farakka, Journal of the Institution of Engineers Vol.82 pp.193-196.

Nuclear Disasters and the Lessons Learnt

Dr. BK Ramprasad
Principal Civil Hydrographic Officer, National Hydrographic Office, Dehradun
E-mail: bkrp1972@yahoo.com

Abstract

The nuclear radiation accidents are more disastrous than the natural one like earthquakes, floods or avalanches. The worst nuclear accidents were occurred in the developed nations like Russia and Japan. Hiroshima and Nagasaki incidents are still unforgettable. In other words vulnerability is directly proportionate to the advanced technological adoptions. That doesn't mean to keep the development process under the dormitory. Safety must be the first criteria. Nuclear power plants are designed to withstand natural disasters like earthquakes. In France, for instance, nuclear plants are designed to withstand an earthquake twice as strong as that experienced in the past 1000 years. In India, the Kakrapar Atomic Power Station, Rajasthan Atomic Power Station, Tarapur Atomic Power Station and Narora Atomic Power Station operated safely when earthquakes of low intensity felt. The plants however, could not withstand tsunami. The 26th April 1986 disaster at the Chernobyl nuclear power plant in Ukraine was the product of a flawed Soviet reactor design coupled with serious mistakes made by the plant operator that killed 30 people and several deaths further due to Acute Radiation Syndrome (ARS). In Japan following a major earthquake, a 15m tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors, causing a nuclear accident on 11 March 2011. The accident was rated 7 on the INES scale, due to high radioactive releases in the first few days.

Twenty first century is known for its GIS based solutions to all users. It is capable enough to map the vulnerable areas of nuclear radiation and its influence on the living things and the contamination levels in natural resources. In the present paper, worst nuclear accidents occurred in the world in recent past and the lessons learnt, improved disaster mitigation and management practices using the latest GIS based mapping tools have been discussed.

Introduction

The March 2011 nuclear disaster in Fukushima in Japan led countries with nuclear power plants to revisit safety measures. The fact finding committee constituted by the International Atomic Energy Agency (IAEA) stated in its report that "there were insufficient defence for tsunami hazards. Tsunami hazards that were considered in 2002 were underestimated. Additional protective measures were not recovered and approved by the regulatory authority. Severe accident management provisions were not adequate to cape with multiple plant failures". Further on the regulatory environment the report states "Japan has a well organized emergency preparedness and response system as demonstrated by the handling of the Fukushima accident Nevertheless, complicated structures and organizations can result in delays in urgent decision making. "The inability to foresee such extreme scenarios is a forewarning to countries that are expanding nuclear capacity at a frenzied pace (Mohan MP Ram, 2011).

For India this is a lesson and an exceptional opportunity to relook at the protected structures of the Department of Atomic Agency (DAE), and establish more transparent processes and procedures. In the past the Three Mile Island incident (1979) and Chernobyl accident (1986) had provided similar opportunities to evaluate nuclear safety and regulatory systems. India in response to these accidents, constituted safety audits to assess the safety of nuclear plants. However, A Gopalakrishnan (former Chairman of Atomic Energy Regulatory Board), in his recent article said "DAE management classified these audit reports as 'top secret' and shelved them. No action was taken on the committees finding.

Nuclear Power Corporation of India Ltd., has undertaken post- Fukushima safety evaluation of 20 operating power plants and nuclear power plants under construction. The safety measures pertaining to strengthening technical and power systems, automatic reactor shutdown on sensing seismic activity, enhancement of tsunami bunds at all coastal stations etc., are suggested in the interim report. Even though adequate provision exist at Indian nuclear power plants to handle station blackout situations and maintain continuous cooling of reactor cores for decay heat removal. The incidents like prolonged loss of power supplies at Narora plant in 1993, flood incident at Kakrapat plant in 1994 and the tsunami at Madras plant in 2004 were successfully managed with these existing provisions. In his recent speech Indian Prime Minister Dr. Manmohan Singh said that "there would be no looking backwards on nuclear energy. We are in the process of expanding our civil nuclear energy programme. Even as we do so, we have to ensure that the use of nuclear energy meets the highest safety standards. This is a matter on which there can be no compromise". However with the memory of Bhopal accident, these assurances have done little to assuage us. The legal administrative and political failure in

Bhopal to effectively respond is a constant reminder that due diligence of major developmental projects is a necessary pre-requisite (Mohan, 2011).

Land acquisition is already a major concern for infrastructure projects and has become an issue at the proposed Jaitapur nuclear power plant as well. However, the biggest challenge in this expansion would be to convince the public of the safety and security of nuclear power plants and also arrive at comprehensive information and communication package for states in whose territory projects are being executed. The public protest against the fuel injection into the Kundankulam power plant in Tamilnadu is the burning example for this. Because of the nature of India's nuclear programme- the combined existence of civilian and military programmes – the nation may not be in a position to achieve the kind of regulatory autonomy, process and engagement that has been witnessed in many European countries and in the US. Europe which has been at the fore front of engagement with its citizens could possibly do so because many countries in Europe moved into peaceful civilian use by shutting down military programmes. This allowed countries to establish credible, autonomous and competent regulatory mechanism with strong emphasis on public and stakeholders engagement for their civilian programmes.

The nature of Indian nuclear policy and engagement are different and what emerges now is the need for an overhaul of the regulatory process and its structure. The bifurcation of India's nuclear establishment into civilian and military, subsequent to commitment under India-Us civil nuclear cooperation has provided with the prospect of an empowered regulatory system. Incidents in Jaitapur and the Fukushima nuclear disaster have further pushed the government to commit to establish an independent nuclear regulator, the Bill of which is yet to be cleared in the Parliament. The Comptroller and Auditor General of India (CAG) also blamed the Central Government for not learning any lessons from the Fukushima disaster as failure to have an autonomous, empowered regulator is fraught with risks. Neighbouring countries may also join the chorus soon since some of the proposed nuclear power plant sites are close to our border (ToI, 24th August 2012).

Lessons Learnt?

If we look back, the April 1986 disaster at the Chernobyl nuclear power plant in Ukraine was the product of a flawed Soviet reactor design coupled with serious mistakes made by the plant operators. It was a direct consequence of Cold War isolation and the resulting lack of any safety culture. The accident caused the largest uncontrolled radioactive release into the environment ever recorded for any civilian operation, and large quantities of radioactive substances were released into the air for about 10 days. This caused serious social and economic disruption for large populations in Belarus, Russia and Ukraine. Two radionuclides, the short-lived idodine-131 and the long-lived caesium-137, were particularly significant for the radiation dose they delivered to members of the public.

Many countries, including India, are dependent upon nuclear reactors for power generations and therefore it is important for all to know more about nuclear radiations and its harmful effects. The nuclear disaster in Japan has raised alarm bells in many counties. China, South Korea and United States, Japan's neighbours, have increased their security level to fend off radiation threat from Japan. German Chancellor Angela Merkel announced that all seven nuclear plants built before 1980 would be closed down for now as safety checks are concerned. Switzerland announced that it would freeze all plants to build or replace nuclear power plants and Austria called for new stress tests on nuclear plants across Europe. India has decided to adopt radiation checks at ports and airports and on all food imports from Japan. In Russia, President Vladimir Putin has ordered a review on all nuclear plants.

The Japanese are well aware of the dangers of the nuclear radiation after falling prey to the atom bombs at Hiroshima and Nagasaki during the Second World War. However they have very few natural resources and therefore decided to go for nuclear power to supply a third of its energy needs. They have more than 50 commercially operating nuclear reactors and many are built in seismically dangerous environment, where the threat of earthquakes is more. Though most of the nuclear reactors are built after taking this factor into consideration, the enormous power of the earthquake and tsunami has toppled all security measures that were put in place. Shutting down a nuclear plant is as complex a processes the nuclear fission process that generates power. Therefore it seems that it would take a long time before the nuclear radiation emission to the atmosphere is brought under control and stopped. The Japanese government has asked people not to panic and has given them guidance on how to avoid getting affected with the radiation. Not even a single add was neither telecasted nor published in the News media in India to make the public to aware about the affects of nuclear radiation and protection guidelines.

The toxic cloud that struck Bhopal 20 years ago provoked the immediate death of 7000 persons. Since then another 15000 persons died from diseases related to that accident. Today more than 100,000 persons suffer from chronic diseases (Amnesty International Report 2004). But the Indian government didn't learn any lesson from the past. The kind of awareness towards prevention and mitigation measures while such occurrence shown by the Japanese government is lacking with us.

India has got many nuclear power plants as well and the nuclear calamity in Japan would be a time that should take our attention to the security of these plants. Indian nuclear scientists have repeatedly said that all our nuclear reactors are safe and we have nothing to worry about if similar environmental disaster as in Japan happens in India. If we look back the past, Kakrapar Atomic Power Station, Rajasthan Atomic Power Station, Tarapur Atomic Power Station and Narora Atomic Power Station operated safely when earthquakes of lower intensity were felt. The plants, however, could not withstand tsunami. The campus of Kalpakkam Atomic Reprocessing Plant was flooded when tsunami hit Tamil Nadu's coast in 2004. It is time to revisit the security measures at all atomic plants. It is quite important for common people to have more about the dangers of nuclear radiation, about how to avoid it and about how to get treated if ever exposed to it. Inarguably, one of the most important outcomes of the Japanese nuclear crisis is that it has re-ignited the anti-nuclear debate around the world. It is extremely important for the global communities to have an impassioned debate on the pros and cons of nuclear power before we move forward with nuclear power projects.

If we see the energy related accidents occurred in India since 1975, Machhu (1979) and Hirakud (1980) were due to Hydro-electric dam failure. The other incidents like Dhanbad (1995) and Bhatdih (2006) were due to methane explosion in coal mines. The accidents related to nuclear reactors are listed in Table 1. Thousands of people lost their lives in the above series of accidents (Contemporary Media Reports). On the other poor nuclear regulatory body framework leads to funny penalty of Rs.500 on an offending nuclear plant, in case of a nuclear accident. A CAG report on the Atomic Energy Regulatory Board (AERB), tabled in Parliament on Wednesday (22nd Aug'2012) has raised concern about the weak regulatory framework in the country that could end up overlooking the potential risk of a disaster like Chernobyl or Fukushima. While this sounds grim, in reality, two recent pieces of legislations are intended to resolve precisely these lacunae. The Nuclear Liability Act passed by Parliament in May 2010 makes the operator liable to pay "no-fault" compensation of up to Rs.1,500 crore, beyond which India can access the Convention on Supplementary Compensation (CSC) for additional liability.

Table 1: Serious Nuclear Reactor Accidents around the world since 1952

Reactor	Date	Immediate Deaths	Environmental effect	Follow-up action
NRX, Canada (experimental, 40 MWt)	1952	Nil	Nil	Repaired (new core) closed 1992
Windscale-1, UK (military plutonium-producing pile)	1957	Nil	Widespread contamination. Farms affected (c 1.5 PBq released)	Entombed (filled with concrete) Being demolished.
SL-1, USA (experimental, military, 3 MWt)	1961	Three operators	Very minor radioactive release	Decommissioned
Fermi-1 USA (experimental breeder, 66 MWe)	1966	Nil	Nil	Repaired and restarted, then closed in 1972
Lucens, Switzerland (experimental, 7.5 MWe)	1969	Nil	Very minor radioactive release	Decommissioned
Browns Ferry, USA (commercial, 2 x 1080 MWe)	1975	Nil	Nil	Repaired
Three-Mile Island-2, USA (commercial, 880 MWe)	1979	Nil	Minor short-term radiation dose (within ICRP limits) to public, delayed release of 200 TBq of Kr-85	Clean-up program complete, in monitored storage stage of decommissioning
Saint Laurent-A2, France (commercial, 450 MWe)	1980	Nil	Minor radiation release (80 GBq)	Repaired, (Decomm. 1992)
Chernobyl-4, Ukraine (commercial, 950 MWe)	1986	47 staff and firefighters (32 immediate)	Major radiation release across E. Europe and Scandinavia (14 EBq or 5.2 EBq I-131 equivalent)	Entombed
Vandellos-1, Spain (commercial, 480 MWe)	1989	Nil	Nil	Decommissioned
Greifswald-5, E.Germany (commercial, 440 MWe)	1989	Nil	Nil	Decommissioned
Fukushima 1-3, Japan (commercial, 1959 MWe)	2011	Nil	significant local contamination (630 PBq I-131 equivalent)	Decommissioned

Source: Contemporary News Reports

The second piece of legislation is the Atomic Energy Regulatory Authority (AERA), which has just been cleared by the Union Cabinet and will subsume the AERB. It is intended to establish an autonomous nuclear energy regulator which will not function under the Department of Atomic Energy as the case is at present (Contemporary News reports).

Environmental Effects

In 1989, the World Health Organization (WHO) first raised concerns that local medical scientists had incorrectly attributed various biological and health effects to radiation exposure. Following this, the Government of USSR requested the International Atomic Energy Agency (IAEA) to coordinate an international expert's assessment of accident's radiological, environmental and health consequences in selected towns of the most heavily contaminated areas in Belarus, Russia and Ukraine. Between March 1990 and June 1991, a total of 50 field missions were conducted by 200 experts from 25 countries (including the USSR), seven organizations, and 11 laboratories. In the absence of pre-1986 data, it compared a control population with those exposed to radiation. Significant health disorders were evident in both control and exposed groups, but at that stage, none was radiation related. Subsequent studies in the Ukraine, Russia and Belarus were based on national registers of over one million people possibly affected by radiation. By 2000, about 4000 cases of thyroid cancer had been diagnosed in exposed children. However, the rapid increase in thyroid cancers detected suggests that some of it at least is an artifact of the screening process. Thyroid cancer is usually not fatal if diagnosed and treated early (IAEA reports). The conclusions of 2005 Chernobyl Forum study are in line with earlier expert studies, notably the UNSCEAR 2000 report which said that "apart from thyroid increase, there is no evidence of a major public health impact attributable to radiation exposure 14 years after the accident. There is no scientific evidence of increases in overall cancer incidence or mortality or in non-malignant disorders that could be related to radiation exposure." As yet there is little evidence of any increase in leukaemia, even among clean-up workers where it might be most expected. However, these workers-where high doses may have been received-remain at increased risk of cancer in the long term.

The Chernobyl Forum report says that people in the area have suffered a paralyzing fatalism due to myths and misperceptions about the threat of radiation, which has contributed to a culture of chronic dependency. A particularly sad effect of the accident was that some physicians in Europe advised pregnant women to undergo abortions on account of radiation exposure, even though the levels concerned were vastly below those likely to have teratogenic effects. The foetal death toll from this is likely very much greater than directly from the accident.

During the recent Fukushima accident releases to air and also water leakage from the plant are concerned, the main radionuclide form among the many kinds of fission products in the fuel was volatile iodine-131, which has a half life of 8 days. The other main radionuclide is caesium-137, which has a 30 years half-life, is easily carried in a plume, and when it lands it may contaminate land for some time. It is a strong gamma-emitter in its decay. Cs-134 is also produced and dispersed, it has a 2 year half-life. Caesium is soluble and can be taken into the body, but does not concentrate in any particular organs, and has a biological half-life of about 70 days. In assessing the significance of atmospheric releases, the Cs-137 figure is multiplied by 40 and added to the I-131 number to give an "iodine-131 equivalent" figure. A large amount of contaminated water had accumulated on site, but with the commissioning of a new treatment plant in June this was progressively being treated and recycled for reactor cooling. However, the main plant is not performing as well as expected, and a supplementary plant was installed. Some radioactivity has been released to the sea, but this has mostly been low-level and it has not had any major impact beyond the immediate plant structures. Concentrations outside these have been below regulatory levels since April. Six workers have received radiation doses apparently over the 250 mSv (millisieverts) level set by NISA, but at levels below those which would cause radiation sickness. There have been no harmful effects from radiation on local people, nor any doses approaching harmful levels. However, some 160,000 people were evacuated from their homes and only in 2012 are allowed limited return (contemporary news reports).

A preliminary report from the World Health Organisation (WHO) in May 2012 estimated the radiation doses that residents of Japan outside the evacuated areas received in the year following the accident. The report's headline conclusion is that most people in Fukushima prefecture would have received a radiation dose of between 1 and 10 mSv during the first year after the accident. This compares with levels of about 2.4 mSv they would have received from unavoidable natural sources. In two places the doses were higher between 10 and 50 mSv, still below any harmful level. Almost all were "below the internationally-agreed reference level for the public exposure due to radon in dwellings" (about 10 mSv/year). The main environmental pathways of human radiation exposure are illustrated in Figure 1.

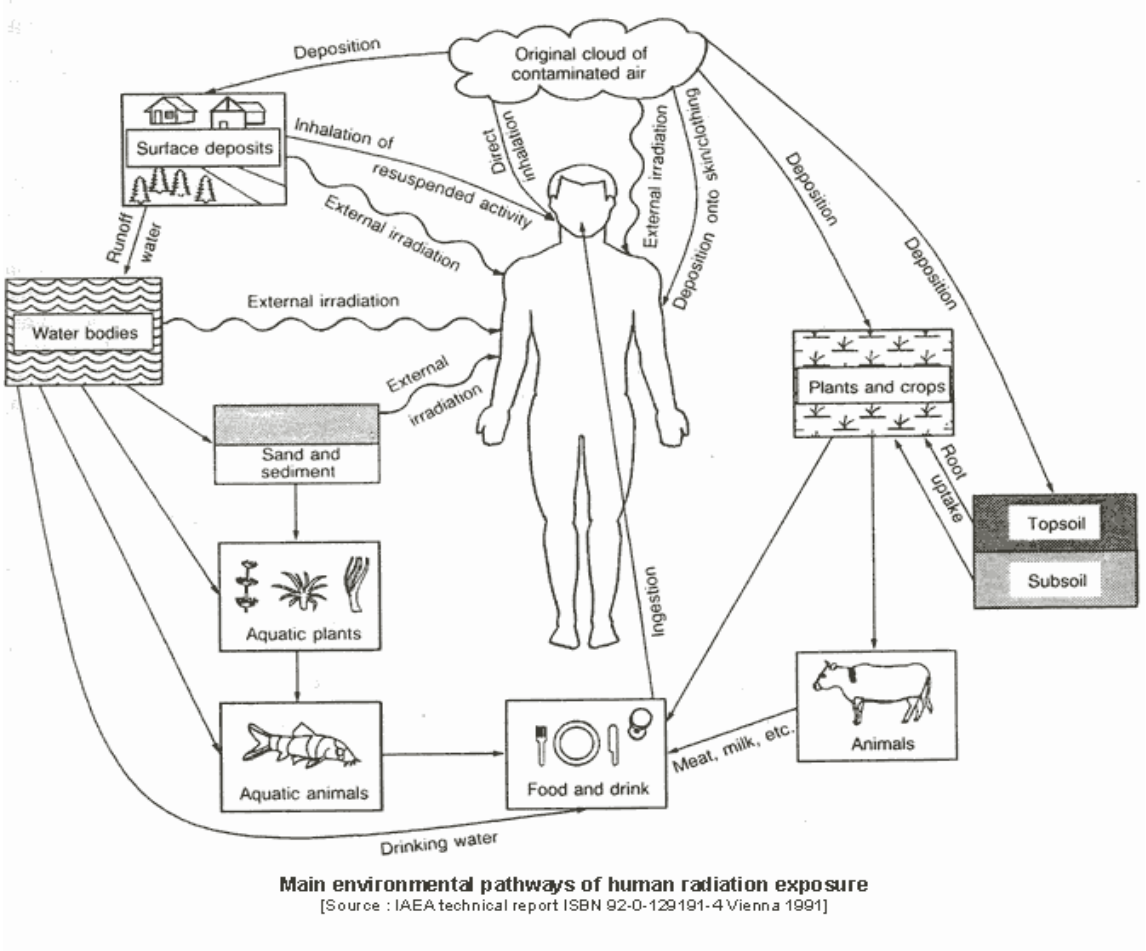


Fig. 1: Main Environmental Pathways of Human Radiation Exposure

Expert's Committee Reports on the Fukushima Nuclear Accident

In May 2011 a team of 18 experts from 12 countries spent a week at the plant on behalf of the International Atomic Energy Agency (IAEA), and its final report was presented to the IAEA Ministerial Conference in Vienna in June. The national Diet later set up a legally-constituted Nuclear Accident Independent Investigation Commission (NAIIC) of ten members which started its work in December 2011. One of the purposes of NAIIC is to provide suggestions including the "re-examination of an optimal administrative organization" for nuclear safety regulation based on its investigation of the accident. NAIIC reported in July 2012, harshly criticizing the government, the plant operator and the country's national culture. After conducting 900 hours of public hearings and interviews with more than 1,100 people and visiting several nuclear power plants, the commission's report concluded that the accident was a "manmade disaster", the result of "collusion between the government, the regulators and Tokyo Electric Power Corporation." It said the "root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions." The NAIIC criticized the regulator for insufficiently maintaining independence from the industry in developing and enforcing safety regulations, the governance and lack of safety culture. The report called for fundamental changes across the industry, including the government and regulators, to increase openness, trustworthiness and focus on protecting public health and safety.

The failure of governance in Japan could be realized by the NAIIC Chairman's comments: "What must be admitted- very painfully – is that this was a disaster 'Made in Japan.' Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity." The mindset of government and industry led the country to avoid learning the lessons of the previous major nuclear accidents at Three Mile Island and Chernobyl. "The consequences of negligence at Fukushima stand out as catastrophic, but the mindset that supported it can be found across Japan. In recognizing that fact, each of us (every Japanese citizen) should reflect on our responsibility as individuals in a democratic society." NAIIC reports also added that Tepco had been aware since 2006 that Fukushima Daiichi could face a station blackout if flooded, as well as the potential loss of ultimate heat sink in the event of a major tsunami. However, the regulator, NISA, gave no

instruction to the company to prepare for severe flooding, and even told all nuclear operators that it was not necessary to plan for station blackout. During the initial response to the tsunami, this lack of readiness for station blackout was compounded by lack of planning and training for severe accident mitigation. Plans and procedures for venting and manual operation of emergency cooling were incomplete and their implementation in emergency circumstances proved very difficult as a result. NISA was also criticized for its "negligence and failure over the years" to prepare for a nuclear accident in terms of public information and evacuation, with previous government interference which undermined NISA.

The Indian government also should review its compliance with nuclear regulatory norms and the safety issues amid of NAIIC comments to the governments for not learning lessons from the past. In India, every region falls in seismic zone in some way, said Durgesh Rai of IIT Kanpur. "Most of our nuclear plants are in weak seismic zones (I&II except Narora plant in Uttar Pradesh, which is situated in zone IV) but lie in coastal areas. Their structure is believed to be vulnerable to tsunami," he said. Nuclear plants are built near the sea because sea water is required to cool the reactor. At the same time we should not ignore the loss to the marine environment in case of an accident.

Conclusions

In light of above discussions it is evident that need of an autonomous regulatory body to control the activities of nuclear power projects their security, safety measures, public health and environmental protection issues. Preparedness of the industry and the government for situation control at the time of accident if happens. Today the spatial technology has grown up to assist the planners by giving the highest accuracy in prediction and inundation modeling. These spatial tools can be effectively applicable for nuclear disaster mitigation and management. However a country like Japan, which doesn't have the sufficient natural resources, they are forced to depend on the alternative source like nuclear power to meet their electricity demand. Whereas India, we have plenty of natural resource through which power generation is possible. The renewable sources like wind, hydro and thermal power could be best used for power generation. Since India has agricultural based economy and more than seventy percent of its population lives in rural area, there is lot of scope for bio-gas production. By empowering the village community towards self sustenance including power generation using bio-gas then half of the migration to cities can be resolved. Renewable sources should be given priority for power generation instead of harmful nuclear energy. A Nation's strength is its natural resources and the healthy population. Therefore, as a responsible citizens we should protect our mother Earth and its resources for our next generations to live healthy on it.

References

1. Amnesty International Reports 2004.
2. Mohan, MP Ram (2011) "How safe is India's nuclear energy programme?"
3. Times of India 24th August 2012.
4. Nuclear Accident Independent Investigation Commission (NAIIC) report 2012.

Integration of Remote Sensing and GIS Analysis as a Tool for Environmentally Sound Land Use Planning

Bidisha Chattopadhyay
Research Scholar, Jawaharlal Nehru University,
New Delhi -110067

Abstract

Environmental planning is a critical aspect of any development project. It plays an important role in creating sustainable projects. Negative impact of a project cannot be completely avoided but can be minimized. In this respect, remote sensing and GIS analysis are vital tools for facilitating planning of projects in an environmentally sound manner. The present paper attempts to utilize remote sensing and GIS techniques for selection of a suitable site for an Industrial area. Land suitability Analysis as part of land use planning has been split into five main tasks - a) creation of the existing land use map b) allocating scores to layers according to their contribution to the development of the industrial site c) derivation of weight for each criteria through the Analytical Hierarch Process (AHP) method d) finalizing the total score as product of the initial score and weight for each unit area through overlay method and d) delineating the site, most feasible for development.

The findings prove that GIS is an extremely useful tool for land use planning in an environment efficiently minimising the project impact on natural resources and people. Inclusion of sustainable development parameters in land use planning is facilitated by GIS, enhancing the degree of data collation and interpretation from several sources.

Introduction

Industries are the engines of growth and are considered important for the economic development of an area. Unfortunately, industrial growth more often than not has been at logger heads with environmental concerns. Right from the planning stage when industries are set up in forested areas or agricultural land to the operation stage when pollution from industries harm the environment, industries and environment are in conflict. On a positive note, this also implies that there are numerous opportunities to intervene in determining the impact of industries on environment and provide solutions for minimizing the negative effects. In this context, Environment Impact Assessment (EIA) has emerged as a popular tool for assessing the future impact of industrial development on the people and environment of the area where the industries are going to come up. The EIA Notification, 2006 of Ministry of Environment and Forests, India demands details of changes in land use, increase in intensity of land use before giving a go-ahead to the project.

Land use planning as a mitigation measure based on the findings of EIA is an important method for minimizing the negative impact of industries on environment and people. The principles of sustainable development confront land planners with a paradox of two apparently contradictory objectives: nature conservation and economic development. Often fertile agricultural land, natural resources and small settlements are put at stake to set up industries.

Efficient land use planning preceded by land suitability assessment with focus on environment and social aspects is an excellent method for solving this dilemma whereby, industries may be set up with minimum impact on environment. On one hand, natural resources can be conserved and on the other hand, sites can be put to their best use.

The present paper seeks to employ the tools of remote sensing and GIS to select an appropriate site for industrial land use taking into account the environmental and social concerns within the study area of Dhar, Depalpur and Mhow tehsils of Madhya Pradesh. The paper has been divided into five sections, first the introduction which gives a broad overview of the subject, second - a description of the inter-linkages between land use planning, environment and GIS, third - the study area, fourth - the materials and methods utilized for the research and last; discussions and conclusion.

Land Use Planning, Environment and GIS

Land-use planning has been defined as "the systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses" (FAO, 1999).

The need for land use planning is brought about by the conscious choices which have to be made for putting a parcel of land to its best possible use. The selection of a land parcel for a particular use needs to be justified by not only land capability but also by the impact of such allocation on the social, economic and environmental aspects. In this context, land suitability assessment is the process which determines the fitness of a given tract of land for a defined use (Steiner *et al*., 2000), usually among multiple, competing uses. It has the potential to minimize conflicts and increase consensus among the stakeholders.

The roots of environmental planning lies in the increasing awareness of the negative impact of anthropogenic processes on the environment. The United Nations Conference on the Human Environment, Stockholm (1972), United Nations Earth Summit in Rio de Janeiro, Brazil (1992), WCED (World Commission on Development) report also known as the Brundtland report (1987) played an important role in focusing the spotlight on environment on the global stage. The Brundtland report emphasized the economic aspects of sustainability by defining sustainable development as “economic development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.” With time, concern for environment has also seeped into land use planning. It is now imperative to select sites for various uses keeping in mind their impact on the environment. Ministry of Environment and Forest, India and Central Pollution Control Board (1995) have recommended the following environmental guidelines for setting of industries with a view to ensure optimum use of natural and man-made resources in sustainable manner with minimal depletion, degradation and/or destruction of environment:

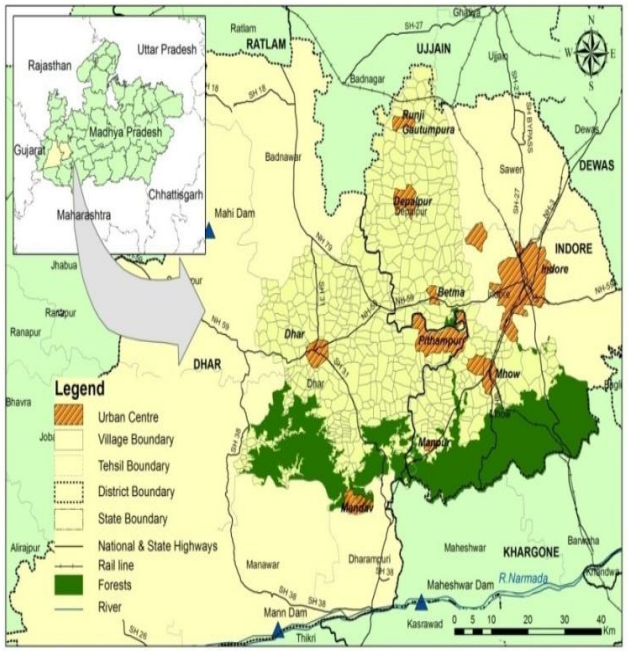
A distance of at least 25 km from ecologically and/or otherwise sensitive areas; depending on the geo-climatic conditions the requisite distance will have to be increased by the appropriate agency.

- A distance of at least 1/2 km from High Tide Line in coastal areas
- A distance of at least 1/2 km from flood plain or modified flood plain affected by dam in the upstream or by flood control systems.
- A distance of at least 1/2 km from highway and railway.
- At the time of setting of the industry if any major settlement's (3 lakh population) notified limit is within 50 km, the spatial direction of growth of the settlement for at least a decade must be assessed and the industry shall be sited at least 25 km from the projected growth boundary of the settlement.

Remote sensing and GIS have emerged as significant tools for land use mapping, land suitability analysis and further planning. Data from remote sensing satisfies the requirement of spatially accurate and timely information on land use while GIS provides the freedom to update data frequently, analyze large amount of spatial data and convert to new scale or coordinate systems. Maps can be easily combined and overlaid, offering various types of information. Densities, quantities and patterns of a specific item in a specific area can be easily derived and terrain models can be generated to aid 3D visualization.

Study area

Dhar tehsil of Dhar district and Depalpur and Mhow tehsils of Indore district in Madhya Pradesh comprise the study area. Indore district lies on the Malwa plateau. The district comprises four tehsils (2001), Depalpur, Sanwer, Indore and Mhow. Indore tehsil is home to million plus population Indore city, an important cultural, industrial and commercial hub of Madhya Pradesh. Mhowhas premier Indian Army training institutes. Northern part of Dhar district lies on the Malwa plateau while a part of the Vindhyachal range extends in the southern part of the district. Dhar district comprised seven tehsils in 2001 and nine tehsils in 2009. Dhar tehsil is home to the district headquarter, Dhar. Besides, an agricultural base, industries are important particularly those located in Pithampur Industrial area. National Highway No.3, 59 and 79 pass through the study area (Map 1).



Map 1: Location of the Study Area

Pithampur Industrial Area, Dhar districts the largest industrial growth centre not only within the study area but also in the State of Madhya Pradesh. It is developed by Madhya Pradesh Audyogik Kendra Vikas Nigam (MPAKVN). It is spread over an area of 20.56 sq.km and houses 130 large and 532 small scale units. Auto sector, textile, pharmaceutical are some of the important focus areas of industries in Pithampur. Popularly known as Detroit of India, Pithampur caters to a heavy concentration of vehicle industries (including Hindustan Motors, Kinetic Honda, Eicher Motors, Bajaj Tempo). Pithampur has an Inland Container Depot (ICD) spread over 17 acres, operating as dry port by Container Corporation of India (Ministry of Railways). It was established in 1994 and caters to industries of Indore, Pithampur, Dewas, Mandideep, Bhopal, Nagda, Ghatabillod, Dhamnod, Sarangpur, Ratlam, Pilukhedi etc. in Madhya Pradesh. Pithampur is located at a distance of 22 km from Indore city and 40 km from Dhar town. It is located on the Mhow-Neemuch State Highway (SH 22), and is at a distance of 16 km from NH-3 (Agra-Mumbai Road). The nearest airport and railway station is at Indore.

Materials

Database

The first step involved the creation of a base map. The Baseline map has been created from a) Quick Bird imagery-2009 b) Topographical map sheets; 1:50,000 (Survey of India); 46N/9, 46N/6, 46N/10, 46N/14, 46N/2, 46N/3, 46N/7, 46N/11, 46N/15 c) District Planning Maps (Dhar and Indore), National Atlas and Thematic Mapping Organization d) Census of India, 2001.

Quick Bird imagery was procured from National Remote Sensing Agency, Hyderabad and further geo-rectified with the help of DGPS (Differential GPS). The other raster maps obtained from all secondary sources were co-registered to the rectified satellite imagery to a common geographic coordinate system (UTM Zone 43 N, WGS 84) to ensure integration of all maps. The land use of the study area was subsequently digitized from both the imagery and the topographical sheet keeping the updated land use, at the same time retaining drainage and official forest boundary not visible on the satellite imagery. Village has been taken as the unit of study. The study area consists of 777 villages and 9 urban centres.

Methods

There are four steps of the process to evaluate industrial land suitability based on environmental and social considerations. The first step involved the selection of factors based on theories and past researches and criteria indicators were worked out. Secondly, scoring of criterion indicators was done as suitability ranges and thirdly, the weights of all factors were determined using Analytical Hierarchy Process (AHP) as developed by Saaty (1977). This was followed by adding the weighted scores of each criterion for each village to make the final land suitability map.

Selection of factors

The factors were selected on the basis of theories and past researches combined with the guidelines laid down by CPCB. Weber (1909) identified three main factors determining industrial location; cost of transportation, cost of labour and advantage of agglomeration. Recent studies suggest that accessibility of the site, infrastructure and facilities, labour availability, land value, topography and flooding play a significant role in determining the location of industries.

The factors selected for this include: a) Forest and major b) water bodies c) slope d) agricultural land e) population f) land price g) accessibility h) Agglomeration (proximity to Pithampur Industrial Area) i) proximity to urban centres j) distance to surface water source

Scoring of criteria

All criteria indicators were scored (4 to 1) based on their four grades of suitability: very good, good, fair, and poor or not suitable. The factors and their criteria indicators, range of measurement, and scores are listed in Table 1 and discussed below.

a) *Forest and major water bodies*: Forests and water bodies are natural resources which should be conserved and thus it is necessary that the location of the industry is such that it has minimum impact on these resources. All forests and water bodies were masked and considered unsuitable for industrial development.

b) *Slope:* Slope of an area is a pre-requisite for a plan to be executed in an economically and environmentally sound manner. Slope below 2 percent results in poor drainage while slope above 8 percent is steep for buildings.

c) *Agricultural land:* The criterion has been calculated as percentage of agricultural land area in total land area in each unit village. It has been taken to minimize conflict between the traditional, existing source of livelihood and the new source.

d) *Population:* All major settlements including towns and villages were masked and considered unsuitable for industrial development.

e) *Land value/price*: Land price plays an important role in determining the cost of the project. Low land price implies a lower fixed cost thus reducing the project cost.

f) *Accessibility/Connectivity*: Accessibility was determined by the distance from road (National and state highway, rail and airport. Good and easy access to the road network is essential for transportation of raw materials, goods distribution, and flow of labour force.

g) *Proximity to Pithampur Industrial area*: Proximity to the existing industrial area will enable the new industries to benefit from the existing infrastructure and facilities, at the same time the old industries will get the advantage of upgraded facilities.

h) *Proximity to urban centres:* Beside providing a market for the finished goods, the urban centres are also good sources of labour. In addition, the guidelines of CPCB also have to be adhered to.

i) *Distance to water source*: The region is already suffering from scarcity of water and Dhar block of Dhar district has been declared as areas Notified for Regulation of ground water development by Central Ground Water Board. Thus it is imperative that a surface water source be identified for providing water to the industries.

Table 1: Selected Criterion - Score

Criterion	Indicator	Range of Measurement	Score
Forests and water bodies	Forest and water body cover	Completely exclude	0
Slope	Slope (%)	Less than 1 % 1 % to 2% 2% to 8% 8% to 15% More than 15%	2 4 3 1 0
Agricultural land	Share of agricultural land area (Ha) to total village land (Ha) (%)	Less than 25% 25% - 50% 50% - 75% More than 75%	4 3 2 1
Village Population	Population of each village as per Census 2001	Less than 500 500-1000 1000-1500 More than 1500	4 3 2 1
Land Price	Average land price of village land	0-5 lakhs/Ha 5 – 10 lakhs/Ha 10 – 15 lakhs/Ha More than 15 lakhs/Ha	4 3 2 1

Connectivity: National Highway	Distance from the transport lines and node	0-5 km 5-10 km 10-15 km More than 15 km	4 3 2 1
State Highway		0-5 km 5-10 km 10-15 km More than 15 km	4 3 2 1
Railway line		0-20 km 20-40km 40 – 60 km More than 60 km	4 3 2 1
Airport		0-20 km 20-40km 40 – 60 km More than 60 km	4 3 2 1
Proximity to PIA	Distance from PIA	0-5 km 5-10 km 10-15 km More than 15 km	4 3 2 1
Proximity to Urban Centres	Distance from urban centre	0-10 km 10-20 km 20-30 km More than 30 km	1 3 4 1
Distance to water source Mahi dam	Distance from surface water source	0-35 km 35-70 km More than 70 km	4 3 2
Mann dam Maheshwar dam		0-50 km 50-100 km More than 100 km	4 3 2

Weighting of the factors

In this study, pair-wise comparison method (Saaty, 1977) was used in weighting factors for industrial land suitability evaluation. a) The procedure involves a) the creation of matrix based on the relative importance of each criteria b) factor weights computation and c) estimation of consistency ratio. Table 2 below shows the calculation of the factor weights.

Table 2: Preference as per Analytical Hierarchy Process

	Slope	Agricultural land	Village Population	Land Price	Connectivity	Proximity to PIA	Proximity to Urban Centres	Distance to water source
Slope	1/1	3/1	3/1	3/1	3/1	3/1	3/1	3/1
Agricultural land	1/3	1/1	1/1	5/1	5/1	5/1	5/1	5/1
Village Population	1/3	1/1	1/1	5/1	5/1	5/1	5/1	5/1
Land Price	1/3	1/5	1/5	1/1	1/3	1/2	1/2	1/3
Connectivity	1/3	1/5	1/5	3/1	1/1	1/1	1/1	3/1
Proximity to PIA	1/3	1/5	1/5	2/1	1/1	1/1	1/1	3/1
Proximity to Urban Centres	1/3	1/5	1/5	2/1	1/1	1/1	1/1	3/1
Distance to water source	1/3	1/5	1/5	3/1	1/3	1/3	1/3	1/1

Saaty Rating Scale 1 = Equal; 3 = Moderate; 5 = Strong; 7 = Very Strong; 9 = Extremely strong/important /preferred

The sum of each row was normalized. The matrix multiplication was iterated four times to give the following weights for each of the criterion (Table 3).

Table 3: Criterion Weights

Slope	Agricultural land	Village Population	Land Price	Connectivity	Proximity to PIA	Proximity to Urban Centres	Distance to water source
0.276239	0.2200	0.219999	0.036067	0.070264	0.066243	0.066243	0.044947

Consistency ratio was calculated by first calculating the consistency index

I	II	III	IV	V	VI	VII	VIII		IX		X	XI
1.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00		0.2762		2.4475	8.8601
0.33	1.00	1.00	5.00	5.00	5.00	5.00	5.00		0.2200		1.9508	8.8677
0.33	1.00	1.00	5.00	5.00	5.00	5.00	5.00		0.2200		1.9508	8.8677
0.33	0.20	0.20	1.00	0.33	0.50	0.50	0.33	X	0.0361	=	0.3207	8.8944
0.33	0.20	0.20	3.00	1.00	1.00	1.00	3.00		0.0703		0.6258	8.9074
0.33	0.20	0.20	2.00	1.00	1.00	1.00	3.00		0.0662		0.5898	8.9036
0.33	0.20	0.20	2.00	1.00	1.00	1.00	3.00		0.0662		0.5898	8.9036
0.33	0.20	0.20	3.00	0.33	0.33	0.33	1.00		0.0449		0.4008	8.9173

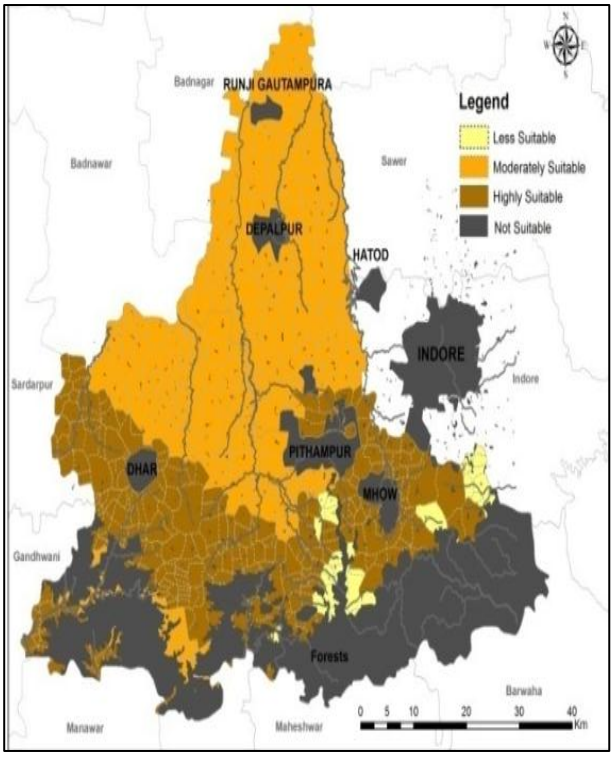
Division of column X by column IX gives column XI.
(8.8601+8.8677+8.8677+8.8944+8.9074+8.9036+8.9036+ 8.9173)/8 = 8.88
Consistency index = (8.88-8)/7 = 0.11; Consistency Ratio = 0.11/0.90 = 0.12. The consistency ratio is borderline acceptable as ideally it should be less than 10 percent.

GIS operation of industrial land suitability

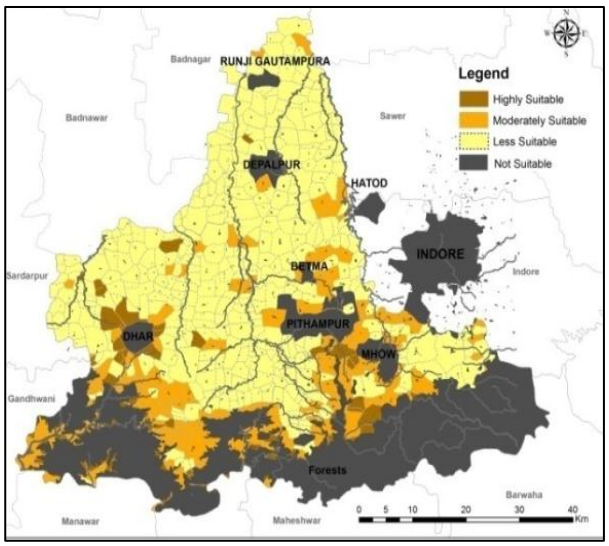
The derived weights for each criterion were multiplied by the scores of 1-4 and finally added to get the final land suitability result. The industrial suitability map was classified into 4 classes; highly suitable, moderately suitable, less suitable and not suitable.

Discussion and conclusion

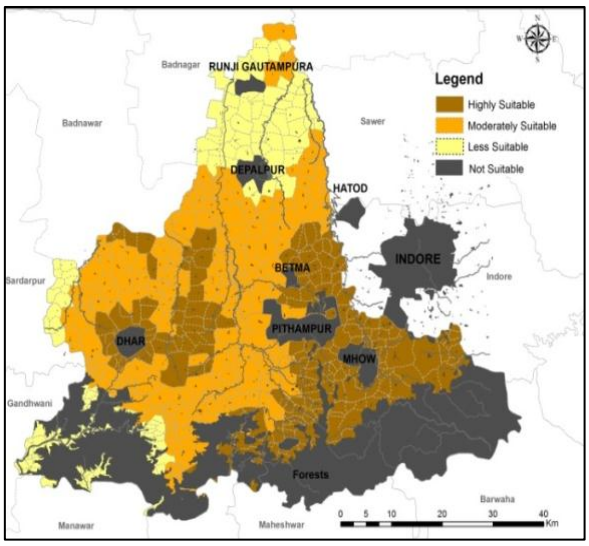
The criteria score maps are presented in Map 2a to 2h while Map 3 shows the composite map derived from the overlay of eight weighted factors and masking of forests, settlements and water bodies.



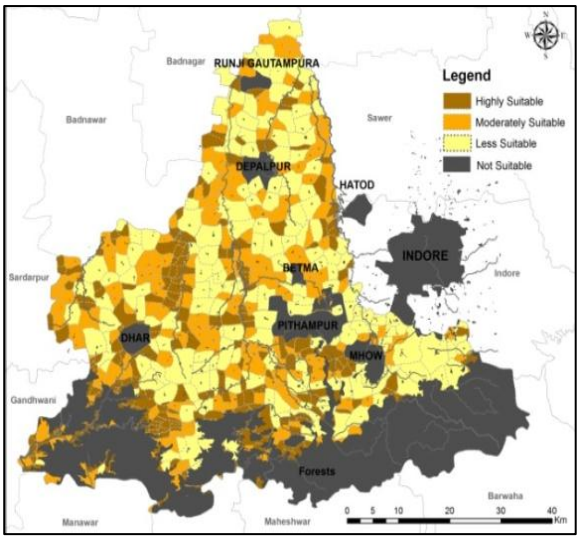
Map 2a: Slope



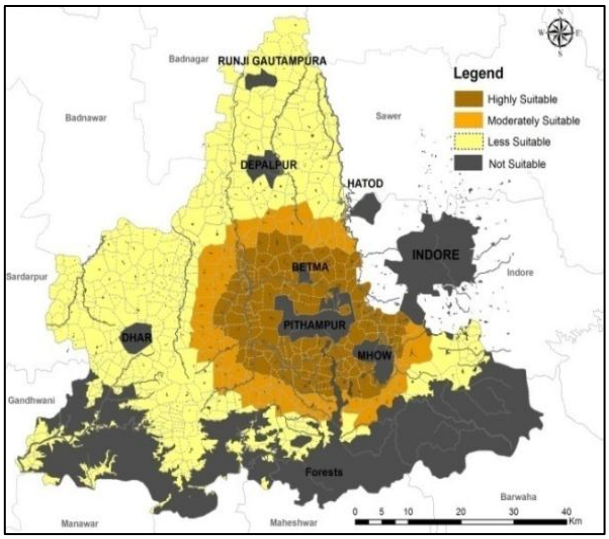
Map 2b: Agricultural land



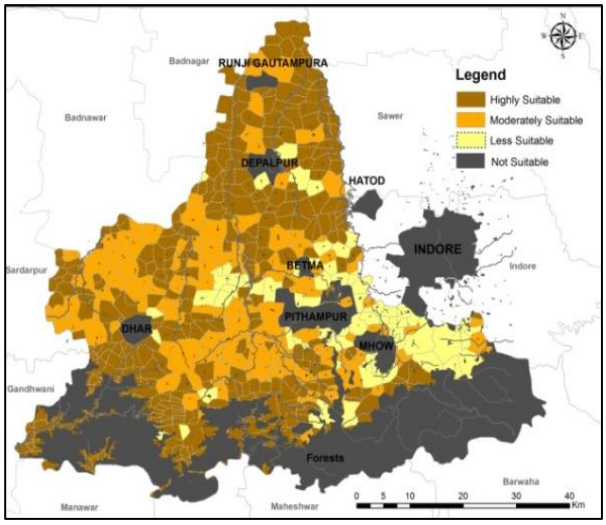
Map 2e: Connectivity



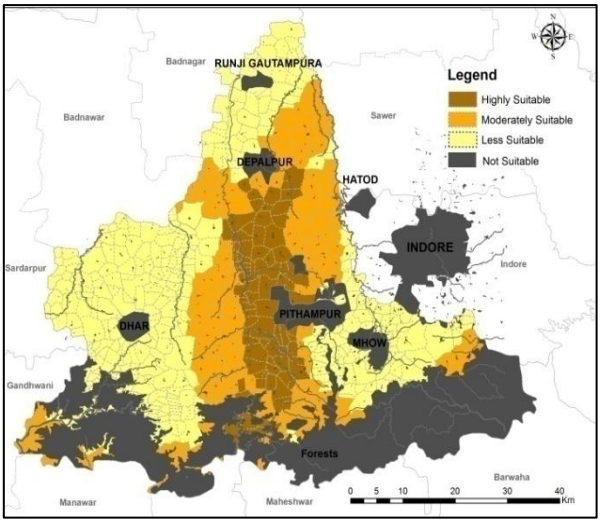
Map 2c: Village Population



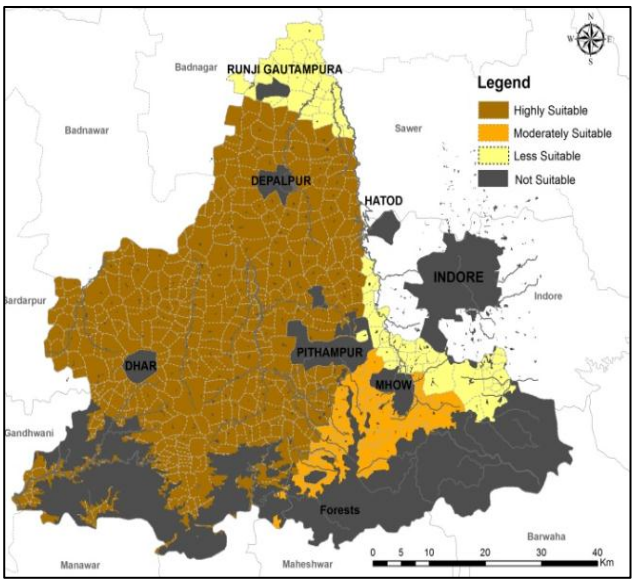
Map 2f: Proximity to Pithampur Industrial Area



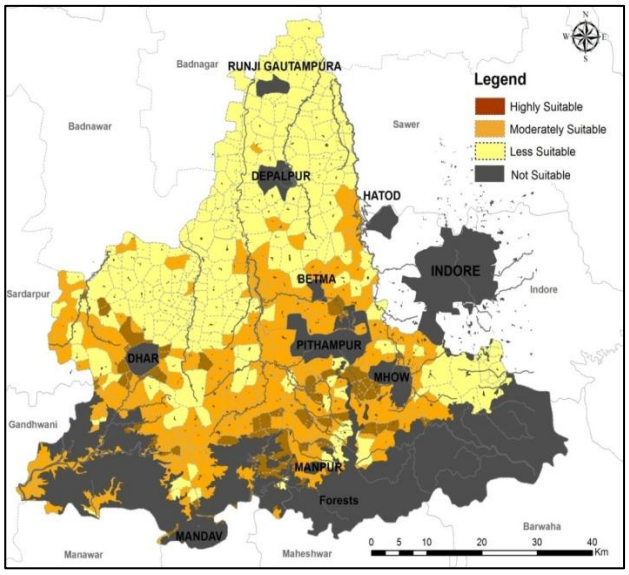
Map 2d: Land Price



Map 2g: Proximity to urban centre



Map 2h: Distance to surface water source



Map 3: Composite Land suitability Map

The results reveal that the most suitable area for industrial development is concentrated in the south and south-east of the Pithampur Industrial Area and around Dhar town. Moderately suitable area is available in large chunk contiguous with highly suitable area around Pithampur Industrial Area and in patches around Dhar town. Less suitable area is mainly in Depalpur tehsil. All settlements including urban centres, forests, rivers and major water bodies have been completely masked and made unavailable for industrial development. It is important to verify the results with the ground truth. In this case, though the area between Mhow and Pithampur was selected as highly suitable for industrial development, further probing shows that this area is in the direct catchment of a small river and thus unsuitable for development. Area to the west of PIA seems to be the most suitable for expansion of PIA and setting up of new industries. Land use planning at the micro level may further incorporate the guidelines laid down by CPCB.

It is evident from the study that remote sensing and GIS are vital tools for land suitability analysis and subsequent environmental planning. They can be utilized for efficient land use planning benefiting environment and people. If coupled with air and water pollution modelling, it can prove to be a more effective tool for planners and decision makers.

References

1. Saaty, T.L., (1977). A scaling method for priorities in hierarchical structures, Journal of Mathematical Psychology,Volume 15, Issue 3, pp 234-281.

2. Steiner, F., L.mcsherry, J.Cohen, (2000).Land suitability analysis for the Upper Gila River Watershed. Landscape Urban Planning.50, pp199–214.

Mini Watershed Characterization and Prioritization using Spatial Information Technology (SIT): A Case Study of Kansachara Sub-watershed, West Bengal

Kartic Bera[1] and Dr. Jatisankar Bandyopadhyay[2]
[1.] Research Scholar and [2.] Assistant Professor
Department of Remote Sensing & GIS,
Vidyasagar University, Paschim Medinipur, Midnapore – 721102.
E-mail: 4kbrsgis@gmail.com., jatiban@gmail.com

Abstract

In the present study, prioritization of sub-watershed was carried out on the basis of morphometric parameters using Geoinformatics in Kansachara sub-watershed, right hand side tributary of Dwarkeswar river in Bankura & Puruliya districts, West Bengal. Prioritization of watershed involve holistic integrated techniques of morphometric parameters, like stream order, stream length, mean stream length, stream length ratio, bifurcation ratio, drainage density, stream frequency, etc. For this analysis, satellite imageries of high resolution IRS-P6 LISS-III, SRTM and different hydrogeo-morphological units have been delineated. The compound parameter values are calculated and prioritization rating of six mini watersheds in Kansachara sub-watershed has been done. The morphometric investigation suggests that the sub-watershed is covered with fractured, resistant, high infiltration soil. The studies conclude that spatial information technology proved to be an inexpensive tool in morphometric analysis.

Introduction

Spatial Information Technology (SIT), Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) have provided important tools (Rao et.al, 2010) for morphometric analysis and watershed prioritization studies in a meaningful way. Development of a drainage system and the flowing pattern of a river over space and time are influenced by several variables such as linear, relief and arial aspects of fluvial originated drainage basin (Rekha et. al., 2011; Singh, 2011). Linear parameters analysis includes Stream order (U), Stream length (Lu), Mean stream length (Lsm) and Bifurcation ratio (Rb). Relief parameters analysis includes Basin relief (Bh), Relief ratio (Rh) and Ruggedness number (Rn). Whereas arial parameters comprises of Drainage density (Dd), Stream frequency (Fs), Texture ratio (T), Form factor (Rf), Circulatory ratio (Rc), Elongated ratio (Rc), Length of overland flow (Lof) and Constant channel maintenance (C). Many works have been reported on morphometric analysis (Horton-1945; Smith- 1950; Strahler-1957) and the use of remote sensing and GIS in morphometric analysis by other authors like, Krishnamurthy and Srinivas (1995); Srivastava & Mitra (1995); Agarwal (1998); Biswas et. al. (1999); Chakraborty *et.al*, (2002); Rao *et.al,* (2006); Thakkar *et.al,* (2007); Christopher *et.al,* (2010); Rekha *et.al,* (2011); Kumer *et.al,* (2011); Singh (2011); Pal *et. al,* (2012). In the present study, morphometric analysis and prioritization of miniwatersheds are carried out for six mini watersheds of Kansachara sub watershed under Bankura and Puruliya districts of West Bengal, using Spatial Information Technology.

Study area

The Kansachara sub watershed is a major tributary of Dwarakeswar river covers an area of 113.21 km^2. The study area geographically located between 23^{0}20$^/$ N to 23^0 30$^/$ N latitude and 86^0 45$^/$ E to 86^0 55$^/$ E longitude and between four blocks under Bankura & Puruliya districts of West Bengal (Fig. 1). The relief undulations of the area are varied between 120m to 300m with gentle gradient from east to west. The dominated geological formation of the area comprises Archaean Dharwarian rocks and is an extension of peninsular

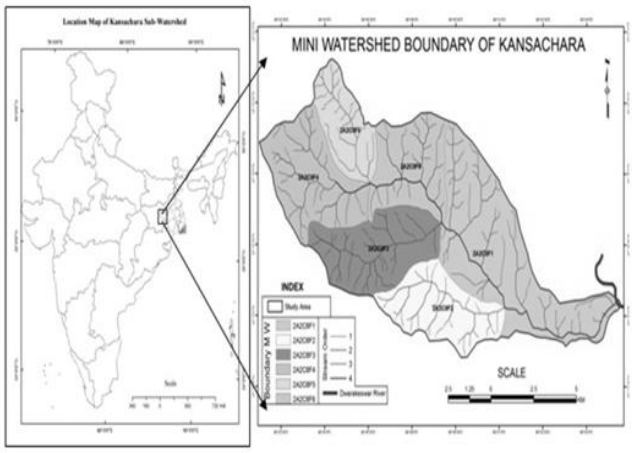


Fig. 1: Location map

mass of Chhotonagpur plateau. The climate conditions of the area are of tropical dry sub humid with normal rainfall ranging from 1100 mm to 1400 mm and also mean temperature ranges from 12^0 in winter to 46^0 C in summer.

The most part of land use is under agricultural fallow whereas some part of the area is covered by the forest mainly in the middle part of sub watershed. The drainage network of the watershed is thin and not well developed having dendritic to sub-dendritic pattern.

Materials and Methods

For the purpose of the watershed prioritization of Kanschara sub-watershed under study, a drainage map was prepared with the help of IRS P6 LISS-III image and SRTM database (Fig. 2). The flow accumulation from the SRTM DEM of drainage network was carried out using Arc GIS (9.3) software and then overly on image in ERDAS Imagine (9.0) software. The stream ordering is carried out following Strahler law, 1964. The detailed information of morphometric parameters in watershed is measured with the help of Arc GIS (9.3) software up to mini watershed level. The calculation of morphometric parameters (Linear, Relief and Arial) was made using formula given in the Table 01. The prioritization was carried out by assigning ranks to the individual indicators and a compound value (Cp) was calculated. Watersheds with highest Cp were of low priority while those with lowest Cp were of high priority. Thus an index of high, medium and low priority was produced. The various indicators which have been used in the prioritization of watersheds are described in Table 06 (Kanth *et.al.,* 2012).

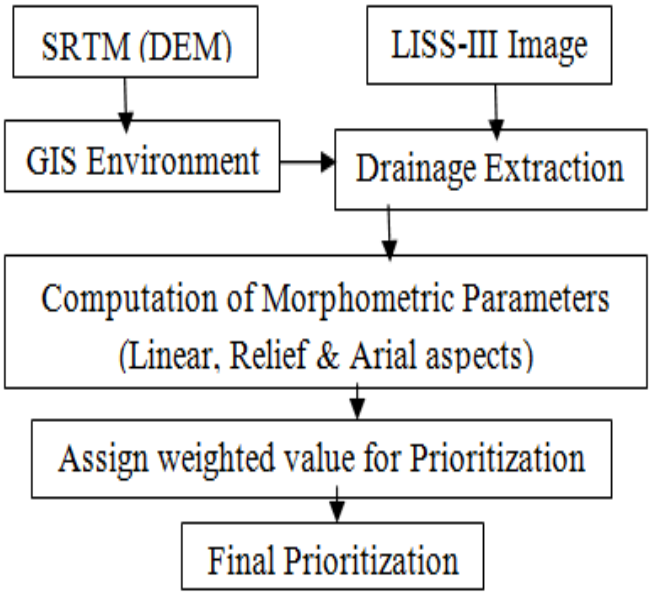


Fig. 2: Flow chart of the work

Result and discussion

The drainage line and boundary of the Kansachara sub watershed is prepared using the spatial analysis tool. The highest stream order of the study area is four. The six mini watershed areas are varying from 10.56 to 35.18 $km^{2.}$ This watershed prioritization is depending on the various morphometric parameters.

***Morphometric* Analysis:** The study 6 mini watershed carried out has been divided into three sections, deals with applicability of Liner aspects (Table 02) of study area. The second parameter deals with the relief aspects (Table 03) of watershed. The third section deals with aerial aspects (Table 04) for prioritization of watersheds.

	Morphometric Parameters	Methods	References
LINEAR	Stream order (U)	Hierarchical order	Strahler, 1964
	Stream length (Lu)	Length of the stream	Horton, 1945
	Mean stream length (Lsm)	Lsm = Lu/Nu where, Lu=Stream length of order 'U' Nu=Total number of stream segments of order 'U'	Horton, 1945
	Stream length ratio (Rl)	Rl=Lu/Lu-1; where Lu=Total stream length of order 'U', Lu-1=Stream length of next lower order.	Horton, 1945
	Bifurcation ratio (Rb)	Rb = Nu/ Nu+1; where, Nu=Total number of stream segment of order'u'; Nu+1=Number of segment of next higher order	Schumn,1956
RELIEF	Basin relief (Bh)	Vertical distance between the lowest and highest points of watershed.	Schumn, 1956
	Relief ratio (Rh)	Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length	Schumn, 1956
	Ruggedness number (Rn)	Rn = Bh × Dd Where, Bh =Basin relief; Dd=Drainage density	Schumn, 1956
ARIAL	Drainage density (Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
	Stream frequency (Fs)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio (T)	T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed	Horton, 1945
	Form factor (Rf)	$Rf=A/(Lb)^2$;where, A=Area of watershed, Lb=Basin length	Horton, 1932
	Circulatory ratio (Rc)	$Rc=4\pi A/P^2$;where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
	Elongation ratio (Re)	$Re=2\sqrt{(A/\pi)}/Lb$;where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn,1956
	Length of overland flow (Lof)	Lof = 1/2Dd where, Dd=Drainage density	Horton, 1945
	Constant channel maintenance (C)	Lof = 1/Dd where, Dd=Drainage density	Horton, 1945

Table 1: Methods of calculating morphometric parameters

Linear aspects

The linear parameters namely stream order, stream length, mean stream length, stream length ratio and bifurcation ratio are calculated (Table 2) by using selected formula. Stream order (U): The stream order (u) is extracted from SRTM DEM by Arc Info 9.3 based on the hierarchic ranking of streams by strahler-1964 (Table 1). After extraction, drainage pattern compared and edited based on IRS LISS-III satellite image. From the drainage line it is observed that the maximum frequency is in case of first order (Table 2) of six mini watersheds. It is also observed that there is a decrease in stream frequency as the stream order increases (Vittala S. *et.al,* 2004). Stream length (Lu): Stream

lengths are automatically calculated by the software in attribute table by Horton, 1945. Mean stream length (Lsm) is calculated according to Strahler-1964 formula. Stream Length Ratio (RL): RL is defined as the ratio of the mean length of the order to previous order by Horton's methods 1964. Bifurcation ratio (Rb) is used to express the ratio of the number of streams of any select order and next higher order (Schumn, 1956).

Table 2: Linear Aspects

M.W.C	Parameter	I Order	II Order	III Order	IV Order
2A2C8F1	Stream order (U)	42	10	1	1
	Stream length (Lu)	31051	15668	2035	13054
	Bifurcation ratio (Rb)	4.2	10	1	_
	Mean Stream Length (Lsm) M	739.3095238	1566.8	2035	13054
	Stream length Ratio (RL)	0.504589224	0.129882563	6.414742015	-
2A2C8F2	Stream order (U)	26	7	1	-
	Stream length (Lu)	14576	9006	6077	-
	Bifurcation ratio (Rb)	3.714285714	7	-	-
	Mean Stream Length (Lsm) m	560.6153846	1286.571429	6077	-
	Stream length Ratio (RL)	0.617864984	0.674772374	-	-
2A2C8F3	Stream order (U)	29	8	1	-
	Stream length (Lu)	21351	6340	6570	-
	Bifurcation ratio (Rb)	3.625	8	-	-
	Mean Stream Length (Lsm)	736.2413793	792.5	6570	-
	Stream length Ratio (RL)	0.296941595	1.036277603	-	-
2A2C8F4	Stream order (U)	27	8	3	1
	Stream length (Lu)	19418	7128	3781	652
	Bifurcation ratio (Rb)	3.375	2.666	3	-
	Mean Stream Length (Lsm) M	719.1851852	891	1260.333333	652
	Stream length Ratio (RL)	0.367082089	0.530443322	0.172441153	-
2A2C8F5	Stream order (U)	19	3	1	1
	Stream length (Lu)	15840	2155	4556	1564
	Bifurcation ratio (Rb)	6.333	3	1	-
	Mean Stream Length (Lsm)	833.6842105	718.3333333	4556	1564
	Stream length Ratio (RL)	0.13604798	2.114153132	0.343283582	-
2A2C8F6	Stream order (U)	22	5	1	1
	Stream length (Lu)	16285	5291	1487	5301
	Bifurcation ratio (Rb)	4.4	5	1	-
	Mean Stream Length (Lsm)	740.2272727	1058.2	1487	5301
	Stream length Ratio (RL)	0.324900215	0.281043281	3.564895763	-

Relief aspects (Ra)

Relief aspects is another important parameter for prioritization of watershed. Element of the relief aspects i.e Basin relief (Bh): According to Schumn-1956, basin relief is the vertical distance between the lowest and highest point of watershed. That is calculated by detailed contour values of mini watersheds generated from SRTM data by using Arc GIS (9.3) software. Relief ratio (Rh) is computed based on the law proposed by Schumn,1956 for the entire six mini watersheds (Table 3).

Ruggedness number (Rn): The ruggedness number is calculated by multiply of basin relief and drainage density, formulated by Schumn, 1956. Table 3 shows the RA values of mini watersheds.

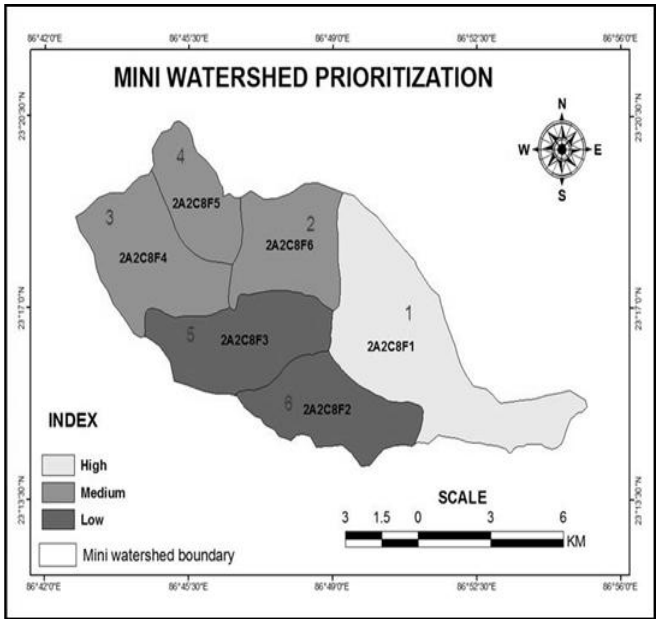
Table 3: Relief Aspects

Mini watershed code no.	Basin Relief (Bh)	Relief ratio (Rh)	Ruggedness number (Rn)
2A2C8F1	58	3.232169729	101.8716681
2A2C8F2	20	0.913264089	38.33397958
2A2C8F3	44	2.150346131	82.75149586
2A2C8F4	48	2.209564471	79.15005057
2A2C8F5	36	1.657173354	82.16354344
2A2C8F6	34	1.661631101	64.39906511

Aerial aspects

Different morphometric parameters like drainage density, stream frequency, texture ratio, form factor, circulatory ratio, elongation ratio, length of overland flow and constant channel maintenance have been discussed in detail and are presented in Table 4. Drainage density (D): Horton (1945) has introduced drainage density, based on the total length of streams divided by area of the watershed. The highest value 2.282320651 in 2A2C8F5 mini watershed and lowest value 1.648959387 occurs in 2A2C8F4 and so on. Stream frequency (Fs): Stream frequency is the total number of stream segments of all orders per unit area flowed by Horton, 1945 (Table 1). Table 4 shows for all six mini watersheds Fs value. Texture ratio (Rt): Texture ratio deals with concepts of geomorphology. According to Horton, 1945, Rt is the total number of stream segments of all orders per perimeter of that area (Table 4). Form factor (Rf): Horton (1932) introduced form factor which is the area of watershed divided by basin length (Table 1). From Table 04, it is observed that the Rf varies between 0.357947617 (2A2C8F1) and 0.421579251 (2A2C8F5) and where as the remaining watersheds are extended with moderate values of form factor. Circulatory ratio (Rc): It is the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin (Miller-1953) (Table 1). All mini watersheds under study, the Rc values ranges from 0.357947617 to 0.698137647 of 2A2C8F1 and 2A2C8F5 mini watersheds, respectively (Table 4).

Elongation ratio (Re): Schumn (1956) defined elongation ratio 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)



(Vittala *et.al,* 2004). In the study area, Re value is varying between 0.674959032 to 0.732499427 (Table 4). Length of overland flow (Lof): It is the length of water over the ground before it gets concentrated into definite stream channels (Horton, 1945) in Table 1. This factor basically relates inversely of the average slope of the channel and is quite synonymous with the length of sheet flow approximately equals to half of the reciprocal of drainage density (Horton, 1945). Constant channel maintenance (C): Channel maintenance method follows a constant as per Horton, 1945 (Table 1). The 'C' values ranges between 0.438150529 to 0.606443074 (Table 4).

Final Prioritization

Mini watershed wise total values of Morphomatric parameter are calculated then cumulative values often by using total values of morphometric parameter. After that weighted value are assign to each of the mini watershed according to the deferent morphometric morphometric parameters (La, Ra & Aa) calculated sum for final prioritization. The final priority classes are classified in three class i.e high, medium and low. The highest priority class under 2A2C8F1 mini watershed, 2A2C8F6, 2A2C8F4 & 2A2C8F5 mini watershed under medium and lowest priority value in 2A2C8F3 & 2A2C8F2, respectively.

Table 4: Aerial Aspects

Mini watershed code no.	Drainage Density (Dd)km/km2	Stream Frequency (Fs)	Texture ratio (Rt)	Form factor(Ff)	Circulatory ratio(Rc)	Elongation ratio (Re)	Length of overland flow (Lof)	Constant channel maintenance (C)
2A2C8F1	1.75640807	1.534531163	1.610819937	0.357947617	0.393649	0.674959032	0.284671887	0.569343774
2A2C8F2	1.916698979	2.197190633	1.786567221	0.400262782	0.537126648	0.7137404	0.260865167	0.521730335
2A2C8F3	1.880715815	2.085962354	1.930883516	0.391478071	0.591298421	0.705864589	0.265856221	0.531712443
2A2C8F4	1.648959387	2.07587627	1.969329958	0.389840488	0.602220501	0.704386699	0.303221537	0.606443074
2A2C8F5	2.282320651	2.271388246	1.739920964	0.421579251	0.698137647	0.732499427	0.219075264	0.438150529
2A2C8F6	1.89409015	1.936561331	1.660190968	0.402052209	0.616980548	0.715334056	0.263978987	0.527957975

Table 5: Final Prioritization

Mini watershed code no.	Total values of Morphometric parameter			Cumulative value of Morphometric parameter			Assign Weighted value			Total Weighted value	Prioritization Class	
	La	Ra	Aa	La	Ra	Aa	La	Ra	Aa			
2A2C8F1	155.46	163.1	7.17	3109.2	5436.67	89.63	1	6	6	13	**1**	High
2A2C8F2	83.58	59.24	8.34	1671.6	1974.67	104.3	4	1	3	8	6	Low
2A2C8F3	93.32	128.9	8.39	1866.4	4296.67	104.88	2	4	2	8	5	Low
2A2C8F4	83.6	129.35	8.29	1672	43.1167	103.63	3	5	4	12	3	Medium
2A2C8F5	68.76	119.82	8.8	1375.2	3994	110	6	3	1	10	4	Medium
2A2C8F6	80.52	100	8.02	1610.4	3333.33	100.25	5	2	5	12	2	Medium

aspects. Then total weighted value of each mini watershed is being calculated, finally prioritization class was made. This class is also verified using Land use / Land cover and considering the water scarcity in dry period of Bankura town Watershed prioritization is one of the most important aspects of planning for developments and management of natural resource. Remote sensing and GIS have proved to be efficient tool in drainage delineation and updating in the present study and this updated drainage has been used for the morphometric analysis. The variation of total value of Linear Aspects (La) is 68.76 to 155.46. Relief aspects (Ra) values varying 59.24 to 163.1, and Ariel aspects (Aa) varying 7.17 to 8.8. On the basis of above

References

1. Chakraborty, *et.al*. (2002). "Morphometric Analysis of a Watershed Using Remote Sensing and GIS - A Case Study" Jour. Agric. Physics, Vol. 2, No.1, pp. 52-56.
2. Christopher, *et.al. (*2010). "Hydrological Analysis of Onitsha North East Drainage Basin Using Geoinformatic Techniques", World Applied Sciences Journal 11 (10) p. 1297-1302.
3. Horton R. E (1945). Erosional development of streams and their drainage basins, hydrological approach to quantitative morphology, Bulletin of the Geological Society of America 56 276-370.

4. Kanth T.A *et.al*, (2012). “Morphometric analysis and prioritization of watersheds for soil and water resource management in Wular catchment using Geo-spatial tools” International Journal of Geology, Earth and Environmental Sciences, 2012 Vol. 2 (1) January-April, p.30-41.

5. Pal. B *et.al*, (2012). Morphometric and hydrological analysis and mapping for Watut watershed using remote sensing and GIS techniques, International Journal of Advances in Engineering & Technology, Jan 2012 p. 357-368.

6. Rao. K *et.al,* (2010). “Morphometric Analysis of Gostani River Basin in Andhra Pradesh State, India Using Spatial Information Technology” International Journal of Geomatics and Geosciences, 1(2) 2010. p.p 179-187.

7. Rekha *et.al*, (2011). “Morphometric Analysis and Micro-watershed Prioritization of Peruvanthanam Sub-watershed, the Manimala River Basin, Kerala, South India” Environmental Research, Engineering and Management, 2011. No. 3(57), P. 6 – 14.

8. Schumn, S A. (1956). Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey Geol Soc Am Bull., 67: 597-646.

9. Singh. V (2011). “Linear Aspect of the Maingra River Basin Morphometry, District Gwalior, Madhya Pradesh, India”. International Journal of Science and Advanced Technology, Volume 1 No 5 July 2011 p. 212-222.

10. Strahler, A. N. (1964). Quantitative geomorphology of drainage basins and channel networks, section 4II, In: Handbook of Applied Hydrology, edited by V.T. Chow, McGraw Hill, pp 439.

11. Thakkar A. *et.al*. (2007). “Morphometric analysis and prioritization of mini watersheds in Mohr watershed, Gujarat using Remote sensing and GIS techniques” Journal of the Indian Society of Remote Sensing, Vol. 35, No. 4, 2007 p. 313-321.

12. Vittala S. *et.al*, (2004). “Morphometric analysis of sub-watersheds in the Pavagada area of Tumkur district, south India using Remote sensing and GIS techniques” Journal of the Indian Society of Remote Sensing, Vol. 32, No. 4, 2004 p. 351-362.

Mapping Coastal Landforms at the Interface of Sheltered Lagoon and Open Marine Environment: An Assessment of Morphodynamics at the Chilika Shoreline

Sk. Majharul Islam and Dr. Ashis Kumar Paul
Department of Remote Sensing and GIS
Vidyasagar University, West Bengal

Abstract

The lagoon system of Chilika Coast includes four subsystems with inter playing processes between them for achieving balance between differential rate of subsystems dynamics. The barrier sand spit, tidal inlet, lagoon itself and discharge of Daya and Bhargavi Rivers into the lagoon are identified as four subsystems of entire system of the Chilika lagoon coast. Activity of the coastal system depends on balanced growth of subsystems. As the discharge of Daya and Bhargavi River is reduced in the northern fringe of lagoon the marine influences have increased across the barrier spit. Tidal inlet keeps the contact between open marine environment and sheltered lagoon environment for renewing the system in normal condition. The new opening, closing and shifting of tidal inlets are the result of dynamics induced by different water levels between open marine and lagoon water bodies.

The present paper deals with dynamism of barrier spit and tidal inlet at the interface of lagoon and open marine environment. A digital elevation model of the spit adjacent to New Mouth is prepared on the basis of total station survey for analysis of morphometric attributes. Temporal changes of spit growth and shifting of tidal inlet are estimated to co-relate other morphological features at the lagoon margin and adjacent shores. Mapping geomorphological features of the lagoon fringes is also an attempt to explore the process dynamism and genesis of individual landforms at the coastal influence.

Introduction

Chilika Lake is India's largest lagoon. The shallow and brackish water lagoon spread over 1108 sq. Km of Puri, Khurda, and Ganjam Districts of Orissa. The lagoon surrounded by Eastern Ghat and Rushikulya river in the north & west, the Bay of Bengal in south, delta of Mahanadi River in the east. The lake is famous for its rich Flora, Faunal resource and their Ecological significant, as it is habitat of about 800 Fauna and 700 Floral species, including many rare endangered threatened species. The lagoon also the largest wintering ground of migratory birds in the Indian subcontinent. With the rich Flora and Faunal resource, the lagoon supplies resources for 150000 fisher men of 132 villages of islands and lake margin areas. For its greater importance, 1981 Ramsar Convention designated Chilika lagoon as Wetland of International Importance.

Present status

The lagoon is connected to the sea with a tidal inlet channel, and this is getting choked by sand deposits. On the other side, silt deposit increases into the lagoon bed by Daya and Bhargavi river, deltaic branches of Mahanadi River in the monsoon months. If tidal exchange decreases, the lagoon will be less saline and if still deposition increases through the rivers then the lagoon will be shallower. New mouth of Chilika always shifting from place to place due to hydro-dynamic nature of the sea and regional cell circulation system. The Chilika spit is a longest spit in India. Cutting the spit to increase saline water flash during the high tide is no longer process because of the cell circulation of Bay of Bengal and sand supply from Rushikullya River chokes the trench in few decades. The lagoon degradation process returns after few years.

Methodology

The entire work is carried on with available S.O.I. Toposheets, geological map, satellite imageries (1972 and 2010), contouring by total station survey, bathymetry by eco-sounder, spit outline survey by GPS, Field visits for identification of Different topographic features. Compilation of survey data with existing literature of previous research work and generate landform maps of this area.

Chilika between Mahanadi & Rushikullya river basin

Chilika lagoon, the largest lagoon in India, is situated in between two watersheds, one is the Mahanadi River basin and other is the Rushikullya River basin (Fig. 1). The Mahanadi Basin is an important basin covers a huge area of middle-east India. Mahanadi River bifurcates at its delta head in the Mahanadi and Kathjuri, which in turn branches out to Kushabhadra, Bhargavi and Daya. The river Daya and Bhargavi feed the lagoon from the north.

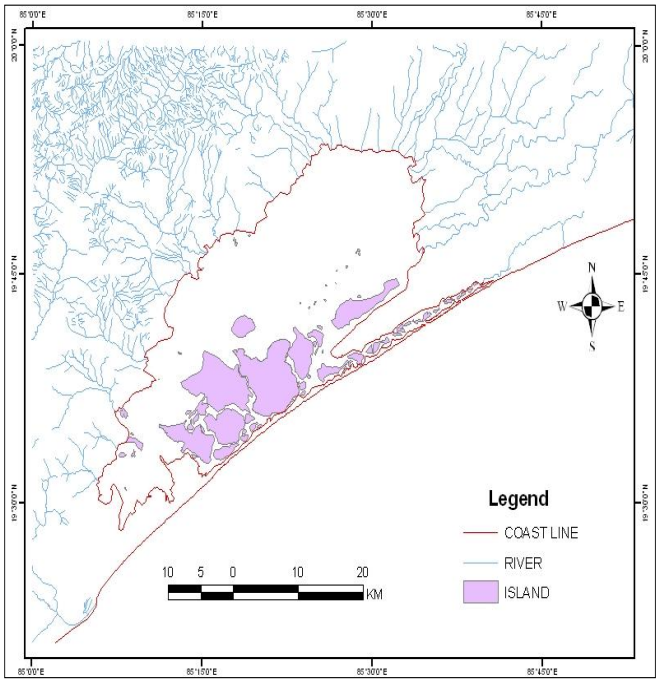


Fig. 1: River network around Chilika lagoon

Anthropogenic effect to lagoon morphology

Before 1970s, population was less and the soil erosion was minimum, but in 1990s soil erosion become dominant. So turbidity in 1972 image is almost 70 percent (Fig. 2). Because of the demand of irrigation water, a dam was constructed in the Mahanadi and its distributaries channel. The barrages restricted natural flow of river and caused siltation to reservoir. This is why in 2003 image spread of turbidity less than 1972 image. But the soil erosion is increased compared to 1970s.

Because of commercial fishing, manure and excess organic matter is deposited in the lagoon, which creates eutrophication problems to the lagoon. Net of weeds catches the silt and deposit it on the lagoon bed, so lagoon become shallower. Weeds prevent the mixing process also and create an unhygienic condition to natural ecosystem. Various types of fishing activities affect the lagoon morphology also. The prawn mafias control the lagoon fringes, mud flats because of the brackish water and mudflat region is good for prawn culture. In the south eastern Chilika, aquaculture is one of the main economic activities. In south western fringes gherrie is more than aquaculture. Chilika lagoon is totally covered with fishing nets (Fig. 3). Fishing net is an obstacle to mixing process and aquatic life's movement and also traps the sediment material, thus increases sedimentation and the lagoon becomes shallow.

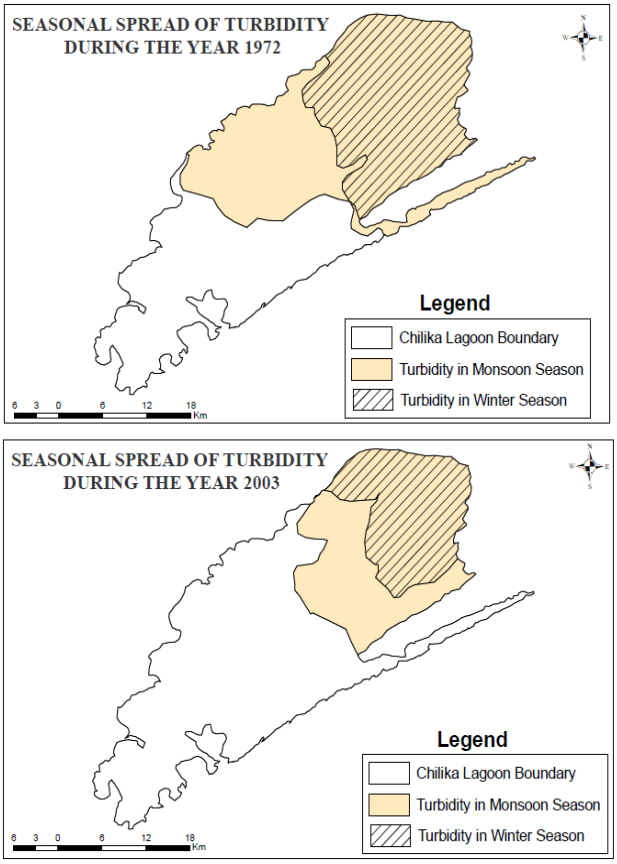


Fig. 2: Spread of Turbid water

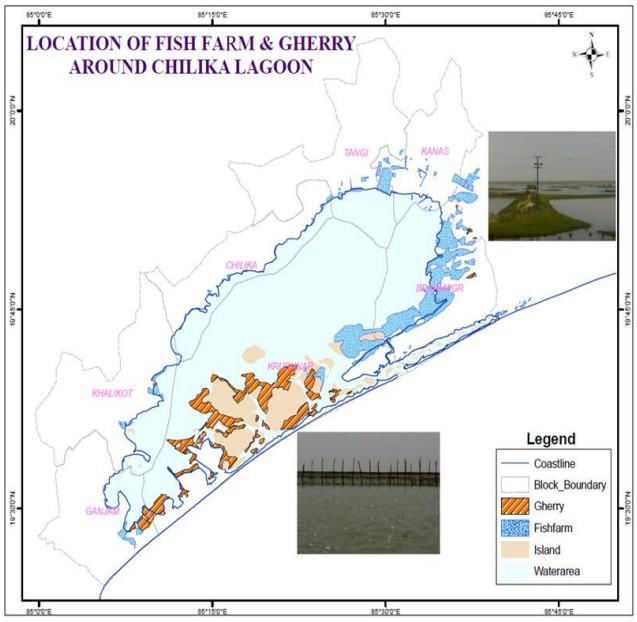


Fig. 3: Location of Fish Farming

Dynamic Chilika spit region

Chilika spit is very dynamic in nature. It was formed because of regular work of wind and wave. Long shore

drifts store sand and silt parallel to Bay of Bengal (Chandramohan, P and Nayak, B. U., 1994). In the spit, sand dunes are well developed. Artificial opening of the new mouth has created an unstable situation in this region. Long shore drift deposited silt and sand in the dredged area and the spit again moving eastward to fill the wound. In the new mouth area the maximum height is 14 m at the dune crest and slope is 40 degree in the dune cliff. The spit morphology is composing of three step topography beach, beach berm, dune cliff, and gentle back spit. Continuous dune morphology is erased in new mouth region where dredging activities happened before. About 6 km dune is abolished by anthropogenic activities followed by marine activity. Highly sloped dune cliff feature is absent in new mouth spit. Now slope of the area is in between 1and 5 degrees. Micro spit development is seen in outer channel region. Because of the effects of ebb and flood tides, sediments are deposited in the back side of spit and create cuspate topography. Later, the cuspate topography changes to micro spit topography and subsequently sediments are arrested in the micro spit. Micro spit topography also present in south western back-spit of the lagoon (Fig. 4).

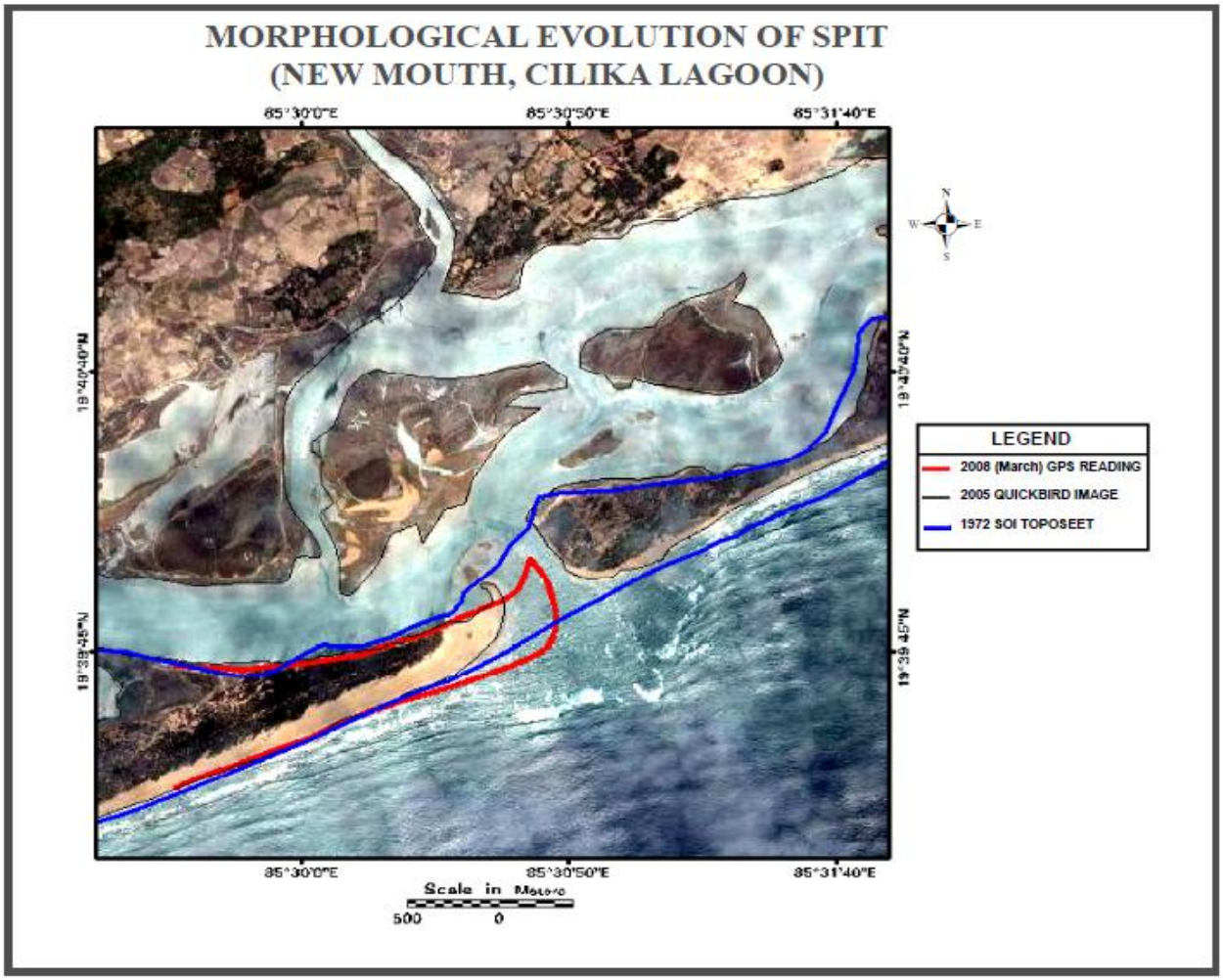


Fig. 4: Morphological Evolution of Spit

Conclusion

Tidal and fluvial interactions were affected in the lagoon due to continuous reshaping of the spit morphology. Artificial cutting of the new mouth region abolish 6 km dune area. Continuous work of ebb tide and flood tide creates micro spit in the back side of main spit in new mouth region and south-western back-spit region. Fluvial sediments are arrested at the upstream reservoir of Mahanadi distributary channel into the lagoon basin. Increasing lagoon eutrophication and reducing depth of lagoon are major causes for diminishing fish population in the lagoon at present. The occupational patterns of the people are largely affected by the changing morphology of lagoon components.

Reference

1. Chandramohan, P and Nayak, B. U., 1994. A study for the improvement of the Chilka Lake tidal inlet, East Coast of India. *Journal of Coastal Research*, 10, 909–918.

A Study on the Changes in the Shape of Coastline in Cochin City using GIS

Dr. Lancelet. T.S.
Associate Professor, Dept. of Geography SSUS, Kalady, KERALA
Email: drlancey2011@gmail.com

Abstract

Coastlines are dynamic environments and so constantly changing shape and form. The coastline of India is undergoing changes due to various anthropogenic and natural interventions. A large number of case studies on the fastest eroding coastlines of India especially Cochin Coast has been attracted the attention of oceanographers, planners and decision makers. The changing urban land use and land values give way to dynamic changes in the urban coasts. Proper planning of urban land is essential for the healthy growth and development of urban areas. Most of the urban areas located in the interior landmasses have stable geomorphology, but lands adjoining the coastal areas are subjected to continuous changes due to various oceanic influences. Such changes produce a strong impact on the nature of the city and its land use, land values and growth pattern. The paper strongly emphasized on Cochin's shorelines that are changing rapidly as a result of natural physical processes and human activities. Natural factors such as sediment supply, wave energy, and sea level are the primary causes of coastal changes, whereas human activities are catalysts causing disequilibrium conditions that accelerate changes.

The study is aimed at identifying the role of physiography over coastal land use change in Cochin city, understanding the major geomorphic changes occurred in the coastlines at different periods of time, and assessing the temporal changes occurred in coastal zones in Cochin City.

Introduction

Coastlines are dynamic environments and are constantly changing shape and form. Role of physiography and land use management of coastal zones by humans are also important (Love Joy, Derk 1979). As we know coastline of India is undergoing changes due to various anthropogenic and natural interventions. A large case study section on the fastest eroding coastlines of India especially Cochin Coast has been attracting the attention of oceanographers, planners and decision makers. The changing urban land use and land values give way to dynamic changes in the urban coasts. Proper planning of urban land is essential for the healthy growth and development of urban areas (Negi BS, 1987). Most of the urban areas located in the interior landmasses have stable geomorphology, but lands adjoining the coastal areas are subjected to continuous changes due to various oceanic influences. Such changes produce a strong impact on the nature of the city and its land use, land values and growth pattern. This paper strongly emphasis the role of physiography on changing land use of Cochin city. Cochin's shorelines are changing rapidly as a result of natural physical processes and human activities. Natural factors such as sediment supply, wave energy, and sea level are the primary causes of coastal changes, whereas human activities are catalysts causing disequilibrium conditions that accelerate changes.

Objectives

1. To identify the role of physiography over coastal land use change in Cochin city.
2. To study the major geomorphic changes occurred in the coastlines at different period of time.
3. To asses the temporal changes occurred in coastal zones in Cochin City (1914-2000).

Methodology

For the preparation of this paper data were obtained from SOI toposheets of 1:63360 (1914), 1: 50,000 (1968) and 1:25,000 (1985) and LISS-III IC, FCC 1:10,000 (2000) from NRSA. The coastal zone (<3 mts above MSL) consists of 3 samples C1, C2 and C3. The necessary sample maps were digitized in Arc view and the area for each feature was calculated by arc view for the periods like 1914, 1968, 1985 and 2000. Coastal land use changes were calculated to find out the amount of changes from 1914-2000. Apart from these physiographic changes also been observed and appropriate cartographic techniques are applied. In Coastal Zone of the study area 3 samples were obtained like C1, C2 and C3 which are almost equally spaced. Physiographically they are low lands ranging from 1mtr to 3 mts height from MSL The sample C1 represents the area of Elamkunnupuzha and Puthuvaipu area. The sample C2 represents the areas

of Vypeen and northern part of Fort Cochin which are dissected landmasses having natural sea passage towards Cochin Port. The sample C3 can be seen in between Edakochi and Kacheripadi. The three samples together represent 12 sq.kms (3x4) of the study area. There are some major physiographic changes in the coastal areas were observed from the micro level analysis in the coastal samples from the period of 1914 to 2000.

Scope of investigation and the study area

The investigation of changes in coastline of Cochin, its position or morphology can aid in predicting the life expectancy of coastal infrastructure. It may be pointed to more complex trends in coastal Planning for Coastline changes especially for saving our beaches.

More attention needs towards the shore as a source of economic and social activities. Using GIS, proper guidelines became the blueprint for Planning Coastline Changes. Most of the Coastlines studies helped to identify high eroding sites and ecological sensitive areas (Nath, V, 1953). It is therefore necessary to monitor coastal zone changes because the importance of environmental parameter, storm impact prevention and human disturbance.

The study area is part of the Lakshadweep Sea Coast and is located in the Western part of Ernakulam district of Kerala State. The central city of Cochin extends between 9^0 53' N to 10^0 05' North latitude and 76^0 12 E' to 76^0 23" East longitude along South Western Coast of India. Cochin City comprises an area of 18.77 sq.kms and 27.00 sq.kms, respectively. This consists of eight census towns with the two adjoining Panchayats of the urban core, which also characterized urban pattern. These towns and Panchayats together having an area of 135.22 sq.kms. They are encircling the core area of the central city with a semicircular shape (Nandeswar MD, 1992)

Some recent reviews

The litho-stratigraphic classification of the coastal sediment deposits of Kerala was worked out by Sankar. G and Nair ASK (1995). According to the coastal sediment layers of Kerala including Cochin Area consists of Vembanad formation (3 – 60 m) with various kinds of sediment layers with an unconformity at its bottom, marked by laterite. Below this is the Ambalapuzha formation (3 – 140 m) with various kinds of sediment layers. Below this is the Quilon formation (0.5 – 130 m) consisting of limestone, sand stone, clay and lignite (Resource Atlas, CESS, 1984). Studies of future built environment for coastal risk assessment of climate change using a GIS-based multicriteria analysis by Mustafa Mokrech, Robert J Nicholls, Richard J Dawson show increases in the number of residential and nonresidential properties within the coastal flood plains.

Another work carried out by Ibrahim Kasawani, Akim Kim Asbiyallah Shah, Ibrahim Sulong, Ismail Mohd Hasmadi, Jusoff Kamaruzaman on Coastal Change Detection Using GIS in Setiu Lagoon, Terengganu, Malaysia was intended to detect changes of coastal area in Setiu Lagoon, Terengganu and to provide future database in coastal management studies. A study on Monitoring changing position of coastlines using Thematic Mapper imagery, an example from the Nile Delta by Kevin White were pointed o**ut** the synoptic capability of Landsat Thematic Mapper imagery enables monitoring of large sections of coastline at relatively coarse (30 m) spatial resolution. They compared positions of the Nile Delta coast in 1984, 1987 and 1990/1991, mapped using a region-growing image segmentation technique, areas of rapid change can be identified and targeted for more detailed monitoring in the field, or using higher resolution images. Researchers like Saied Choopani, Hossain Hossaini Pour and Mahmood Damizadeh of Center of Hormozgan on the Investigation of Kouhestak- Karian Coastline changes using GIS revealed that the determination of the rate of coastline changes in short period (26 years) and long period (quaternary) and determination of effective factors in these phenomena. This research was based on GIS investigations, field operations and laboratory Studies, Preparation of ortho-photos for two periods of aerial photo (1967, 1993), GIS studies. All these studies show the role cartography on shoreline research.

Coastal Zone Analysis of Cochin

In Coastal Zone of the study area 3 samples were obtained like C1, C2 and C3 which are almost equally spaced physiographically they are low lands ranging from 1mtr to 3 mts height from MSL. The sample C1 represents the area of Elamkunnupuzha and Puthuvaipu area. The sample C2 represents the areas of Vypeen and northern part of Fort Cochin which are dissected landmasses having natural sea passage towards Cochin Port. The sample C3 can be seen in between Edakochi and Kacheripadi. The three sample together represents 12 sq.kms (3x4) of the study area.

Major Physiographic changes occurred in Coastal Zone

There are some major physiographic changes in the coastal areas were observed from the micro level analysis in the coastal samples from the period of 1914 to 2000.

Changes in the shape of coast line and formation of new land:

The changes observed over a period one hundred years starting from 1914-2000 shows that there was a tremendous accretion by Sea resulted new land, added to the coast. According to Marine Geographers and Coastal Geomorphologists this change has occurred

from the last hundred years due to the marine process of accretion by sea waves. Especially this process witnessed near mouth of river Periyar and Chalakudy River, which are together, deposited a large amount of silt and muds during monsoon season.

Moreover a large number of streams and tidal canals are also draining silt towards backwaters and gradually converting into mud banks. The sample C1 and C2 refers to this process of accretion. Investigation carried out by Geological Survey of India found that the mud banks are predominantly covered with clays, sets of laterite and alluvial formation deposited by present and past rivers and streams. According to geologists, the interaction of various forces of nature such as currents, tides, waves, ground swell, river discharges, occasional cyclones, exceptional storms and seismic disturbances are believed to be responsible for the formation of mud banks. Based on the observation, coastal engineers speculate that during monsoon, the 'swells' (the rough monsoon sea waves) drains the ocean bottom and suspends the fine bed materials increasing the density and viscosity and they gradually deposits this materials in the northern parts of the coast line. The backwaters in the passage (sample C2) do not allow deposition of the materials and they act as an obstacle for siltation in Port areas. So that naturally the fine bed materials attenuate gradually. The waves ride over it. Due to this process a new land was formed between Vypeen and Kodungalloor called 'Puthuvaipu' means new land. This new land has contributed much to the formation of coastline and changes its shape to parallel to the sea.

Formation of inland, water bodies and wetlands

The formation of new accreted land was not fit for settlement and cultivation. They were used for pisciculture and aquaculture because of their marshy nature. During the time of heavy precipitation the water tries to accumulate in the lower basins of the area and became streams and water logged areas. Due to the tidal action by the sea the number of tidal canals has originated in this portion and it has paved the way for the formation of wetlands and water bodies having high salinity. For recent times this portion seems to be occupied with mangroves and isolated hamlets. The instability and watery nature of this land, it is not suitable for recreational purposes unlike other coastal beaches.

Changes in the beach lines

Slight changes can be noticed in the beach line in this coastal zone. The width of the beaches is wider and not parallel to the sea. However they are shrinking to smooth and continues shape. According to Oceanographers Kerala coast was an emergence coast and also it is a pro grading coastline. The accretion process may be due to excessive deposition environment, possibly due to ideal oceanographic condition. It facilitates transportation and deposition of fine grain sediment, which has changed the orientation

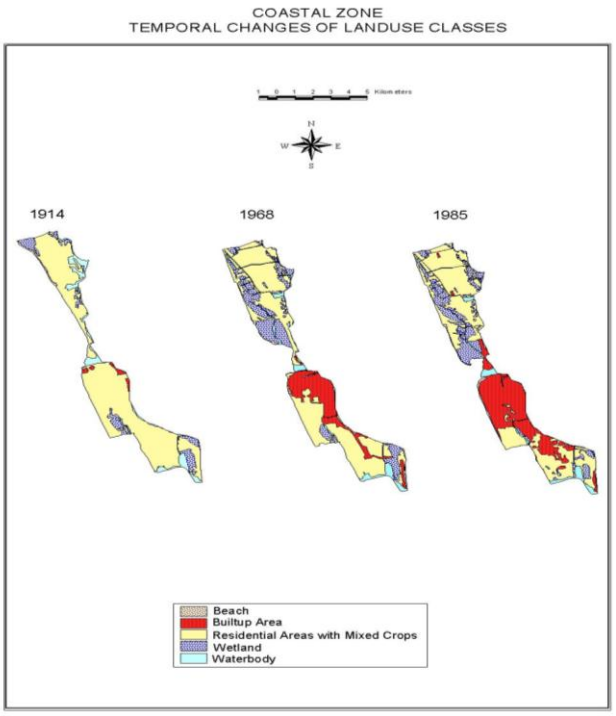


Fig. 1: Coastal Zone Temporal Changes

of coastline and beach line. Over this emergent coast, anthropogenic intervention could have caused the change in land use pattern and that is a change in natural eco system namely wetland and water bodies etc. The growth and change of coast and beach line may be due to the dynamic theory of deposition silty materials in mud bands (Nair ASK and Thrivikramji, 1966).

Disappearing wetlands and water bodies

The micro level analysis of coastal samples also revealed that a good amount of wetlands are disappearing due to the reclamation either by the mud from backwaters or from the soils of eastern elevated portion of the study area. The major land use problem faced by Cochin is the shortage of dry urban land for various urban uses especially near CBDs. For the creation of new dry lands, this type of unscientific reclamation is going on progressively. As a result of this the amount of wetlands and water bodies are disappearing day by day.

Coastal Sample – C1:

In 1914, the coastline was almost in a zigzag shape but in 2000 the shape has shown transformation which was almost paralleled to the sea (Fig. 2). It is due to sea wave action and swells during the monsoons. In 1914, the region was bare of any settlements, but it has been gradually growing as an agricultural region with settlement. The slow rate of growth is chiefly due to its location and the changes of sea that the land is still at its primitive stage of growth. Although the old city centre is hardly 3kms from CBD yet the rate of growth is very slow, hence there is a strong influence of the physiographic impact on urban

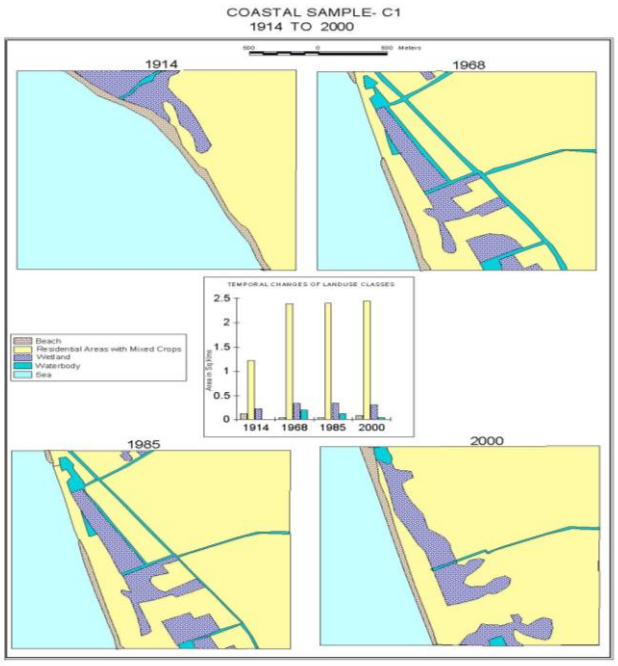


Fig. 2: Coastal Sample C1

growth and land use. The rate of agricultural area were increased from 1.22 sq.kms (1914) to 2.37 sq.kms (2000) showing the increase in population and settlement. The graph showed an increase in agricultural land and settlement with a simultaneous decrease in water body.

Coastal Sample –C2

The location of the sample C2 is including the historic urban centre of Fort Cochin, which was the trade centre of the Romans, the Chinese, the Arabs and the Europeans. It was the city centre even in the 15th century. So in 1914 the amount in growth of built-up area can be observed as 0.001 sq.kms, however, from 1985-2000 this amount has increased rapidly with 0.27 sq.kms annually (Table 1 and Fig. 3). When compared the growth of built up land (1.40 sq.kms) to the growth of agricultural land (0.30 sq.kms), the latter has a very slow growth due to saline intrusion and both of other infrastructure. Reclamation of wetlands is taking place progressively due to urbanization, proximity of Cochin Port and ranging land values. It is observed that the amount of sea portion 3.03 sq.kms (1914) was decreased to 2.07 sq.kms in 2000 due to severe accretion and siltation processes.

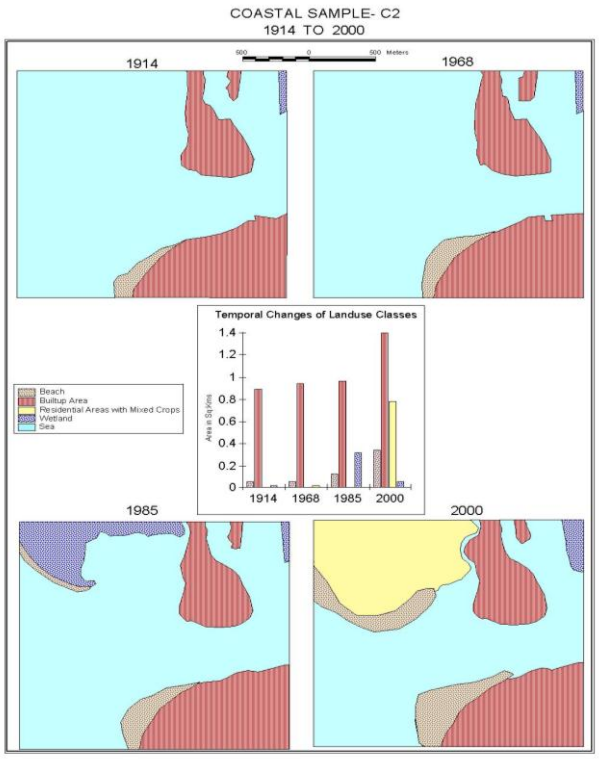


Fig. 3. Coastal Sample

Table 1: TEMPORAL DISTRIBUTION OF LAND USE (1914 – 2000) in sq.kms.

COASTAL ZONE

Sample I – Coastal Zone (C1)

Year	Beach	Built-up Area	Residential Area with mixed crops	Wet Lands	Water Body	Sea Portion
1914	0.14	0	1.22	0.24	0.01	2.39
1968	0.06	0	2.39	0.35	0.21	0.99
1993	0.05	0	2.44	0.36	0.14	1.01
2000	0.10	0	2.37	0.32	0.05	1.16

Sample II – Coastal Zone (C2)

Year	Beach	Built-up Area	Residential Area with mixed crops	Wet Lands	Water Body	Sea Portion
1914	0.06	0.89	0	0.02	0	3.03
1968	0.09	0.97	0	0.02	0	2.92
1993	0.13	0.99	0.30	0.02	0	2.60
2000	0.34	1.40	0.30	0.19	0	2.07

Sample III – Coastal Zone (C3)

Year	Beach	Built-up Area	Residential Area with mixed crops	Wet Lands	Water Body	Sea Portion
1914	0	0	2.60	1.05	0.35	0
1968	0	0.43	2.54	0.65	0.38	0
1993	0	0.63	2.72	0.31	0.34	0
2000	0	3.43	0	0.24	0.33	0

Source: Computed by the Investigator after the preparation of Land Use Detection Analysis.

Coastal Sample – C3

This sample shows a gradual change of all types of land use from rural to urban nature is in 1914 – 2000 periods. During 1914 land under agriculture was predominated (2.60 sq.kms) compare to other land use types. But in 1968 the western part of the sample with (0.43 sq.kms) of area were converted to built up land due to urbanization, commercialization through Cochin Port and development of Cochin harbour. The growth of built-up areas increased as 3.43 sq.kms is 2000. When the urban area increased, amount of wetlands and water bodies have decreased simultaneously (Table 2 and Fig. 4). One of the specialties of this sample is that it doesn't cover sea portion and beach area. There is a healthy relation between urban land and agricultural land with settlement in this particular sample.

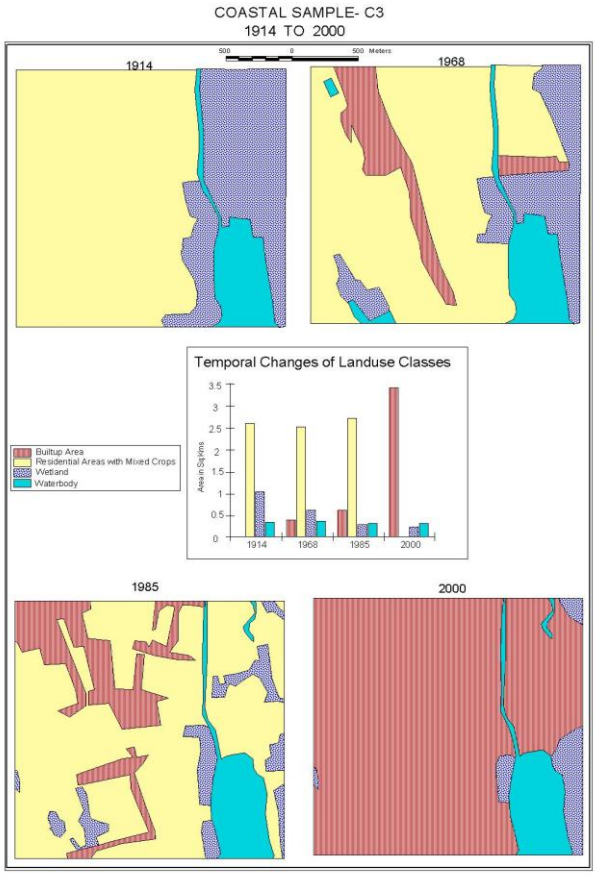


Fig. 4: Coastal Sample C3

Table 2: Increasing built-up area (sq.km) with reduction of sea portion (1914 - 2000)

INCREASE **1) Residential Area with mixed crops**

Year	1914	1968	1993	2000
C1	1.22	2.39	2.44	2.37
C2	0	0	0	0
C3	2.60	2.54	2.72	0
Average	1.91	2.46	2.58	**2.37**

2) Built-Up Area

Year	1914	1968	1993	2000
C1	0	0	0	0
C2	0.89	0.97	0.99	1.40
C3	0	0.43	0.63	3.43
Average	0.89	0.7	0.81	**2.41**

REDUCTION **3) Water Body**

Year	1914	1968	1993	2000
C1	0.01	0.21	0.14	0.05
C2	0	0	0	0
C3	0.35	0.38	0.34	0.33
Average	0.18	0.29	0.24	**0.19**

4) Sea Portion

Year	1914	1968	1993	2000
C1	2.39	0.99	1.01	1.16
C2	3.03	2.92	2.60	2.07
C3	0	0	0	0
Average	2.71	1.95	1.80	**1.61**

Conclusions

- Major physiographic changes occurred in coastal zone of Cochin are changes in the shape of coast line and the formation of new land due to accretion process.
- Changes in the width of beaches due to the variation in deposition over a period of time.
- Formation of inland water bodies and wetlands due to oceanographic influence of tidal canals.
- Disappearance of wetlands and water bodies due to reclamation and filling for creation of new urban lands in the coasts.

- To help Prediction of future coastline behavior of Cochin.
- Study look forward to Protection of coastal resources,
- Management of coastal development and reduction of coastal hazards. Stick on permanent vegetative layer like mangroves on the shorelines.

References

1. Love Joy, Derk (1979): *Land Use and Land Scape Planning*, Loonar Hill Glasgow.
2. Nair, A.S.K and Thrivikramji, K. P (1966): *Coastal Erosion*, proceedings of VIII Kerala Science Congress, P. 89 – 90.
3. Nair, A. S. K and Sankar, G (1995) : *Coastal geomorphology – Kerala coast,* proceeding Seventh kerala science congress, P. 46
4. Nath, V (1953): *Land Utilization in India*, Journal of the soil and water conservation in India, Vol. 1, No. 2, P. 8.
5. Nandeswar, M. D 1992: A comparative study of agricultural situations in different physiographical zones of Kerala – A geographical approach, published, Ph. D. Thesis.
6. Resource Atlas (1984), Centre for Earth Science Studies, Trivandrum, Govt. of Kerala.

Evolution of Balari Bar in the Estuarine Reach of the River Hugli

Dr. Aparajita Sen
Research Scientist and Principal Investigator
Department of Geography, University of Calcutta
E-mail: aparajita72@gmail.com

Abstract

The Hugli Estuary, extending from Hugli Point to Sagar Island, a distance of 65.61 km, is the most dynamic macro-tidal delta of India. The river Bhagirathi-Hugli, the westernmost distributary of river Ganga, deteriorated into a spill channel due to the eastward migration of the Ganga since 16th century. The decrease in the upland supply of water resulted in deposition over the various bars or shoals on the channel resulting in acute navigational problem for the vessels coming to the Kolkata Docks. The Farakka discharge through the Feeder canal has been able to flush out sediments and improve the navigability of the channel up to the Hugli Point. The Hugli estuary, therefore acts as a silt trapping zone. The tides along with the sediments play a crucial role in shaping the various bars and islands located in this region. This paper attempts to study the gradual growth of Balari Bar from 1967-2009. This Bar lying just north of the Haldia Dock Complex has developed over the years creating tremendous problem to the navigability of the Haldia channel and the port-industrial economy of this region. Survey Charts prepared by the KoPT has been used to study the development of this Bar and its implications over the years.

Introduction

The river Bhagirathi-Hugli is the western most distributary of the mighty river Ganga (Fig. 1). It takes off from the right bank to form the spinal chord of the truncated state of West Bengal. The Port of Kolkata (KoPT), situated on the left bank of the river Hugli, is the only riverine port of India. The overwhelming evidence of silting in the lower reaches of the river Bhagirathi-Hugli has all along played a crucial role in determining the health of the port and also the industrial scenario of this state.

Historical background

Within the historical times there has been a consistent eastward shift of the off-take points of the river Bhagirathi-Hugli and today it lies at Mithipur (Ghosh, 2000). These off take points changed from acute to obtuse angles before closing down. As a result the discharge from Ganga dwindled in the dry months. The maximum discharge of the Bhagirathi at Jangipur reduced gradually from 3022.12 cumecs in 1914 to 1305.79 cumecs in 1970 (Sen, 1998). This meager discharge resulted in rapid siltation in the river bed forming new bars (shoals) and enlarging the existent ones in the navigable reach from Cossipore to Sagar.

To remedy this situation and to increase the navigability of the river the Farakka Barrage project was commissioned in 1975, with a view to divert at least 1132.8 cumecs of water from the Ganga to Bhagirathi-Hugli through a feeder canal. It was hoped that the silt free water would restrict further sedimentation of the river channel and gradually move the sediments seawards.

This sudden increase of water from the upland sources during the dry months aggravated bank erosion along the river throughout the year, which was previously restricted to monsoon months only. In the year 1977, the total volume of bank erosion along the Bhagirathi was 30.36 million cubic meter (Sen, 1998). It was estimated that about 220 hectares of land is lost every year along the banks of the river Bhagirathi-Hugli (Parua and Das 1994). Thus a huge volume of sediments is regularly added to the existing amount increasing the peril of the river. Furthermore, the upland discharge from the Farakka dwindled over the years due to reduction of water in the Farakka pool. As a result the seaward movement of sediments was restricted up to the Hugli point and the estuarine reach beyond it became a silt trapping zone.

The Estuarine Reach

The Estuarine reach of the river Hugli extends from the Hugli Point to the Sagar Island, a distance of 65.61 km. The river Hugli takes an eastward bend from the Hugli point to reach Kantaberia 23 km downstream where the river is about 2 km wide. From this point the river mouth widens into a funnel shape and at Haldia attains a width of 15 km. the river here divides into two channels, the Haldia channel in the west and the Rangafalla in the east separated by the Nayachar Island in the centre (Sen, 1998).

The Haldia Dock Complex was commissioned in 1977 to avail the draft of about 10m and to cater to the large ocean liners and oil tankers which could not call at the Kolkata docks and without which the percentage of the volume of cargo handled by KoPT fell from 49.5% (of

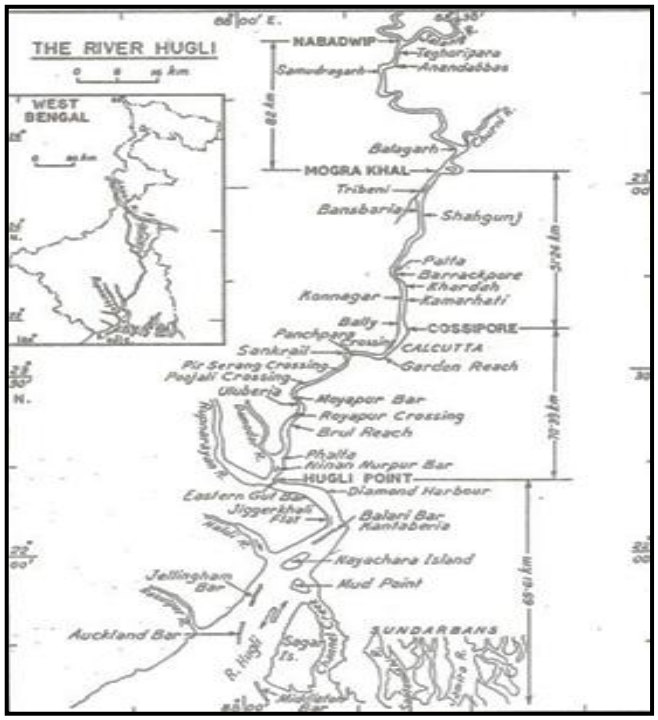


Fig. 1

the India's total) in 1928-29 to only 10.7% in 1970-71 (Sau, 1990). The HDC lies at the right bank of the river at the confluence of the river Haldi.

Downstream of Hugli point, the river Hugli is a handiwork of the tidal actions. The sediments which moved down from the upper reaches mainly got deposited in this estuarine reach due to loss of velocity and the carrying capacity of the ebb tide. The deposition of sediments mainly took place downstream of Hugli Point during the post freshet periods between November and February. As a result the Jiggerkhali Flat lying near the right bank, north of HDC, started growing eastward. This deposition of sediments was mainly cut through during the month of March when the equinoxial flood tides flowed northward through the Haldia channel. This helped the Haldia channel to resume its channel line. But since 1987-88 the Rangafalla channel opened up and the majority of the flood and the ebb tide started flowing through it. The Jiggerkhali Flat thus left unharmed gradually extended east and southwards and nearly stopped the ebb flow into the Haldia channel. As a result the condition of the Haldia channel started deteriorating.

The Study

The Survey charts of the river Hugli prepared by the River Survey Department of KoPT shows the depth of the river at various points with the help of soundings (which are calculated at 3.23 m below MSL.). The charts of the years 1967-68, 1975-76, 1990-92, 2000, 2003, 2006 and 2009 were used to study the changes occurring between the reach Balari Semaphore to Balari Tower (Fig. 2). The charts were registered using remote sensing software, Geomatica 2012, and a point vector layer was created. In the attribute table depths (field) were added from the survey charts and exported to MS Excel. To data was adjusted by adding 3.23 m to bring the water level to MSL (according to the Tide Table). The adjusted depth was then used to construct bank to bank cross sections of the river Hugli at four locations (CS1, CS2, CS3 and CS4) in this reach (Fig. 3a-d). These cross sections have been superimposed to give a clear picture of the gradual choking up of the channel and development of the Balari Bar. From the section CS1, it is clear that the depth of the channel decreased in the Haldia channel (near the right bank) and increased in the Rangafalla channel (near the left bank). Further south, the sections CS2, CS3 and CS4 clearly indicates the growth of the bar with dry soundings at some points proving that the bar has developed into an island. On the other side the channel deepening persists in the Rangafalla channel. As these bars are not stable there has been a change in the position.

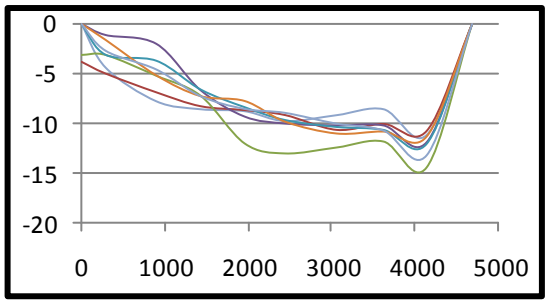


Fig. 2

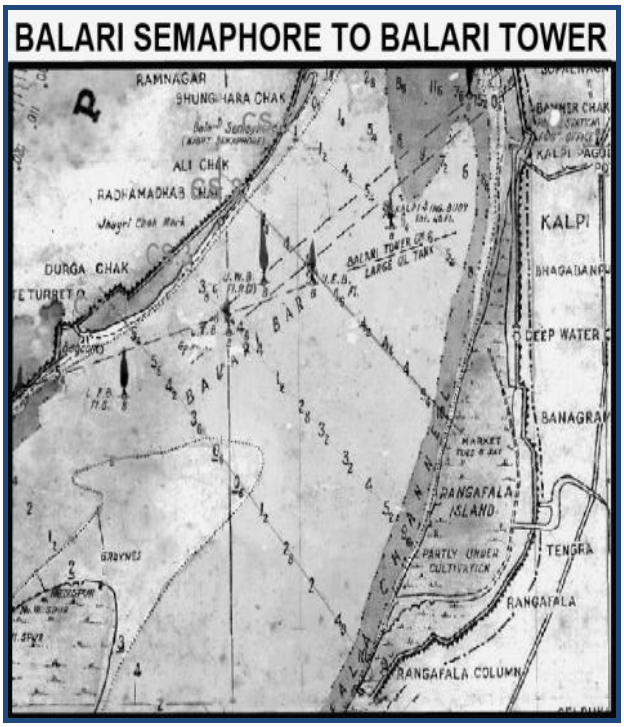


Fig. 3a

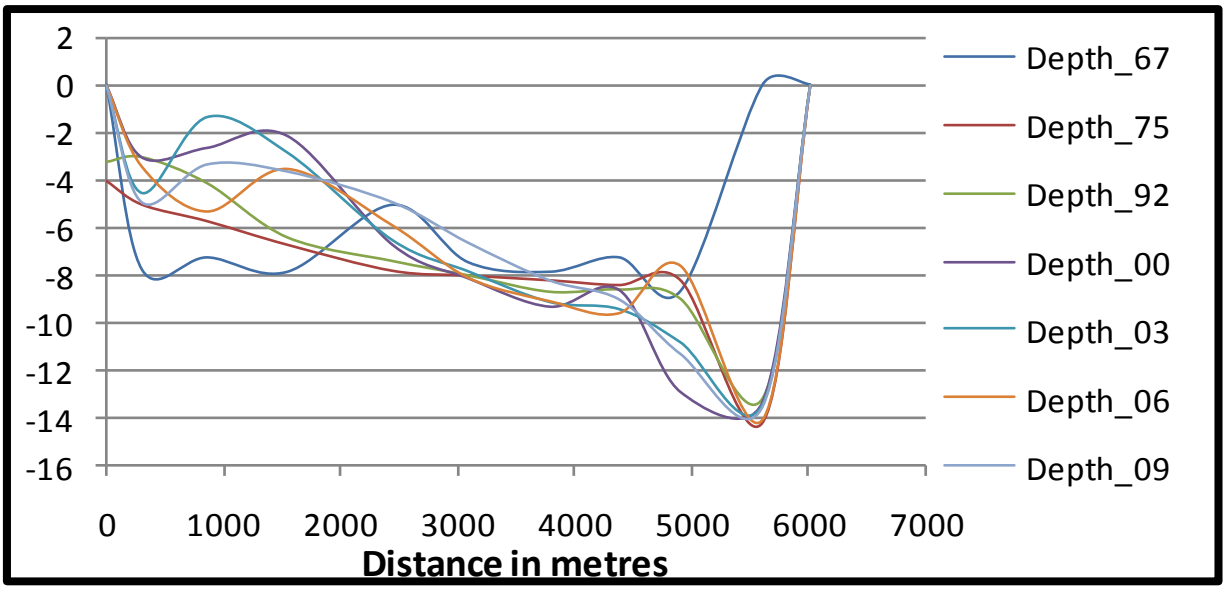


Fig. 3b

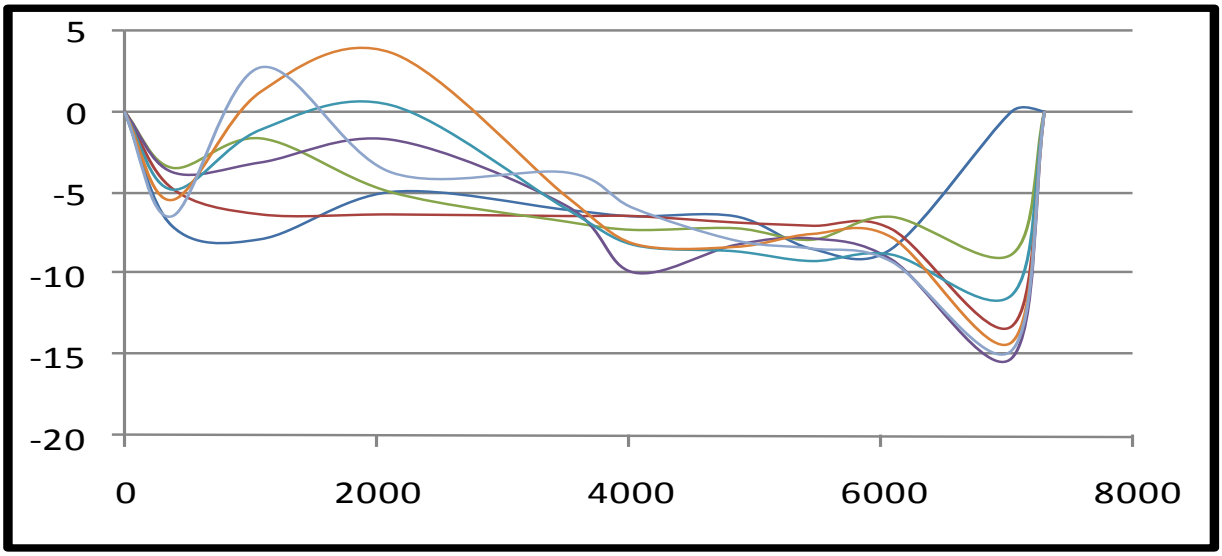


Fig. 3c

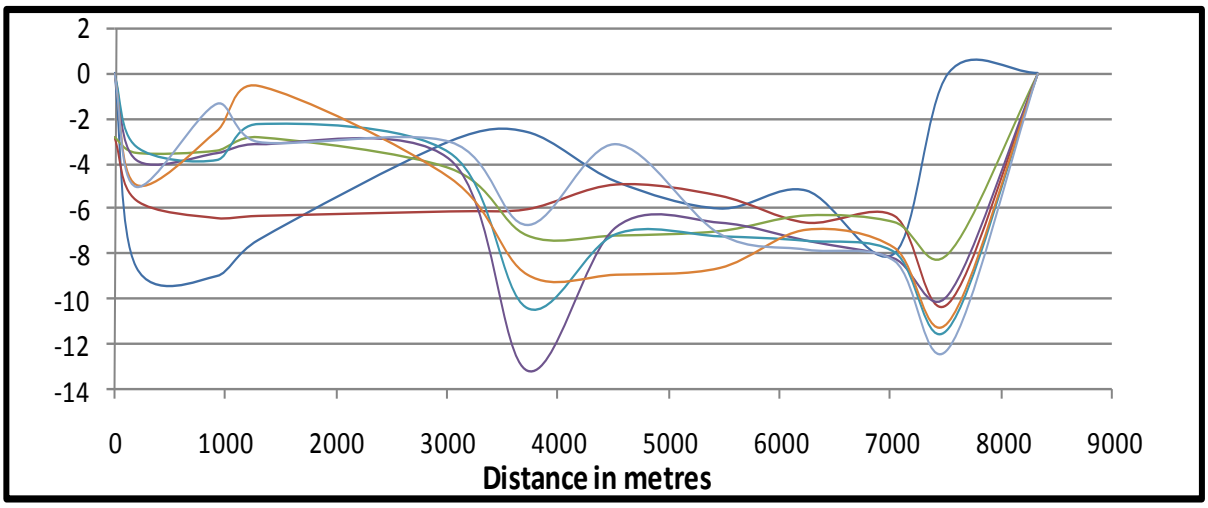


Fig. 3d

Furthermore, a polygon vector layer was created for the years 2000-2009 to study the supratidal area and the perimeter of the developing Balari Bar (Fig. 4). The graphs show the gradual increase in area from 0.65 to 3.99 km^2 from 2000-2009 (Fig. 5). Similarly the increase in perimeter has been from 4.05 km to 10.7 km (Fig. 6).

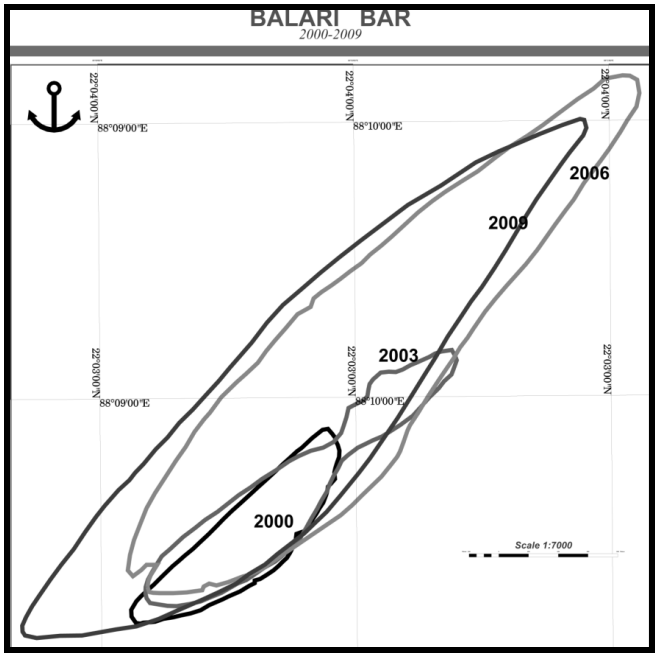


Fig. 4

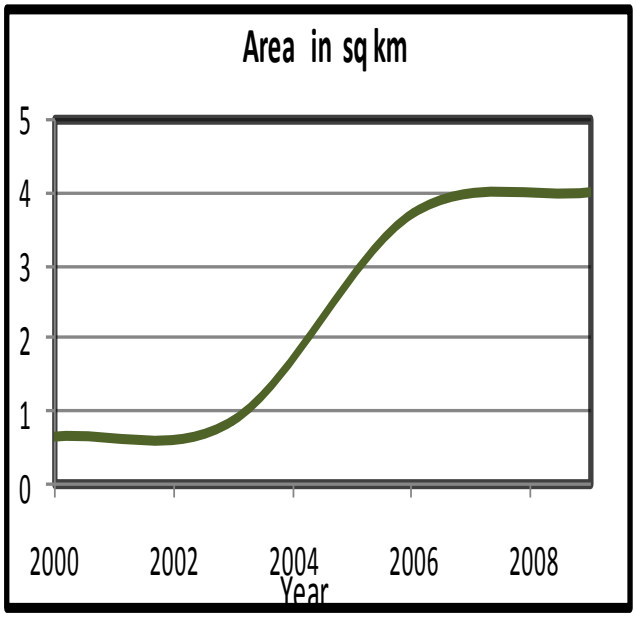


Fig. 5

To study this area in detail, the large scale charts available from the year 2000-2009 were used. A line layer and point layer was created for 29 cross sections. The depths of all the years were added the attribute table. The attribute table was exported to MS Excel and adjusted to mean sea level by adding 3.23m to each depth. The area for each cross section was calculated and the average area was plotted (Fig. 7).

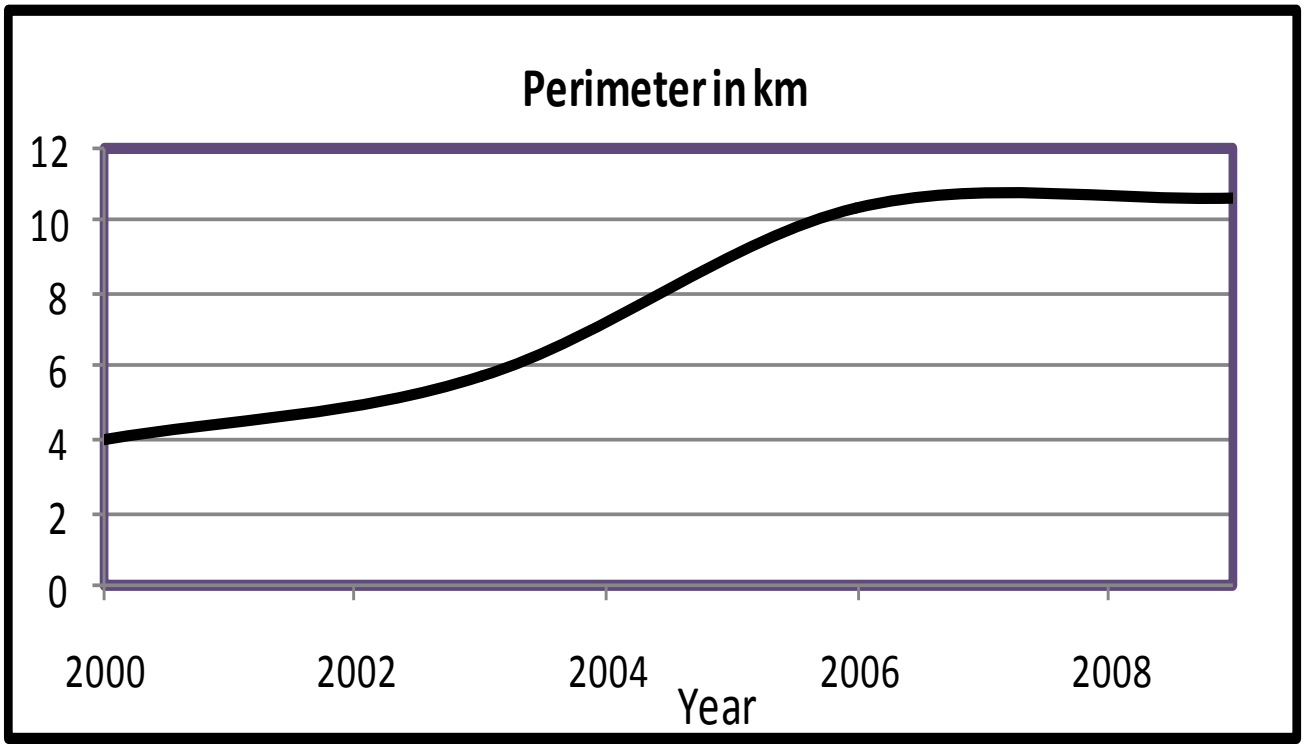


Fig. 6

The average area of the cross sections shows a gradual reduction from 95215.04 m^2 in 2000 to 88863.97 m^2 in 2009. Further, with the help of the area and distance between the cross sections, the capacity (volume) of this reach was calculated. The capacity has decreased from 1344.9 million m^3 in 2000 to 1310.52 million m^3 in 2009. It had increased to 1366.25 million m^3 in 2003 due to the deepening of the Rangafalla channel but again fell sharply to 1320.8 million m^3 in 2006 (Fig.8).This condition of the Haldia channel has restricted the movement of ships from HDC to Kolkata docks via this channel. By 1994 the Balari had become a permanent shoal and every year an additional 4 million m^3 of spoil has been lifted from around the HDC to keep it open to traffic (Dredging Statistics, 1994). Consequently, the bar expanded vertically as well as longitudinally choking up the northernmost oil jetty (Oil Jetty 1) where the draft falls to 5m or less becoming virtually impossible to accommodate Suezmax (Length 270m and above) vessels. It also becomes difficult to accommodate Panamax (Length 225m and above) vessels during post freshet months. Regular maintenance dredging is done here to keep the channel and the berths open to ships and oil tankers. The KoPT has to shell out huge amounts for this maintenance dredging.

The ships travelling from HDC to Kolkata docks has to skirt the southern tip of the Nayachar island and take the Rangafalla channel and travel a extra distance of about 97.2 km. Skilled river pilots are maintained by KoPT who bring the ships from the Sagar anchorage to the Docks with the help of navigational charts and advanced GPS systems. The northern part of Haldia channel is now abandoned for shipping.

Conclusion

The above study gives a clear picture of the gradual deterioration of the northern part of Haldia channel and the growth of the Balari Bar from a shoal to an island hampering the navigability of the river Hugli in this reach. HDC which initially acted as the major dock system handling all the ocean liners is now struggling for survival. As a result the total percentage of cargo handled by the KoPT is facing a decline and the port is facing a severe competition from the neighbouring sea ports. Several measures have been proposed by the KoPT authorities who include capital dredging at Balari and other river training measures to improve the condition of the river. It is only to be seen whether the struggle of man, armed by his recent developments in technology working against the whims of the tidal Hugli, can resuscitate the only riverine port of India.

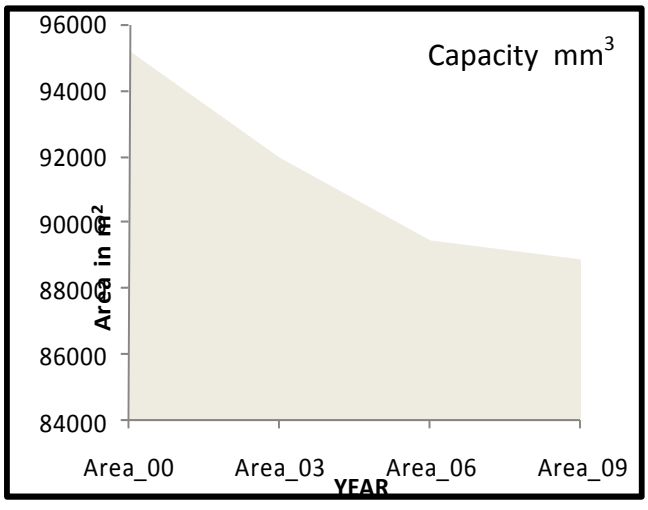


Fig. 7

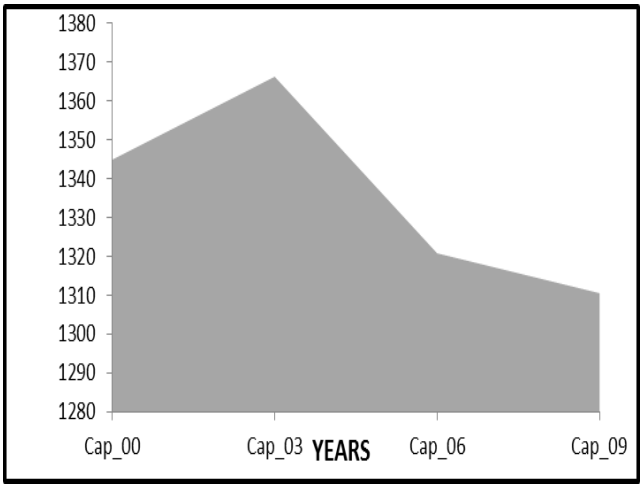


Fig. 8

References

1. Calcutta in 2001, (1994) – "*Problems of the navigability of river Hooghly*", Calcutta.
2. Dredging Statistics, (1994), Calcutta Port Trust.
3. Ghosh, A (2000) – *"A Systematic Study of the effect of Farakka Barrage on the morphological changes of the river Bhagirathi",* PhD Thesis (unpublished), Geography Dept., CU, Calcutta.
4. Parua, P.K and Das, S.C, (1994) – "*Bank Erosion of Bhagirathi-Hooghly river in the Post Farakka period",* Nat. Seminar on impact of Wat. Res. Dev. on Environ, January, Calcutta.
5. Sau, S.N, (1990) – "*Economics of Calcutta-Haldia Port Complex*, Economic and Political Weekly, May.
6. Sen, A., (1998) – "*The Decay of the river Hugli and its impact on the Port of Calcutta – A Geographical Appraisal"*, PhD Thesis (unpublished), Geography Dept., CU, Calcutta.
7. Tide Table (2000)

LiDAR Bathymetry for Nautical Charting

Cdr. Sanjeev Sharma, IN (Retd.)
Head Hydrography
IIC Technologies Ltd, Hyderabad, AP – 500 034 (India)
e-mail – sanjeev.sharma@iictechnologies.com

Abstract

Safety Of Life at Sea (SOLAS) is the overarching principle for all offshore operations and one of the major contributing factors to SOLAS is quality navigational charts that are comprehensive and adhere to International Hydrographic Organisation (IHO) established standards of accuracy. However, a chart is only as good as the data that is used to compile it and one of the more challenging areas for hydrographic surveyors is the coastal/shallow areas where it can be very time consuming, difficult and sometimes impossible to obtain data using traditional acoustic techniques. The main weapon in the hydrographer's toolbox is the sonar, whether it is a multibeam, singlebeam or sidescan. Even with these tools we cannot always get data in the shoalest area due to a variety of factors including the vessel's draught, dangerous terrain etc.

Advancement and development in laser technology, electronics and computing systems over the past few decades has resulted in development of systems capable of conducting bathymetric surveys using platforms other than traditional boats/ ships.

Airborne Laser (or LiDAR) Bathymetry (ALB) is a technique for measuring the depths of relatively shallow, coastal waters using a scanning, pulsed laser beam operated from an aircraft. It is also known as Airborne LiDAR Hydrography (ALH) when used primarily for nautical charting. It not only provides the capability to survey faster but also enables the hydrographer to reach dangerous areas inaccessible by boat.

Though not considered a replacement for acoustic surveys, ALB can be used in conjunction with traditional acoustic surveys for better area coverage and charting the unreachable areas. The paper discusses LiDAR bathymetry concept, its advantages and limitations, operational methodologies, meeting the accuracy challenges with reference to a combined acoustic and LiDAR survey that IIC Technologies has recently undertaken.

Introduction

Airborne Laser (or LiDAR) Bathymetry (ALB) is a technique for measuring the depths of relatively shallow, coastal waters using a scanning, pulsed laser beam operated from an aircraft[2-4]. It is also known as Airborne LiDAR Hydrography (ALH) when used primarily for nautical charting[1]. It can be effectively used for varied hydrographic applications such as nautical charting, repetitive port and harbor surveys, rivers/ lakes/ canals/ inland waterways charting surveys, coastal zone management and environmental assessment surveys. Apart from providing the capability to survey faster it also enables the surveyor to reach inaccessible areas by traditional boats and simultaneous coverage of land and sea areas.

History of LiDAR

Airborne Laser Hydrography (ALH) concept grew out of efforts in mid-sixties to use the Laser technology, primarily for Submarine detection. The seminal paper confirming the ability to perform near shore bathymetry was written by Hickmann and Hogg[2] based on work done at the Syracuse University Research Center, USA. The first generation airborne hydrographic LiDAR systems were successfully tested by US, Canada and Australia in early 1970s. Joint efforts by NASA, NOAA and US Navy led to production of a scanning Airborne Oceanographic LiDAR (AOL) for hydrography. Successful testing of AOL was conducted in 1977. In 1980 the experience with the AOL led to the HALS (Hydrographic Airborne Laser Sounder) program sponsored by the US Navy, the Defense Mapping Agency (DMA) and NASA. Other second generation systems were built and tested in Canada, Australia and in Soviet Union.

In 1986, the LARSEN 500 system was built by Optech, sponsored by the Canadian Hydrographic Service (CHS) and based on the surveys performed in Northwest Territories; it became the world's first operational ALH system.

Successful testing of Australian WRELEADS II in 1980s lead to construction of its operational version called LADS for the Royal Australian Navy.

In 1990s, systems that became operational were LADS for Royal Australian Navy, SHOALS (Scanning

Hydrographic Operational Airborne LiDAR Survey) for US Army Corps of Engineers (USACE) and Hawkeye ALH system in Sweden.

LADS is flown in a dedicated Fokker F-27 fixed wing aircraft, SHOALS is operated from NOAA Bell 212 helicopters and various recent platforms, the Hawkeye systems operated from different types of helicopters, whilst the Canadian LARSEN-500 system continued to perform in several fixed wing aircrafts.

Few new systems in development/ validation stages, worth mentioning, are CZMIL (Coastal Zone Mapping and Imaging LiDAR) presently in validation phase and Airborne Laser Terrain Mapper (ALTM) Aquarius, both from Optech and Chiroptera from Airborne Hydrography AB (AHAB) for very shallow applications (< 10m)

ALB concept

The general technique of laser bathymetry involves use of a pulsed laser transmitter with green and Infrared (IR) beams. The green laser is used for bottom detection since this wavelength can penetrate typical coastal waters with least attenuation. The IR laser penetrates very little and is used for sea surface detection. Depending on the system design, IR beam may be nearly collimated and scanned collinearly with the green beam, or it may be broader and constrained at nadir. Red energy generated in the water from green-excited Raman backscatter (the incident 532 nm green laser frequency is altered at the air/water interface, shifting it to red spectrum) immediately beneath the air/ water interface may also be used as a surface return when its arrival time is properly corrected to the interface[1]. The transmitted laser pulses are partially reflected from the water surface and from the sea bottom back to the airborne receiver. In effect, distances to the sea surface and bottom can be calculated by measuring the times of flight of the pulses to those locations and knowing the speed of light in air and water. Water depths are determined from the resulting time differences and corrected for known errors such as electronic and atmospheric delays.

The receiver consists of a telescope, various optical filters and field-of-view controls, light detectors, amplifiers, analog surface detection logic, and analog-to-digital converters (a digitizer). The receiver, system control logic and tape storage are all operated under computer command. Because of the complexity of the environment and of the interactions of the LiDAR beam with the environment, it has not been possible to calculate all depths with high accuracy and reliability in real time. Approximate depths are calculated in the air for quality control, but precise depths, involving more-detailed calculations and a limited amount of manual intervention for difficult cases, are determined via post-flight processing of stored waveforms. A schematic representation of the ALB concept is depicted in Fig. 1.

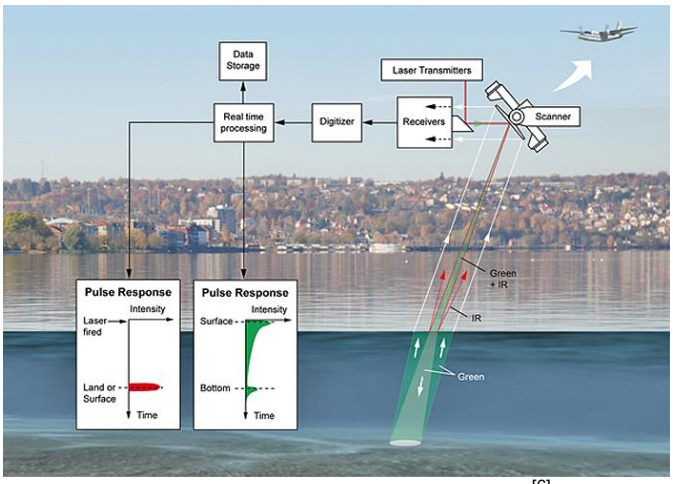


Fig. 1: The LiDAR bathymetry concept[6] (Photo courtesy - Canadian Hydrographic Service (CHS))

All systems use a solid state Nd-YAG (Neodymium doped – Yytrium Aluminum Garnet crystal) pulsed dual frequency laser to output simultaneous pulses at 532 nm (green beam) and 1064 nm (IR beam). As discussed earlier, the IR beam is used to detect the water surface whilst the green beam penetrates water and is used to detect the seafloor. A moving average window is used to create a mean water surface, in order to remove the wave action and heave so that tides can be applied. Distances to the sea surface and seafloor are calculated from the times of the laser pulses, using the speed of light in air and water. System orientation while airborne is typically provided by the Applanix POS AV Inertial Movement Unit (IMU) or equivalent.

The bathymetric LiDAR system also incorporates digital RGB cameras which acquire one 24-bit or better colour photo per second. The POS AV, combined with and the relatively low flying heights, helps the camera to produce a pixel resolution of 8-30cm (depending upon flying height and actual system). This digital camera imagery forms an important QC tool as it is used during processing to detect elements interfering with the laser (vessel traffic, Sun glint, turbidity etc.) and to assist in the identification of bathymetric features and aids to navigation.

ALB Advantages

The reasons for pursuing such an innovative and expensive technology arise from the following requirements:-

1) *Perform surveys within small operational window*

2) *To complete survey quickly*
3) *Rapid mobility*
4) *Fairly large survey areas*
5) *Survey where it would be difficult or impossible to use traditional water borne techniques of surveying.*
6) *Mobility to perform rapid assessments of seasonal change.*
7) *Better swath coverage.* LiDAR systems with relatively fixed swaths independent of depth are efficient for surveying in shallow waters to IHO Order 1 accuracy. MBES systems, whose swath widths are reducing with a decrease in depth, are more efficient in deeper waters and areas where higher order of accuracies are envisaged. Fig. 2 represents a graphic comparison of LiDAR and sonar operations in shallow waters.
8) *Simultaneously survey water and terrestrial areas.* ALB provides unique survey opportunities and capabilities in shallow waters and across the land/water boundary which are worth even if they are expensive. A few examples could be beach gradient and coastal engineering surveys.

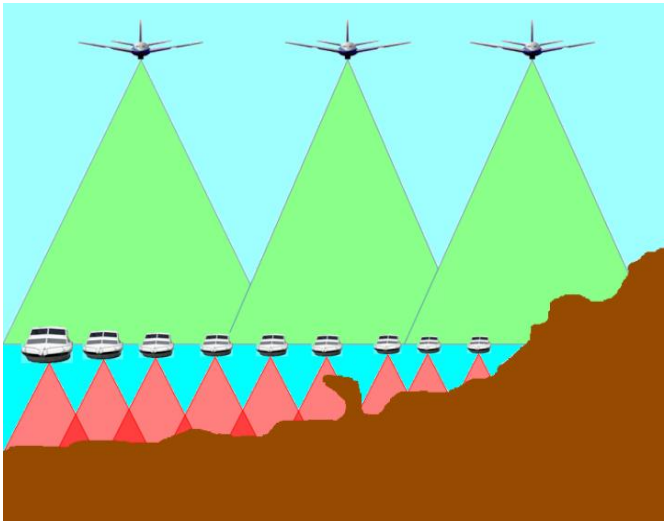


Fig. 2: A comparative depiction of LiDAR and Multi-beam swath coverage. (Photo courtesy – IIC Academy)

Aircraft Operations

Most of the aircrafts operate at an altitude of 300 – 500 m with an average speed over ground of 130 kn. The maximum scanner nadir angles are up to 20° which corresponds to survey swaths with widths roughly equal to one half of aircraft altitude[1]. Larger scanner nadir angles would mean unacceptably larger timing errors in the surface and bottom returns due to extreme geometry. A typical survey flight mission is of about 5 – 6 hrs depending on the type of aircraft in use and the weather conditions. For a 6 hour mission with a 65% online fraction, about 70 km^2 can be surveyed. Higher coverage rates can also be achieved by having a wider swath width coupled with a faster air craft speed; this would have an adverse effect on the sounding density.

Limitations

A. *Water Clarity*. It is the most significant limitation for Airborne Laser bathymetry systems. For a typical eye safe operation, the max surveyable depths range from 50 m in very clean waters to less than 10 m in very murky near shore waters. Surveying may not be possible for extreme murky waters (due to turbidity, water discharge from industrial plants, muddy water, algal growth etc.). As a rule of thumb, successful operations can be expected for depths between 2 – 3 times the Secchi disk reading. However, it is a broad estimate and cannot be relied 100% for aircraft operations unless you run a test flight in the survey area. The Secchi depth is not a very good predictor of performance as the Secchi disk readings can vary daily at the same location. This is because its relationship to the proper optical parameter, the attenuation coefficient, varies with the scattering to absorption ratio. The water property which most nearly dictates the received bottom return pulse energy in an ALB system is the diffuse attenuation coefficient (K) at the Green laser wavelength (Fig. 3).

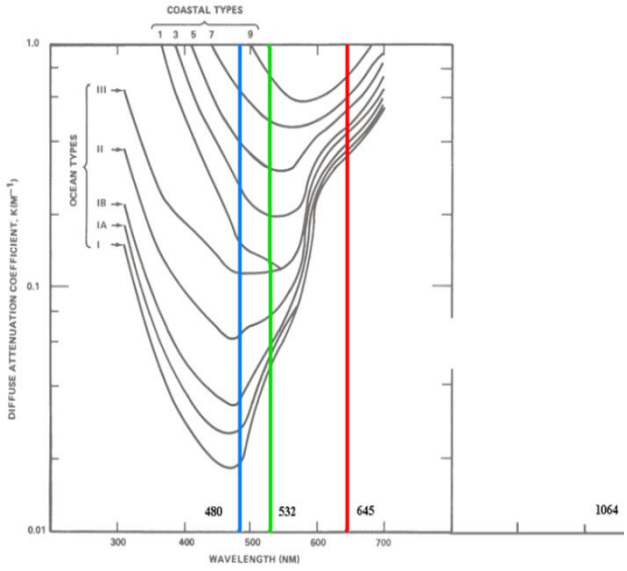


Fig. 3: Jerlov curves. [5]Greater the K Value, dirtier is the water column. (Jerlov, N.G., 1976)

B. *Sun Glint*. Sun glint is a known issue with bathymetric LiDAR and line direction is planned to reduce its impact. Sun glint increases the amount of noise in the data which becomes more significant with weak bottom returns from deeper areas combine with areas of high turbidity

C. *Small Object detection*. Another limitation of ALB systems is that it cannot prove, beyond doubt, that a navigation channel is free of small objects of the order of 1 m^3. The problem lies in the fact that it is almost impossible to resolve the small target return in the presence of the much stronger and immediately following bottom return. The detection probability for such small objects can be increased by increasing the

D. survey density, but this would not be a fool proof method and is also not economically a viable option. In general, it can be said that, objects with larger surface areas and smaller heights are well detected, as are objects with smaller areas and larger heights.

E. *Detection in extreme Shallow waters*. Very Shallow water can cause extreme glint even at low altitude, the resultant reflections can reduce the quality of the surface and seabed return. In extreme shallow waters (less than 0.5 m), the shallow water algorithm does not work well and will drift in and out thus causing variation in the depths. This is due to the fact that surface and seabed return are so close on the waveform that it is beyond the system's ability to discriminate between the two returns.

F. *Operational limitations*. Weather plays an important role in successful ALB data collection. It not only restricts the aircraft's operational window, but weather conditions such as low cloud, fog and rain can also severely affect the LiDAR performance. Another factor limiting the operational data collection window is the permissions and clearances from the Air Traffic Control (ATC)to operate the aircraft due to prevalent traffic at airports.

G. *Logistic considerations*. One of the most important factor limiting ALB surveys is the plethora of logistic considerations and meticulous planning for aircraft operations. An aircraft not only needs daily permissions to fly, but also needs to carry out routine planned maintenance schedule, effective ground support infrastructure, daily refueling, restricted availability of power supply (all equipment has to be run on the aircraft generator supply, no additional generator can be installed) and above all aircrew rest as per FAA safety recommendations.

Planning an ALB Survey

A. ***Environmental Risk study*****.** Climatology is an important criterion to choose the season of survey. Hence it is most important to conduct an environment risk study, even if it is a statistic figure and depends on the hazards of the weather. The risk can be minimized by extending work over large areas, presenting different weather patterns. The weather prediction reports must be exploited for the operation of the aircraft and the laser sensor. The important parameters to be checked are wind, sea state, precipitation, heat &humidity and cloud cover. Tidal predictions allow one to know not only the height and time of the High Water/ Low Water. It also gives an indication on the stream coefficients during Spring/ Neap tides and can help in decision making for surveying either during Low water or High water to get good coverage in very shallow waters.

B. ***Line Planning*****.** An ALB survey line planning, unlike MBES survey lines, is independent of the depth. The line spacing is of fixed width depending on the density and coverage requirements, something akin to single beam surveys. However, the line planning is guided by the topography and wind conditions in the survey area. It will be prudent to plan survey lines in the direction of wind and along the coastline. ALB survey lines should not be planned perpendicular to the depth contours if there is an abrupt change (steep change) in bathymetry, as the depth recording algorithms take some fractions of seconds for providing a depth solution from shallow to deep waters.

C. ***Ground truthing*****.** ALB ground truthing is akin to the calibration patch tests for MBES surveys. It goes up a notch further as an essential element in proving that the survey is not only progressing as per the required specifications but it also provides mechanism for monitoring and identifying system changes over a period of time. Ground truthing over water requires MBES support. For this, a suitable patch with flat seabed or gently shelving seabed is required. For an efficient sea control patch the MBES itself has to be calibrated and relied upon for accuracy compliance. The sea control patch site should not be chosen at the extreme limit of LiDAR depth. The calibration flights are then run daily over the chosen calibration patch to ensure system compliance and satisfactory performance.

IIC Experience

IIC technologies along with its partner Pelydryn Ltd, UK, recently completed an ALB survey in the Red Sea for General Commission for Survey (GCS), Kingdom of Saudi Arabia (KSA). The survey was conducted using a Hawkeye IIb bathymetric LiDAR sensor (Fig. 4a) fitted on a Caravan aircraft (Cessna) operated by CAE Ltd (Fig. 4b)



Fig. 4a: Hawkeye IIb LiDAR sensor



Fig. 4b: Caravan Aircraft (Cessna)

*A. Survey planning***.**

The requirement for LiDAR in this project was to survey depths less than 30 m. Based on the initial assessment from existing nautical charts, the survey area (Fig. 5a) was divided into 8 blocks (Fig. 5b). Following an initial period of operations by the MBES, the potential for a large number of uncharted shoals was deemed to present a hazard to operations. Subsequently, an additional block was planned for survey to detect any uncharted shoal / reef (Fig. 5c)

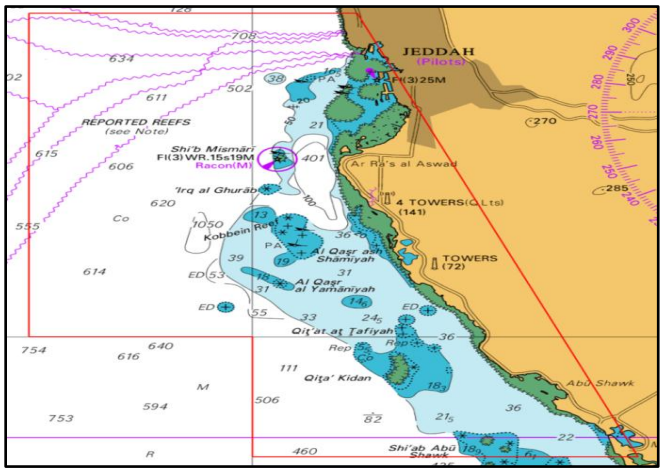


Fig. 5a: Survey Area



Fig. 5b: Survey Area

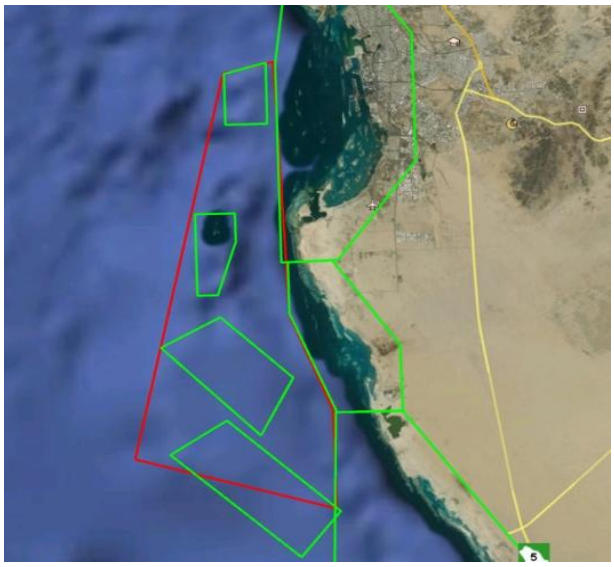


Fig. 5c: Additional Survey Block (In Red)

B. *Challenges during the conduct of survey*.

1) *Meteorological Impact.* Weather during the early part of the year had little impact on operations with 3 ½ days being lost to sandstorms (Fig. 6) and inclement winds. The major problem was loss of visibility with 10km of visibility dropping to less than a km in minutes.



Fig. 6: Sandstorms



Fig. 7: Sun Glint

2) *Sun Glint.* Sun glint (Fig. 7) was a significant factor whilst surveying deeper areas later in the period, when the sun angle remained higher than 70 degrees for longer periods during the day.Subsequently, flying

sorties were timed around the sun's elevation to reduce its impact.

3) *Extreme Shallow waters*. Designed to operate across the land/sea interface the system generally can detect depths up to 0.5m. In most areas the range of tide allows either a deeper return at a higher state of tide or a topographic detection at low water. The tidal range experienced in survey area was no more than 0.5m during the survey, which meant that the shallow fringing reef plates (Fig. 8) would be difficult to survey.



Fig. 8: Extreme Shallow Waters

4) *Land Reclamation and dredging activities*. Dredgers working in and around Jeddah bay (Fig. 9a) undertaking land reclamation & channel clearance and vessels operating from the port (Fig. 9b) posed a serious block in the progress of LiDAR survey.



Fig. 9a: Dredgers operating for channel clearance

The turbidity in water as a result of these activities has reduced depth penetration in the area already suffering from sediments and shipping activities. Such areas, though flown twice, had to be covered again by MBES.



Fig. 9b: Vessels operating in port

5) *Coverage in deep reef pockets / sink holes*. The reef structures consist mainly of limestone and this is prone to erosion and collapse and this evident in the large number of sink holes (Fig.10a, 10b) that were encountered on the reefs. In a large number of cases no coverage of the seabed at the bottom of the sinkhole could be achieved.

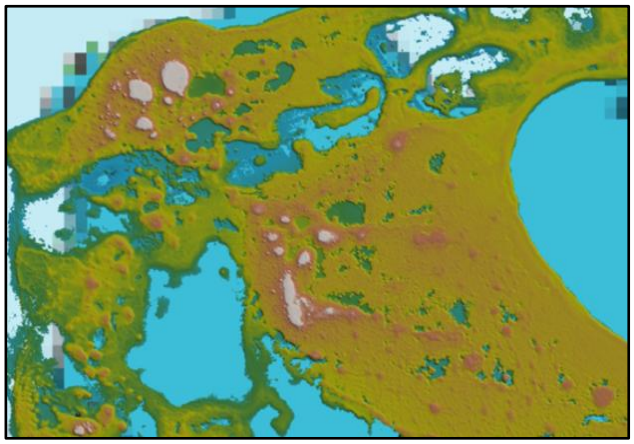


Fig. 10a: Sink Holes

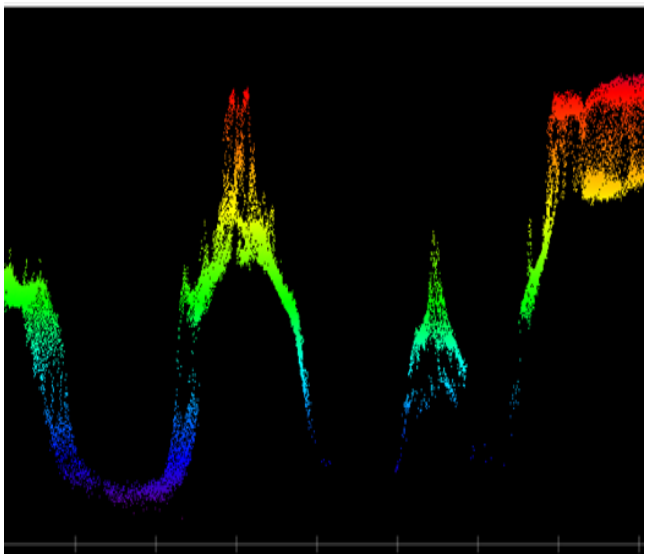


Fig. 10b: Sink Holes in waveform format

This is a result of a number of reasons:

i) The seabed lies beyond the extinction depth of the system.

ii) The sinkhole size and orientation is such that the system is unable to detect the seabed but can detect the steep sides due to masking from the shallower reef plate and shoals that may be within the sinkhole or channel (Fig. 10c).

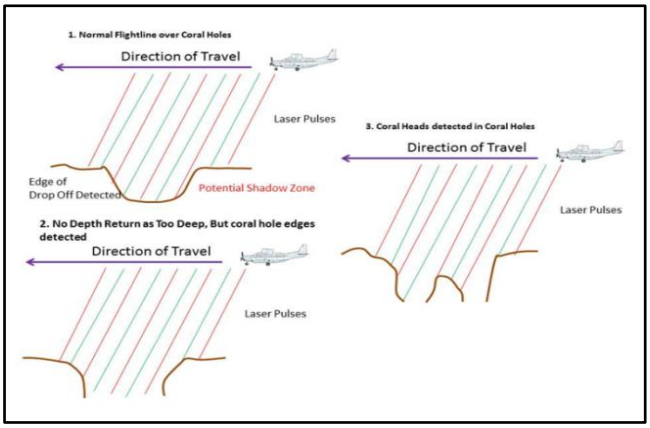


Fig.10c: Graphic depicting seabed detection in sink holes

6) Complex Geomorphology. There are two recognised reef types present in the Red Sea. The first type called the fringing reef is generally connected to the coast or surrounds islands. This reef type is evident all along the coastline and on offlying islands. In between these reefs a second reef type is present. Called a Platform or patch reef they are scattered in the calm, shallow waters between the mainland and edge of the continental shelf often rising from great depths to form isolated coral pinnacles. They often tend to be more broken up and do not always present a defined barrier to the sea and these have been encountered in the area surveyed covering extensive areas.

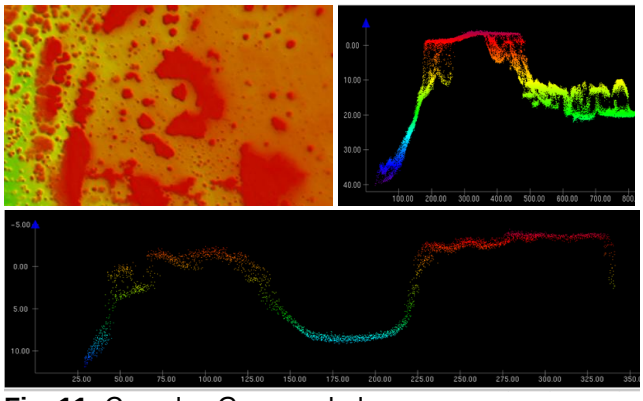


Fig. 11: Complex Geomorphology

The reef structures are complicated (Fig. 11) and provide unique challenges for hydrography. The reef flat is often in very shallow water and provides additional challenges to LiDAR systems because of the shallow depths encountered. Reef crests are easily visible and often form small islands. As the water gets deeper the fore reef and shelf can extend for significant distances before the reef edge and drop-off is encountered. Alternatively on the seaward side of fringing and patch reefs they can abruptly drop off in a near vertical wall. Within the reef flats and fore reef it is common to find isolated coral heads, gullies and highly irregular seabed due to the breakdown of dead coral to form boulders and new growth on and around it.

C. The Accuracy Challenge.

The accuracy standards, accepted for hydrography are established by the International Hydrographic Organization (IHO) in Monaco and disseminated in Special Publication 44. The accuracies achieved for the present survey fall in IHO Order 1 (1b) category. Table 1 summarizes the Horizontal and vertical uncertainties computed from the survey error budget and a-posteriory computed uncertainties of each equipment.

Depth (m)	Horizontal Uncertainty		Vertical Uncertainty	
	IHO Specified for Order 1b	Achieved	IHO specified for order 1b	Achieved
5	5.25	2.318978691	0.504207299	0.237321466
10	5.5	2.546759573	0.516623654	0.28017122
15	5.75	2.886726157	0.536679606	0.339784201
20	6.0	3.304432315	0.563560112	0.408893202
25	6.25	3.774154128	0.596343022	0.483442813
30	6.5	4.278795072	0.634113554	0.561269287
35	6.75	4.807371069	0.676036242	0.641180496

Table 1: Accuracy standards achieved as against IHO Order1b accuracy standards

Conclusion

Though not considered a replacement for acoustic surveys, ALB can be used in conjunction with traditional acoustic surveys for better area coverage and charting the unreachable areas. LiDAR systems with relatively fixed swaths independent of depth are efficient for surveying in shallow waters to IHO Order 1 accuracy. MBES systems, whose swath widths are reducing with a decrease in depth, are more efficient in deeper waters and areas where higher order of accuracies is envisaged. ALB systems can be used safely, for efficient conduct of survey by MBES systems, by delineating the dangerous areas and features that might imperil the survey boats. If used wisely, the ALB systems can provide great cost savings whilst ensuring good coverage benefits and timely completion of surveys.

Acknowledgement

General Commission for Survey, Kingdom of Saudi Arabia, Véronique Jégat, IIC Academy.

MSL Variation Along East and West Coast of India

U.N. Mishra[1], Dhiraj Shah[2], S.K. Singh[1], Rakesh Kumar[3] and Sanjay Kumar Shandilya[3]
[1] Director, Geodetic & Research Branch
[2] S.S., Officer-in-Charge, Marine Geodesy Wing
[3]Officer Surveyor, SOI, Dehradun

Abstract

The Indian subcontinent divides the north Indian Ocean into two semi-enclosed seas, the Arabian Sea and the Bay of Bengal, both of which encroach onto the equatorial regime of the basin. To facilitate the engineers and planners with the elevation model of land scape, it was felt to establish a levelling network in the entire country. In Survey of India, the first level net adjustment was carried out during 1909 on the basis of levelling data collected from 1858 to 1909 and MSL of the Tidal Stations with the assumption that height of mean sea level is same at all tidal stations.

One of the assumptions of levelling operations in 1858-1909 was that the mean surface of the Arabian Sea and the Bay of Bengal are very nearly at the same elevation. Further at that time order of accuracy of observations of levelling as well as tidal are not high. The mean sea level of any point may be permanently influenced by wind and current, and the tidal observations may be affected by instrumental error also. The high precision leveling is also having inherent error. If the observed difference of elevation between the mean sea level at different tidal station, connected by Levelling, is considerably greater than the error to which levelling is ordinarily liable, it may be fairly inferred that two sea levels do not belong at same level.

During 2006-08, levelling observations have been conducted by the Geodetic & Research Branch, Survey of India, starting from one point i.e. Apollo Bunder tidal observatory, Mumbai. These observations have showed that mean sea level along the coast of India is higher in the Bay of Bengal than in the Arabian Sea, the difference in sea level between Mumbai and Vishakhapatnam is about 4.9 cm, whereas New Mangalore is 3.2cm higher than Chennai. Observations also reveals that Mean Sea Level (MSL) is showing increasing trend from Ennore to Paradip towards North direction and Ennore to Tuticorin towards South direction.

Introduction

Survey of India has the mandate to carryout systematic tidal observations along the Indian coastline and islands. On 4th July 1877, the Government of India has passed a resolution entrusting the general superintendence and control of systematic tidal observations to the Survey of India, Captain Baird being the first officer detailed to carry out these duties. Since then Survey of India (SOI) has been collecting tidal data through a well distributed network of tidal observatories along Indian coastline and islands.

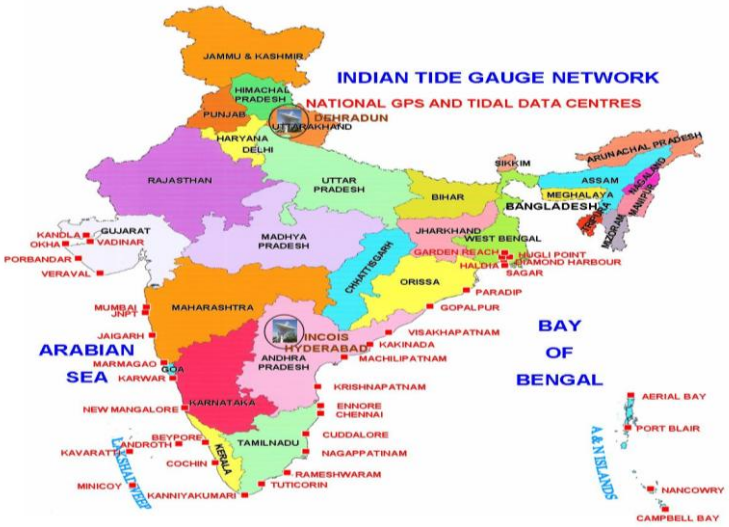


Fig. 1

During first level net adjustment, two types of data was taken into consideration:

(i) Levelling data collected during 1858 to 1909 and

(ii) Tidal data collected at various locations since the inception of tide gauges till 1909.

Levelling data was observed using wooden staves and simple levelling instrument having limited accuracy, whereas tidal data was collected using self registering tide gauges with a least count of 2 to 4 cm (1 Division of graph is 2 to 4 cm). During failure of self registering tide gauges, data was also collected manually, thereby introducing human error in the collected data.

In the recent levelling operations, carried out under the project "Redefining Indian Vertical Datum (RIVD)", precise instruments are used. Bar Coded Invar staves and Digital level instrument with a least count of 0.0001 m have been used in carrying out High Precision Levelling. Similarly, upgraded version of Tide gauges have been used in tidal data collection.

Methodology for Calculating Height

i. Leveling Observation:

Geodetic & Research Branch of the Survey of India felt to redefine the vertical datum of country after a long span of 100 years period i.e. after first level net. High precision Levelling work started from April 2006 and first phase completed in winter season of 2008 covering the periphery of India with one central line and four cross section line as given in the chart.

Eleven circuits with nineteen junction points are observed for levelling height with gravity observation along levelling lines at an interval of approximately 5 to 7 km apart. High precision leveling has been carried out by Digital levels with bar coded staves, 18 ports having tidal observations have also been connected with high precision levelling network. The standard procedure has been adopted by carrying out levelling observations in Fore & Back direction. To maintain the internal accuracy of the measurement, following specifications have been taken into consideration:

1. The Maximum limit for agreement for the two sets of observation should not be more than 0.0009 m.
2. The permissible discordance between the fore & back measurements of a levelling section kept within $4\sqrt{k}$ mm, where k is the length of leveled section in km.
3. The maximum distance between instrument and staff position was restricted to 60 m and instrument was kept in the middle of the two staff positions.
4. All precautions of high precision Levelling were observed.
5. All observation of each line have been checked statistically by calculating the Probable accidental and systematic errors and found that each line classified as High Precision Levelling as adopted in the conference of International Geodetic Association in 1912.
6. The gravity observations were carried out with the help of relative gravimeters which provide an accuracy of ±5μgal in the observation.

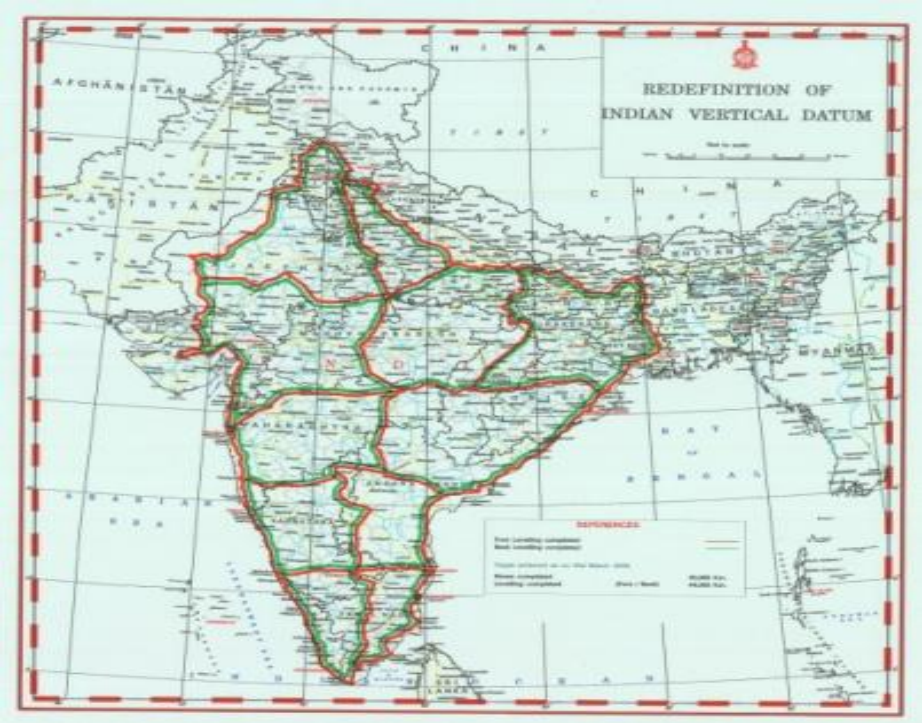


Fig. 2

Adjustment:

The levelling network adjustment is based on the well known method of observation equation using principle of Least Square Adjustment method in the term of Geo-potential number ($C_p=g_p*\Delta h$) taking Mumbai Port as fixed datum. All 29 levelling lines are adjusted separately for the residuals that come as a difference of fixed adjusted gpu of junction points and the actual observed values. The linear methods of distribution of error are carried out for the said purpose. The Helmert Orthometric Height of the bench mark is calculated with the help of corresponding adjusted geo-potential number by the following formula:

$$Hp = \frac{Cp}{(gp + 0.0424Hp)}$$

Where Hp is the computed orthometric Height in kilometers at point p. Cp is the geo-potential number at point p in gpu. Gp is observed gravity in gals at the same points. With the combination of two types of observables i.e., High Precision Leveling & Tidal observation, Case study has been carried out.

i. Establishment of Relation between Bed Plate and Local Mean Sea Level

Tidal height at a port is referred to an arbitrarily fixed datum, called Chart Datum (CD), below which sea level seldom falls. All the bathometric contours shown on the Hydrographic charts are also referred to this datum. For fixation of Chart Datum and further to calculate its relation with Local Mean Sea Level (LMSL), round the clock tidal observations are carried out. Hourly tidal heights and high/ low water times and heights are extracted from the observed data. Local Mean Sea Level (LMSL) is determined by taking mean of the hourly tidal data for a period of one month, one year or 19 years. Also using this data, Harmonic Tidal Analysis is carried out to obtain tidal constituents which in turn used for advanced tidal predictions and further establishment of relation between Local Mean Sea Level (LMSL), Chart Datum (CD) and Tide gauge Zero (TGo) (which is the depth of bottom of Tide pole w.r.t. Bed Plate) /Tide pole zero (TPo). Tidal observations are also connected with Standard Bench Mark of National Levelling Frame work by means of High Precision/ Precision / Secondary levelling. Generally, a Bench Mark is established near the tidal observation site. This is called Bench Mark of Reference (BMR). Tidal observations are carried out by fixing tide gauge or tide pole at a place where sufficient water depth is available so that tide is captured without losing any bit of data. Zero of the tide gauge / tide pole is connected with BMR by means of levelling so that a relation is established between BMR, IMSL, LMSL CD and TGo. Height of the zero of tide gauge is measured with respect to the reference point marked on the platform. This Bed Plate is further connected with the Bench Mark of Reference by means of levelling.

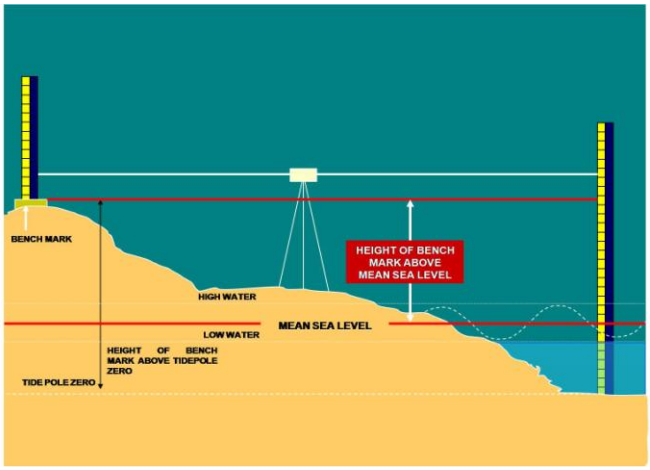


Fig. 3: Establishment of Bench Mark of Reference using Tide Pole Observations

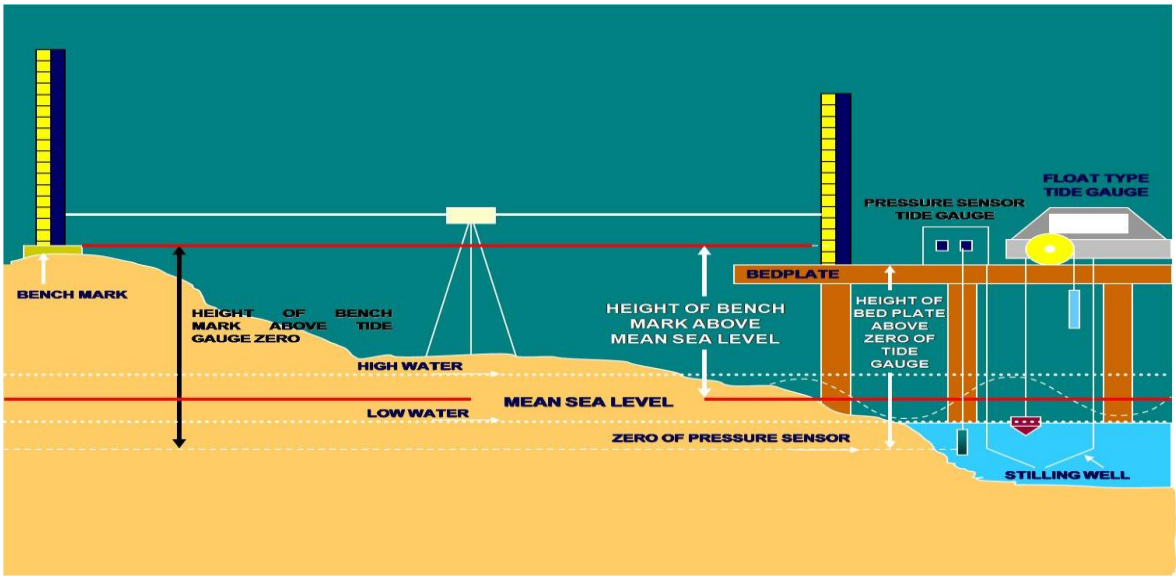


Fig. 4: Establishment of Bench Mark of Reference using Self Registering Tide Gauge Observations

Table 1: Chart Showing MSL Variation at East & West Coast

TABLE SHOWING HEIGHTS OF BED PLATE DEDUCED BY LEVELLING AND TIDAL OBSERVATIONS				
Sl. No.	**Tidal Station**	**Year of observations used in computation of LMSL**	**Gaps (years)**	**Diff. between MSL and LMSL heights in (m)**
1.	**Mumbai**	1976 -1994	-	0.0000
2.	**Paradip**	1976 -1994	1976&1977	0.0710
3.	**Vishakhapatanam**	1976 -1994	-	0.0493
4.	**Chennai**	1976 -1994	-	-0.1594
5.	**Tuticorin**	1976 -1994	1981 to 1984,1992 to 1994	-0.0060
6.	**Nagapattinam**	1976 -1994	1978,1979,1991 to 1994	-0.0303
7.	**Ennore**	32 days observation data (2006)		-0.1966
9.	**Cuddalore**	32 days observation data	-	-
10.	**Cochin**	1976 -1994	-	0.0472
11.	**New Mangalore**	1976 -1994	-	-0.1269
12.	**Karwar**	1976 -1994	1983,1993,1994	-0.1070
13.	**Marmagao**	1976 -1994	1981 to 1985 & 1994	-0.1077
14.	**JNPT, Mumbai**	1976 -1994	-	

Table 2: Old IMSL Height and Helmert Heights of Bed Plates of CDTG at Two Different Epoch

Sl. No.	**NAME OF PORT**	**Difference between Helmert Orthometric Heights of epoch 2007 and 2011**	**Difference between old MSL height and new Helmert height**
1	**JNPT**		0.0417
2	**APOLLO BUNDAR**		0.0077
3	**MARMAGAO**		-0.0576
4	**KARWAR**		-0.0380
5	**NEW MANGALORE**		-0.0526
6	**COCHIN**		0.1383
7	**TUTICORIN**	-0.00420	
8	**NAGAPATTINAM**	-	
9	**CHENNAI**		-0.0880
10	**VISAKHAPATNAM**	+0.02630	-0.0020
11	**GARDEN REACH**		0.0879
12	**PARADIP**	-0.00260	0.0192
13	**MACHILIPATNAM**		-0.0604
14	**VADINAR**		0.0018
15	**KANDLA**		0.1474

Conclusion

The Helmert Orthometric height of the Bed Plate of Mumbai Tidal observatory has been calculated with respect to the Local Mean Sea Level of Mumbai (Mean of the Annual MSL value taken for a period of 19 years from 1976 to 1994). Levelling circuits have been run throughout the country as shown in the Fig. 2 and connected the Bed Plates of all the tidal observatories for which data is used in the present study.

(A) Following computations have been done:-

(i) Helmert Orthometric heights of the Bed Plates of all tidal observatories have been computed with respect to Mumbai MSL.

(ii) Heights of these Bed Plates for each port have also been computed with respect to Local Mean Sea Level (Mean of the Annual MSL value taken for a period of 19 years from 1976 to 1994 for each respective port).

Both heights have been compared for each port and the findings are as under:

1. Mean Sea Level is showing increasing trend from Ennore to Paradip (Refer Fig. 6).
2. Mean Sea Level is also showing increasing trend from Ennore to Tuticorin (Refer Fig. 6).
3. In general Arabian Sea is lower as compared to Bay of Bengal which is in conformity with the salinity of both seas.

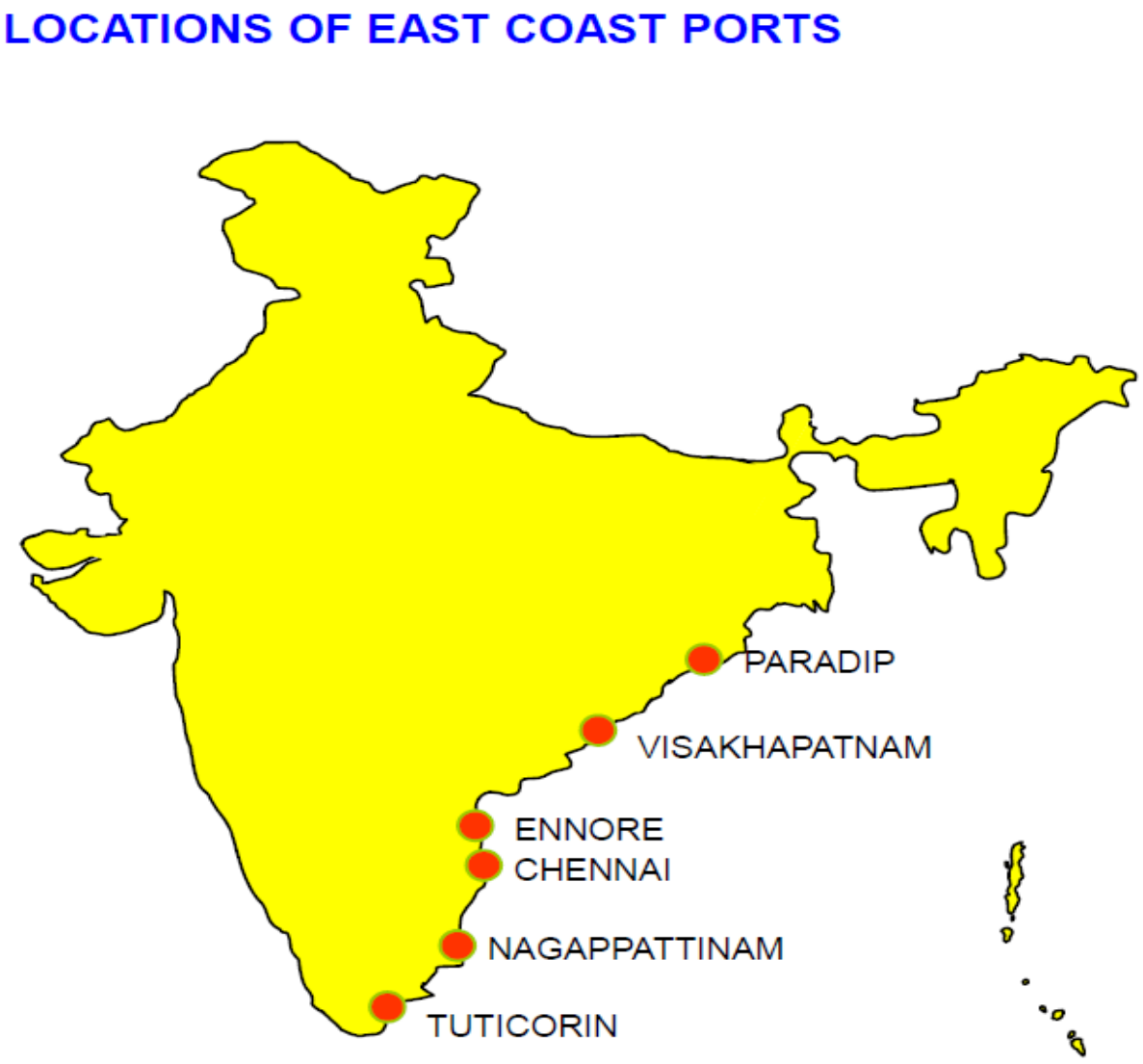


Fig. 5

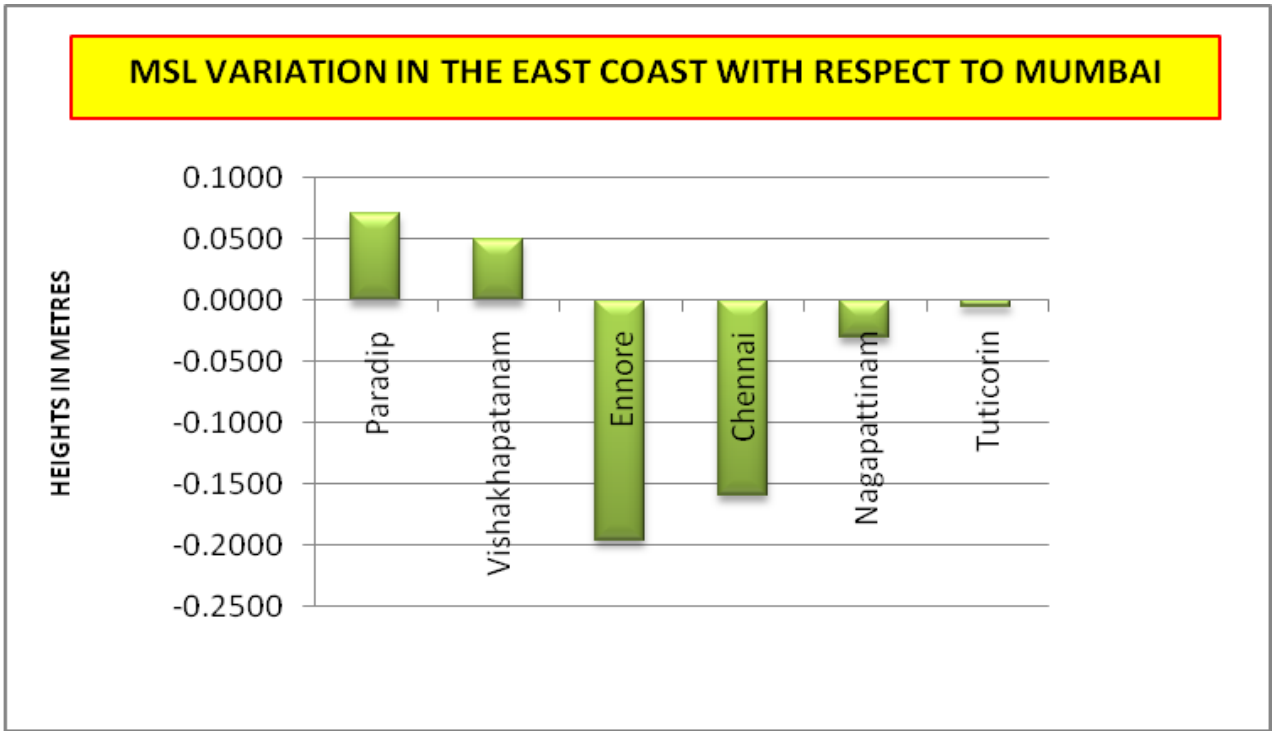


Fig. 6

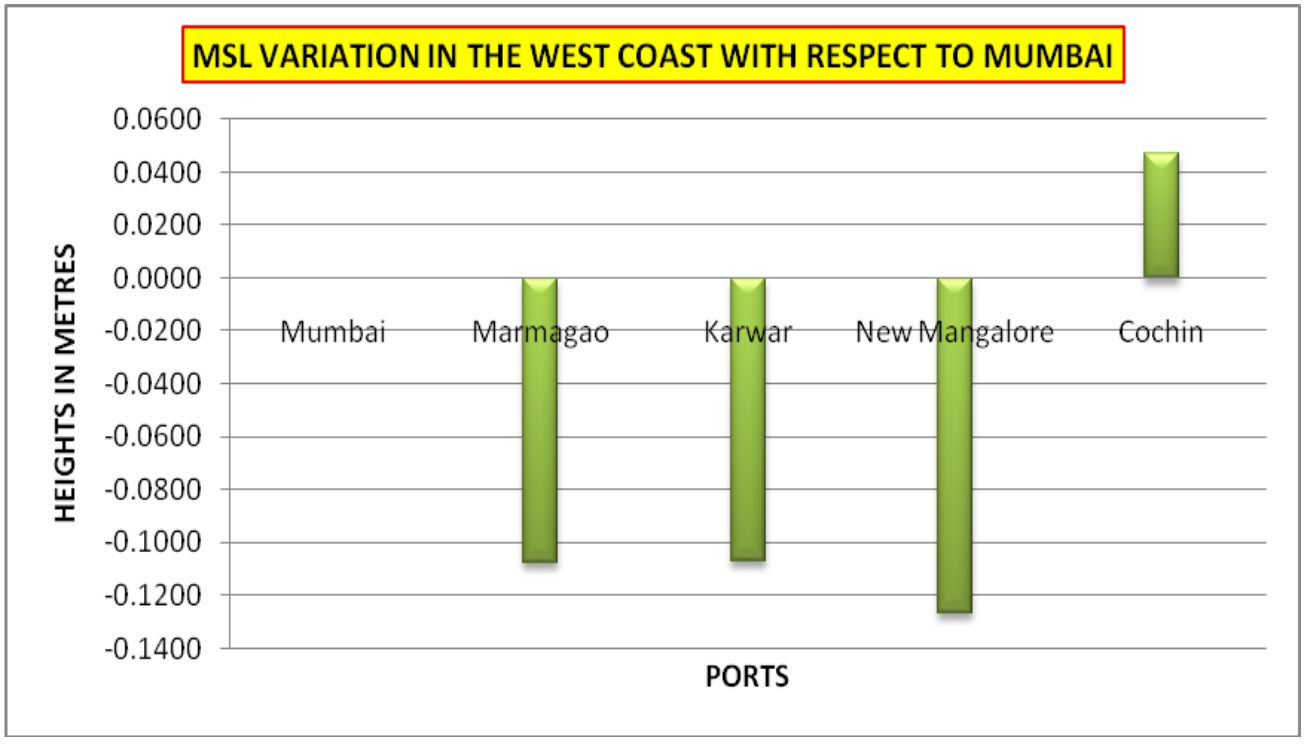


Fig. 7

(B) Above Fig. 7 shows the trend of MSL in the west coast, which reveals that MSL values are increasing from New Mangalore to Mumbai in the North direction and New Mangalore to Cochin in the South direction.

(C) Two sets of ports, one each in east and west coasts have been chosen at almost same latitude for comparison purposes and observations are as under:

(i) Mumbai (West Coast) – Visakhapatnam (East Coast): East coast is higher than the West Coast.

(ii) New Mangalore (West Coast) – Chennai (East Coast): East coast is lower than the West Coast.

(D) Another study has been carried out using differences between the old IMSL values and New IMSL (Mumbai) values. It shows rising trend from Chennai to Garden Reach in the east coast of India (as shown in the Fig. 8). Whereas, rising trend is seen in the west coast from Marmagao to Kandla in the north direction and Marmagao to Cochin in the south direction (Refer Fig. 9).

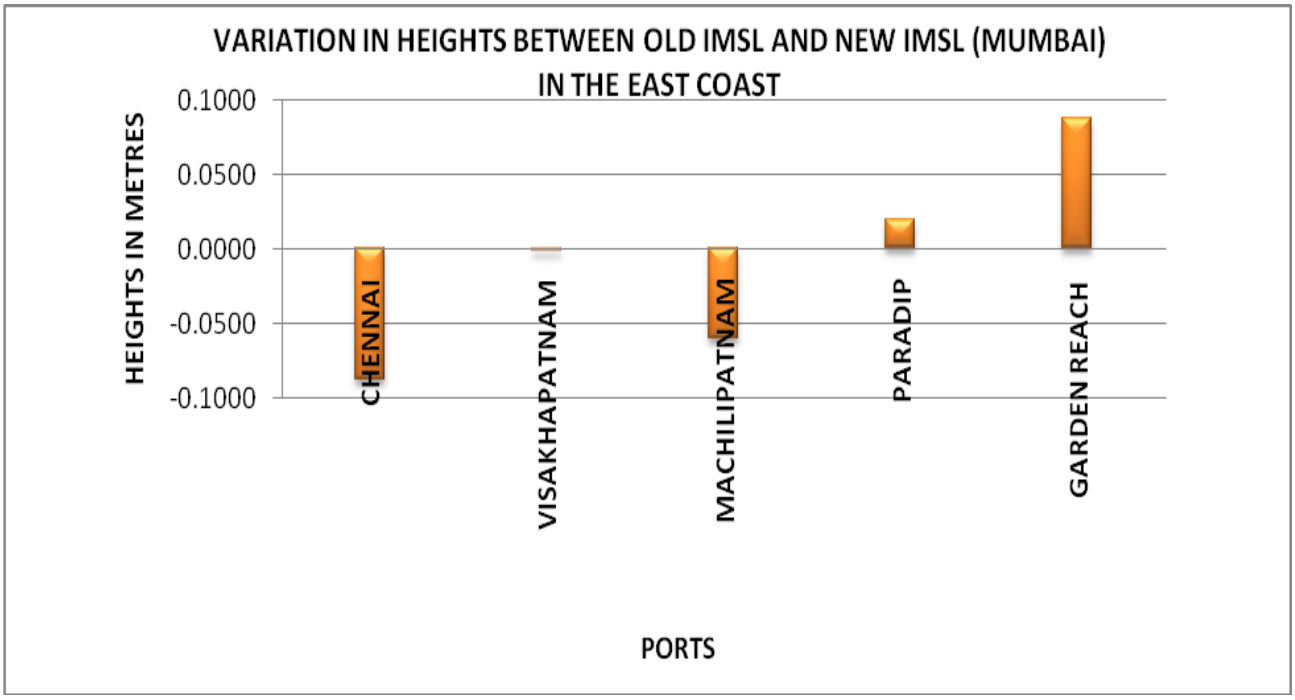


Fig. 8

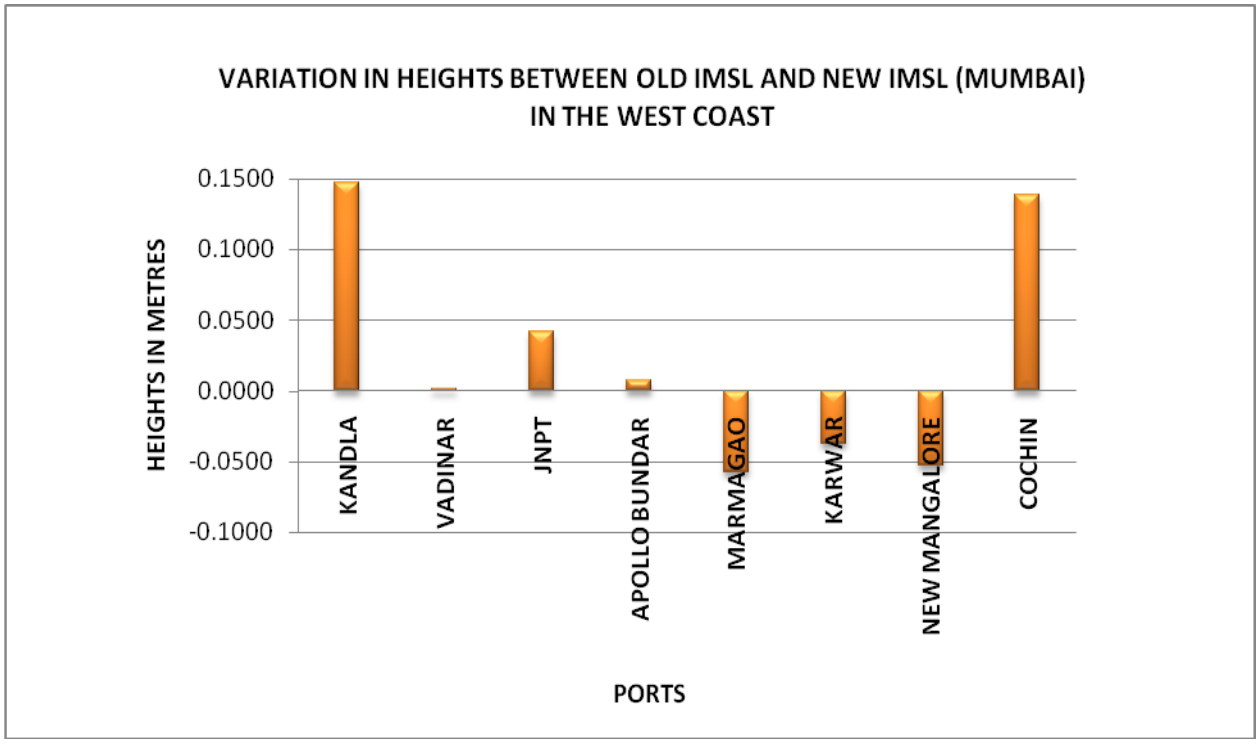


Fig. 9

(E) Levelling observations were carried out during 2007 for determinining the Bedplate value at the ports listed in the Table 3. Further, repeat levelling observations were made during 2011 at 3 ports for which old data is available. No definite pattern is seen in the data due to non-availability data at all the ports (refer Fig. 10).

Table 3: IMSL Heights of Bed Plates of CDTG at Two Different Epochs

Sl. No.	NAME OF PORT	NEW MSL HEIGHTS EPOCH 2007	NEW MSL HEIGHTS EPOCH 2011	DIFFERENCE BETWEEN TWO EPOCH
1	**JNPT**	8.9277		
2	**APOLLO BUNDAR**	8.1774		
3	**MARMAGAO**	6.0506		
4	**KARWAR**	4.8266		
5	**NEW MANGALORE**	5.4671		
6	**COCHIN**	2.8849		
7	**TUTICORIN**	2.8807	2.8849	-0.0042
8	**NAGAPATTINAM**		4.9584	-
9	**CHENNAI**	5.7440		
10	**VISAKHAPATNAM**	4.0273	4.0010	***+0.0263***
11	**GARDEN REACH**	8.7319		
12	**PARADIP**	6.3216	6.3242	-0.0026
13	**MACHILIPATNAM**	3.0992		
14	**VADINAR**	9.7910		
15	**KANDLA**	9.9023		

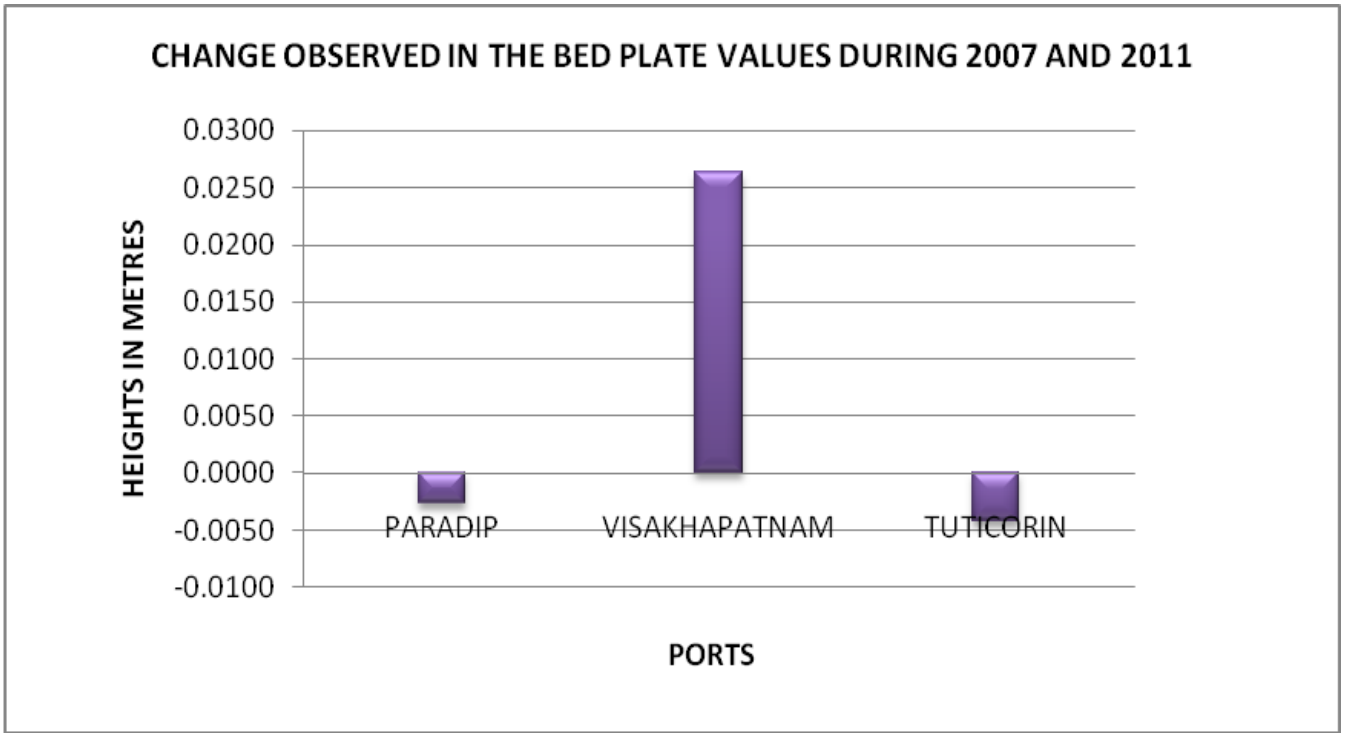


Fig. 10

GIS Mapping of Urban Deprivation and Construction of the Index of Substandard Living in Kolkata Metropolis

Dr. Anuradha Banerjee & Miss Mala Mukherjee
Centre for the Study of Regional Development
School of Social Sciences, Jawaharlal Nehru University
New Delhi-110067

Abstract

*GIS Mapping of the 'Urban Deprivation' is a recently emerging field in Urban Geography. Rapid urbanisation in Kolkata is leading to the degeneration of the quality of life or the '**Standard of Living'**. The main objective of the paper is construction of the '**Index of Sub standard Living**' which will highlight intra-city disparity in standard of living. A composite index named as 'the Index of Substandard Living' has been constructed with following7 variables (taken from Census 2001 data):*

i. *Percentage of Households having none of the specified assets (Television, Radio/Transistor, Bicycle, Two Wheelers, Four wheelers, Telephone)*
ii. *Percentage of Household living in Kuchcha or informal houses (Houses with kuchcha wall, kuchcha roof, kuchcha floor or mud floor)*
iii. *Percentage of household living without electricity*
iv. *Percentage of household having no access to banking service*
v. *Percentage of household living in slums*
vi. *Percentage of household living without access to safe cooking fuel or LPG*
vii. *Percentage of household using water sources away from the place of residence*

*Values of this index have been mapped within a ward map of Kolkata with the help of **ARC-GIS**. It has been found that, highest values or highly substandard living are found in the southern, north eastern and western peripheral parts of the city indicating the fact that urban deprivation is maximum at the peripheries.*

Introduction

The concept of urban deprivation is relatively newer in urban geography; it is considered as the one of the main outcome of urban decay and poverty, but it has multi faceted dimensions and incorporates socio-cultural variables other than income and calorie intake data. No doubt the concept of deprivation is closely interlinked with poverty; but it defines relative poverty rather than absolute one. The concept of urban deprivation is closely associated with poverty and substandard living.

Literature Review

According to D.T. Herbert, 'Deprivation' implies a standard of living or a quality of life below that of the majority in a particular society, to the extent that it involves hardship and inadequate access to resources. Comparisons are made less to an average than to a threshold and all writers upon the subject have emphasised the relative nature of these comparisons and standards (Herbert, 1975). Therefore, standard of living is one of the crucial indicators of deprivation, but, standard of living changes with time and space. Old mansions built during the 19th century cannot be treated as good ones in the twenty first century; similarly, people living in the American ghettoes live in luxury compared to the slum dwellers of India, because the general standard of living is high the USA. The typical nature of deprivation is that it is concentrated to specific sections of the population and city cores depict the epitome of deprivation. Deprivation indices measures deprivation level in a particular geographical area and thus, it is an important tool for measuring the deprivation level.

Origin and development of the deprivation index show an interesting trend. Deprivation indices measure the proportion of households in a defined small geographical unit with a combination of circumstances indicating low standard of living or a high need for services or both (Bartley, M. and Blane, D., 1994). This measure is based on geographic areas rather than individual circumstances. It should be kept in mind that all deprived people do not live in deprived locales (Townsend P., Phillimore, P. and Beattie, A., 1988). Deprivation indices may be gainfully used to identify areas of relative concentration of disadvantage, in absence of data at the present level or where the fact of geographic concentration is pertinent, but deprived people also live elsewhere and can be excluded in large numbers of interventions are planned purely on the basis of a local census data (Sloggett, A. and Joshi, H. 1994).

Construction of deprivation indices for measuring material deprivation has gained popularity since the late 1980s. The ***Townsend Material Deprivation Score*** has been developed in 1988. Here deprivation

score is based on just four variables originally taken from the 1981 Census of the UK and it represents material deprivation. It combines variables like unemployment, lack of car ownership, home ownership and over crowding (Townsend, P., Phillimore, P. and Beattie, A., 1988). ***Carstairs and Morris Scottish Deprivation Score (SCOTDEP)*** has been constructed in 1989(Carstairs, V. and Morris, R. (1989a and 1989 b). It represents health deprivation in Scotland and includes variables like overcrowding (household density, per capita room availability), male unemployment, lack of car ownership and percentage of households living inSocial Class IV and V. The Jarman Underprivileged Area (Jarman, B 1983 & 1984) is another type of deprivation index which is initially developed for measuring practice workload. It combines eight variables like unemployment, overcrowding, lone parents, under 5s, elderly living alone, ethnicity, low social class and residential mobility. It is also a z-score index. MATDEP (Material Deprivation Index) and SOCDEP (Social Deprivation Index) are both indices of deprivation that are developed by Forrest, R. and Gordon, D. (1993). Indicators used in MATDEP are overcrowding, lack of access to basic amenities, cars and central heating system. SOCDEP includes variables like unemployment, youth unemployment, lone parents, elderly living alone, prolonged illness and dependency. The history of the origin and development of deprivation indices cannot be completed unless and until one can have glance on the DETR Index developed in the 1990s. The DETR Index better known as Indices of Deprivation has been developed by the Department of the Environment, Transport and Regions (DETR) of the UK. It includes variables socio-economic indicators and housing indicators into a single deprivation score for each ward of England. This index has been modified in 2000. Wards with severe concentration of deprivation is called 'Hot Spots of Deprivation', it also measures income and employment deprivation separately and ranks wards according to the score.

Therefore, since the 1980s, the concept of deprivation indices gained popularity in the western world because these indices represent several types of deprivation indicators into a single deprivation score and application of z-score technique has gained popularity because of its comprehensiveness. Unfortunately in India very few literatures are found on deprivation indices. As it has already been stated that deprivation or substandard living varies from one state to another, thus, variables for measuring deprivation indices for the Indian cities should be different from those of the western experiences. In this paper a deprivation index named as the Index of Sub Standard Living has been constructed on Kolkata with the help of ward level data provided by 2001 census.

Objectives

Main objectives of the paper are:

- To select appropriate variables for measuring deprivation level
- To identify hotspots of deprivation
- To show intra-city concentration of deprived locales within Kolkata and
- To compare the level of sub standard living or urban deprivation between the city core and the periphery

Methodologies

Following methodologies have been adopted for analysis:

- Extraction of data on urban growth, density, areal changes from the Census 2001 and 1991; joining operations of spatial and Census data; **Query Building** (x>n%, where x = indicator / attribute) to find out the localities with haphazard urban growth and high slum population; and finally
- **Thematic mapping** using GIS technique.
- **Composite Index**: With the help of Z-score method composite index has been constructed and with the help of the average Z-score values ward level deprivation mapping has been done. Formula used for this technique is

$$z = \frac{x - \mu}{\sigma}$$

Where μ is the mean of the population; σ is the standard deviation of the population.

The quantity *z* represents the distance between the raw score and the population mean in units of the standard deviation. *Z* is negative when the raw score is below the mean, positive when above. . In statistics, a **standard score** indicates by how many standard deviations an observation or datum is above or below the mean. It is a dimensionless quantity derived by subtracting the population mean from an individual raw score and then dividing the difference by the population standard deviation.

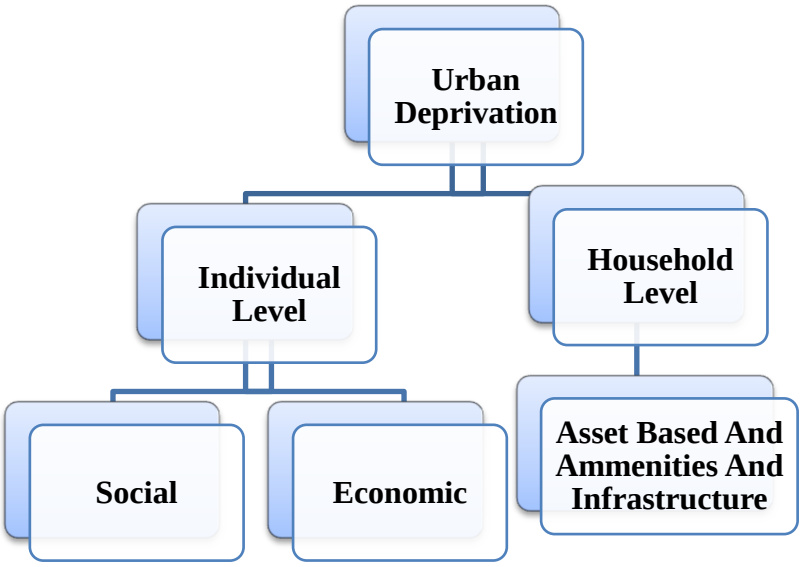
Data Sources

- Data Sources: The Census of India, 2001, Series -20, West Bengal, Final Population Totals. Distribution of Rural-Urban Population, Director of Census Operations, Kolkata, West Bengal (2001), Registrar General of India, Government of India

- ***Census 2001; H – Series (Table: H3a, H3b, H3c,H5, H9, H8, H11 and H13)*** Director of Census Operations, Kolkata, West Bengal (2001), Registrar General of India, Government of India

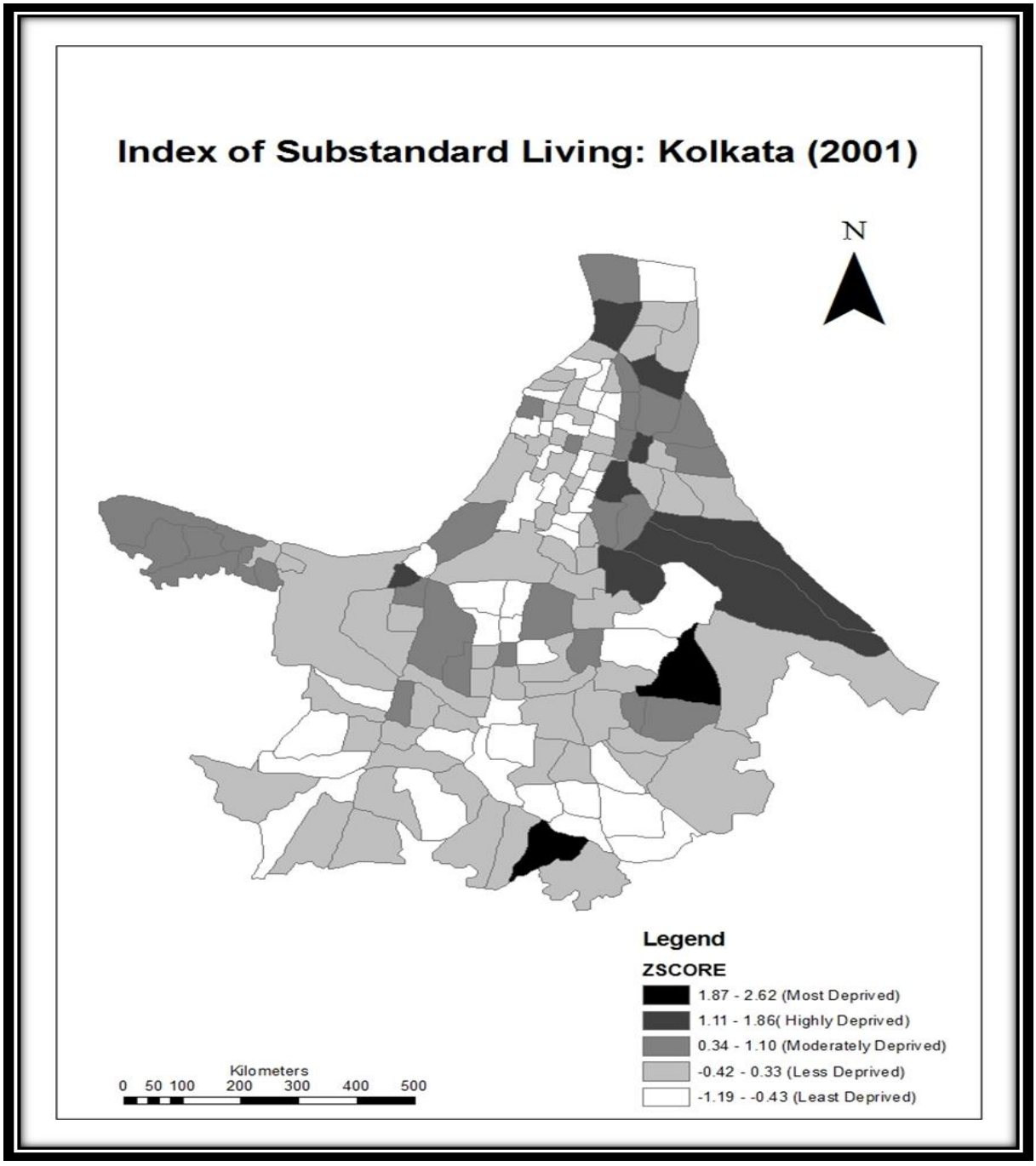
Selection of Variables for Deprivation Index

Two types of deprivation have been measured; the first one is Individual level deprivation from individual level data and the second one is household level deprivation from household level dat A household is an unit composed of the group of people living in the same dwelling space who eat meals together and have at least one common plot together or one income generating activity together (for example, herding, business or fishing) and acknowledge the authority of a man or woman who is the head of the household. Therefore, everyone living in a particular household faces some common forms of deprivation like lack of access to certain assets, infrastructure and basic services. The Census 2001 of India provides detail ward level information on households having lack of access to certain assets, basic services, amenities and infrastructure essential for any family's overall development. Following indicators have been chosen for measuring household level deprivation and its correlation with the existence of slums in that particular ward.



Household Level Urban Deprivation across Kolkata

Asset based indicators	**Housing infrastructure base indicators**	**Amenities and basic service based indicators**
Households **not having** access to • Television set, • Radio or Transistor • Telephone • Bicycle • Two wheelers (scooter, motor cycle, moped) • Four wheelers (car, jeep, van) • None of the specified assets.	Households **not having** access to formal housing- • Household having lack of access to formal housing • Inadequate room	Households having **lack of access to** • Banking service • Electricity • Safe cooking fuel or LPG • Potable drinking water • Nearby source of drinking water



Source: Z-score Composite Index computed from Census 2001 data

Fig. 1: Index of Sub Standard Living

Major Findings:

According to map number 1 highest score is recorded in ward number 108 (2.62) and 109 (2.40). Therefore, highly deprived wards are 57, 58, 29, 6, 13 and 36. These wards cover Tangra-Tiljala-Topsia region (57, 58, 108, and 109) and are situated in the eastern margin of Kolkata along the Eastern Metropolitan Bypass. Other wards constitute parts of Narkeldanga-Beliaghata region (ward 29), just adjacent to Tangra-Tiljala-Topsia region, Ultadanga-Maniktola area (ward 13) and part of Cossipore region (ward-6) in the extreme north. Ward number 79 in the south-west also records high deprivation, it covers part of Khidirpore-Ekbalpore area. Though Garden Reach-Metiabruz region has recorded very high percentage of household living in slums and a significant number of households not having access to various assets or amenities but wards found in this area can be termed as moderately deprived locales. Moderately deprived wards are also found in north Kolkata as well as in central Kolkata, but in the south they are very few in number except those are located in the south-eastern fringe of Kolkata.

Deprivation Index	Score	Wards	Location
Most deprived	**1.87-2.62**	**110, 109**	**Eastern periphery, parts of Tiljala-Topsia-Kasba area**
Highly deprived	**1.11-1.86**	**58,57, 79,29, 13, 6, 36**	**North Tangra, Narkeldanga-Beliaghata, Ultadanga-Maniktola, Cossipore**
Moderately deprived	**0.34-1.10**	**1, 3,7,12, 14, 15, 21, 28, 31, 32, 39, 56, 59, 65, 80, 82,134, 135, 136, 137, 138, 139, 140, 141**	**Parts of Ultadanga, Cossipore, Tangra, Narkeldanga in north Kolkata Garden Reach Metiabruz, Ekbalpore area in south**
Less deprived	**-0.42 to 0.33**	**Wards are scattered in north, central and extreme southern part of Kolkata**	
Least deprived	**-1.93 to -.041**	**Central and south Kolkata**	

Conclusion

The Index of Sub Standard living considers ward wise deprivation level and helps in identifying the hot spots of deprivation. Though it is a generalised calculation and deprived population may live outside these locales, but for urban planning, mapping of the deprived locales have immense importance. Kolkata shows concentration of highly deprived wards in its northeast and western peripheries, indicating a reverse trend from that of the western findings. Wards located in the city core score lower in the deprivation index than the wards located in the peripheries. Tangra-Tiljala-Narkeldanga area in the northeast consist largest deprived zone. Some wards in the extreme north (Cossipore, Maniktola and Ultadanga) also come under the highly deprived zone. Garden Reach-Metiabruz region in the west, near the Kolkata port forms the second largest deprived zone. Thus, Kolkata exhibits a unique concentration of deprived zones in its peripheries, not in the core city.

References

1. Bartley, M. and Blane, D. (1994) 'Appropriateness of deprivation indices must be ensured' British Medical Journal 309: 1479

2. Carstairs, V. and Morris, R. (1989a) 'Deprivation: explaining differences in mortality between Scotland and England and Wales'. British Medical Journal 299: 886-9.

3. Carstairs, V. and Morris, R. (1989b) 'Deprivation and mortality: an alternative to social class?' Community Medicine 11: 210-9

4. Herbert. D.T., 1975: Urban Deprivation: Definition, Measurements and Spatial Qualities, Geographical Journal, volume-141, number-3, pp-362-375

5. Forrest, R. and Gordon, D. (1993) People and Places: a 1991 Census atlas of England. SAUS.University of Bristol

6. Jarman, B (1983) 'Identification of underprivileged areas'. British Medical Journal 286: 1705-9.

7. Jarman, B (1984) 'Underprivileged areas: validation and distribution of scores'. British Medical Journal 289: 1587-92.

8. Sloggett, A. and Joshi, H. (1994) 'Higher mortality in deprived areas: community or personal Disadvantage?' British Medical Journal 309: 1470-4.

9. Townsend, P., Phillimore, P. and Beattie, A. (1988) Health and Deprivation: Inequality and the North Routledge, London.

Levels of Regional Development in Bankura District: A Cartographic Appraisal

Md Azfar Mondal & Dr. Jitendra Shukla
Department of Geography,
Ranchi University, University, Ranchi

Abstract

Disparities in the levels of regional development and rates of economic growth are common feature of the economics of the many countries .The persistence of stagnation or backwardness in particular regions leads government to undertake programs for their growth. The growth programs have been undertaken everywhere in the country. The geographers are interested in precise delineation of regional disparities in the growth because besides being the subject of development or welfare programs, they are among the most important manifestations of areal differentiation resulting from human activity. The district Bankura is a part of Burdwan Division. It is situated between to 22° 38́ N - 23° 28́ N latitude and between 86° 36́ E – 87° 46́ E longitude with a total area of 6882 sq. km. The District is characterized by relief ambiguity. Resource is meager and unequal. In due course of implementation of developmental programs, some parts after getting locational benefit develop more than the other parts. The indicators of development are not equal in all the blocks of the district. Regional disparities in the level of development have been shown in the present paper. Various indicators have been taken to represent the levels of development of the District Bankura through the cartographic approach.

Introduction

The concept of development defined in the sense of an objective or a desired state of affairs was conceived in terms of growth targets with little regard to the beneficiaries of growth or composition of output. In 1990 AD the human development report of the World Bank visualized people as the wealth of the nation. The basic objectives of development are to create an enabling environment for people to enjoy long, healthy & creative lives. There is enough disparity between the western & eastern part. The western part is more backward from almost of all sides of developmental indicators. The per capita income, health & literacy level is lower at the western part. The problem& probability should be examined carefully by which actual levels of development should be possible .The district Bankura is a part of Burdwan Division. It is situated between 22° 38' N to 23° 28' north latitude & 86° 36' E to 87° 46' east longitude. It has been area of 6882 sq. km (2657 sq. miles). On the north and northeast, the district is bounded by Burdwan district, from which it is separated mostly by the River Damoder. On the southeast it is bounded by Hoogly district, on the west Purulia district and from south by west Medinipur district. The district is constituted by 22 blocks & 21 police stations, 3 municipalities and 190 gram panchayat & 1587 villages.

Objectives

The main objectives of the study is that

1. To show the levels of Regional development of the district so far .
2. To findout the new parameters or indicators of development .
3. To findout the several economic & social issues emerges owing to imbalances in development.
4. To suggest the promosional measures for the development of the district.

Data collection & methodology

The study is based on from primary & secondary sources, census report 2001, 2011 and human development report (2007). The district statistical handbook 2003, 2004, 2008, has provided most of the data required for the study. The primary data has been collected through observation, collection of taking photo & oral interview of the different people`s of the district are most important. The parameters for calculating the human development index of Bankura district are as follows –

1. *Longevity i.e. life expectancy at birth (nutrition and health).*
2. *Literacy which is the first step of learning & and knowledge building.*
3. *Resource required for a decent living (per capita income)*
4. *To show the block level disparity between teacher student ratio and doctor patient ratio are analyzed by simple regression method and plotting by residual mapping etc.*
5. *Certain other cartographical representations such* as line graph, bar graph, have been used to analyze the present situation of the levels of development of the district.
6. Diagrammatic representation etc.

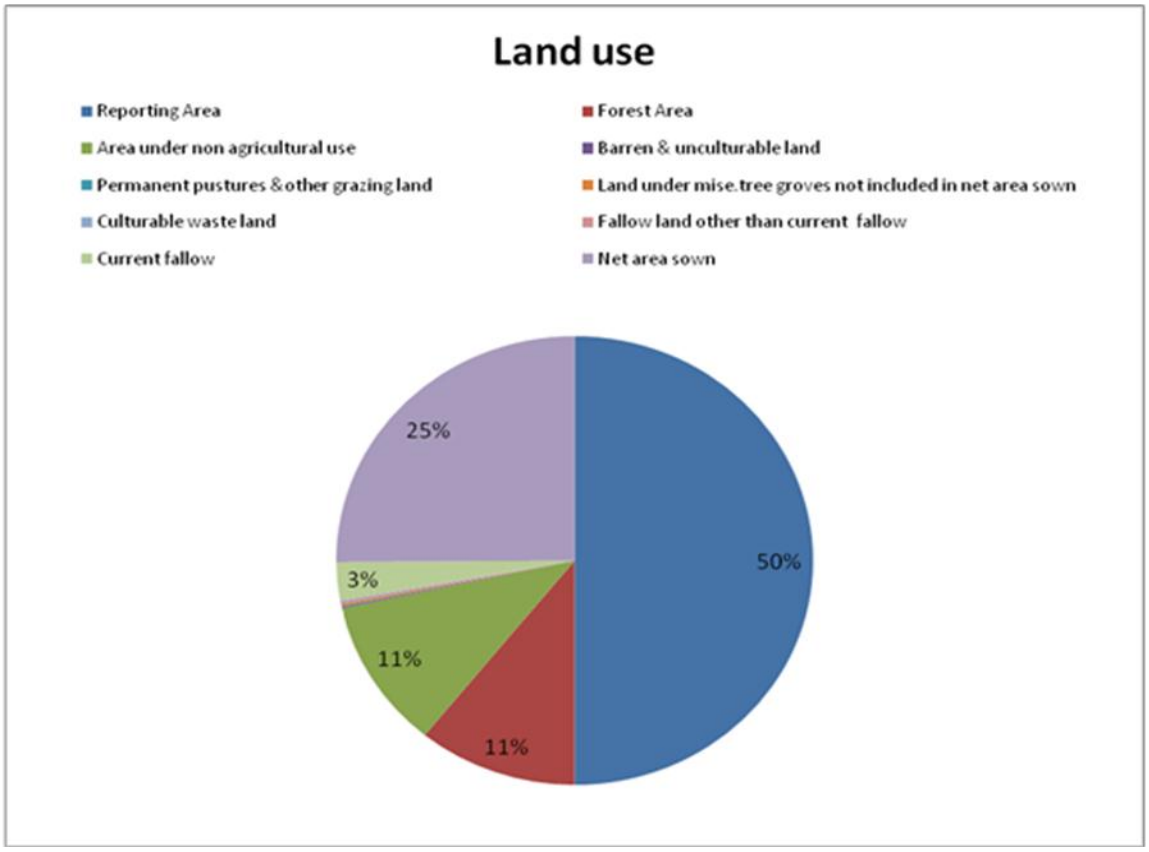
Discussion

The levels of development should be examined by showing the following Indicators of developmental parameters through chart & statistical diagram.

Classification of land utilization statistics in the district of Bankura Area in thousand hectares

Year	Reporting Area	Forest Area	Area under non-agricultural use	Barren & uncultiv-able land	Permanent postures & other grazing land	Land under misc. tree groves not included in net area sown	Cultiva-ble waste land	Fallow land other than current fallow	Current fallow	Net area sown
2007-08	688.00	148.93	147.97	1.72	0.70	2.66	2.12	1.03	37.48	345.39

Source: Directorate of agriculture (evaluation), Govt. of West Bengal



Human development indices for Bankura vis-a- vis other selected districts of West Bengal

Sl.	District	Health index	Income index	Education index	H.D.I. Value	H.D.I Rank
1.	Kolkata	0.82	0.73	0.80	0.78	1
2.	Howra	0.77	0.53	0.75	0.68	2
3.	North 24 Pargana	0.72	0.49	0.76	0.66	3
4.	Bankura	0.67	0.26	0.62	0.52	11
5.	Birbhum	0.53	0.27	0.61	0.49	14
6.	Purulia	0.61	0.18	0.55	0.45	16
7.	Malda	0.49	0.36	0.48	0.44	17

Source: West Bengal Human Development Report 2004

Occupational Diversification by District in rural west Bengal percent of total (main + marginal) workers in rural areas (percent)

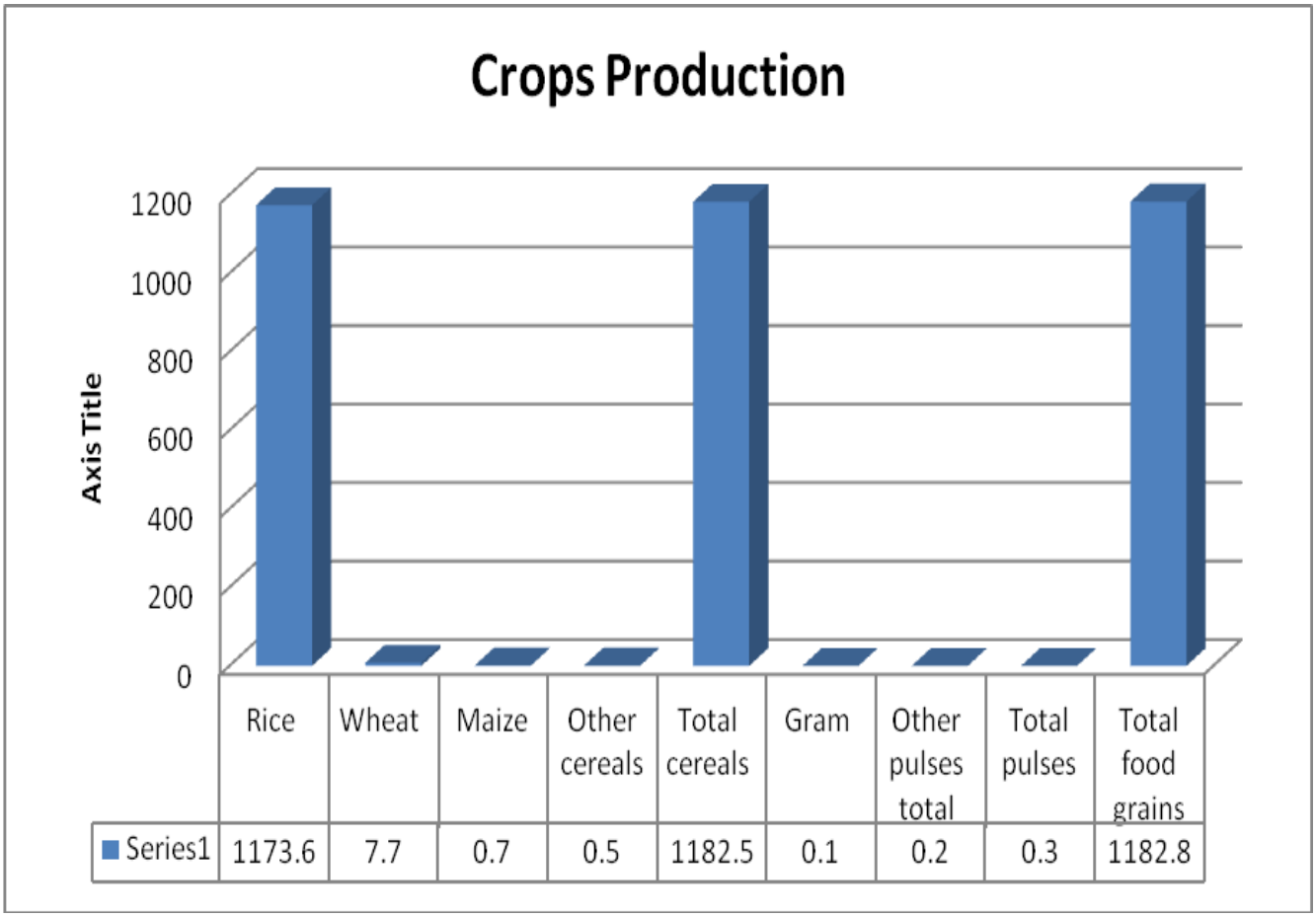
Sl.	District	Farmers %	Agricultural labour %	Non agricultural occupations %
1.	Uttar Dinajpur	38.0	43.7	18.3
2.	Dakshin Dinajpur	34.3	40.0	25.7
3.	Coochbehar	40.4	31.8	27.8
4.	Purulia	33.3	38.4	28.3
5.	Bankura	32.6	37.1	30.3
6.	burdwan	20.4	41.9	37.7
7.	Medinipur	30.4	33.9	35.7
8.	West Bengal	25.0	33.0	41.6

Source: West Bengal Human Development Report 2004, Page – 96

Production of principal crops in the district of Bankura

Rice	Wheat	Maize	Other cereals	Total cereals	Gram	Other pulses total	Total pulses	Total food grains
1173.6	7.7	0.7	0.5	1182.5	0.1	0.2	0.3	1182.8

Source: Bureau of Applied Economics & statistics Govt. of W.B (Bankura)



On the basis of the following discussion by chart, tables and maps the following inferences may be followed to uplift the district at standard levels.

1. Requirement of more government grant for health, income growth, & educational facilities. Non government organization may be helpful for these purposes
2. Agricultural growth is necessary by proper irrigation, use of manures, pesticides, high yielding variety seeds etc.
3. Requirement of Industrial growth at the huge barren lands of the western part of the district.
4. Teacher student ratio is not satisfactory in some blocks. More concentration is so necessary for this minimization.
5. About 13 blocks have a negative ratio between the doctors & peoples. Government should take immediate steps for these problems.

Conclusion

The district H.D.I. (Human Development Index) Rank is 11 amongst 19 district of West Bengal. Most of the peoples of S.C & S.T groups of the western part do not get enough food, clothes & other basic needs of life. They are seasonal migrant to the eastern most part of Bankura, Burdwan & Hooghly district at boron season. Most of the people live below the poverty line. Land ownership is acquired by some farmers and others are landless labours. Job facility is not enough at western part. If the entire above requirement is supplied by the government and other non-government organization the District should be a developed one at the coming years.

Mapping of Housing Deprivation in Indian Megacities: A Comparison between Delhi and Kolkata Metropolises

Pravin Kumar Shukla and Mala Mukherjee
SRF, JNU, CSRD, School of Social Sciences, New Delhi-110067
E-mail: pravincsrd@gmail.com

Abstract

Recent trend of rapid urban growth and globalisation in many developing countries may have increased the economic growth, but housing crisis severely threatens to jeopardise the urban growth process. Just like other South Asian cities, Delhi and Kolkata are often portrayed as overcrowded, haphazardly grown and congested with seemingly insurmountable problems of inadequate shelter, lack of clean water, overwhelmed infrastructure, filthy air and poverty. This paper aims to map intra-city concentration of slums within Delhi and Kolkata. Indices of Housing Deprivation have been constructed for these two cities by using ward level secondary data on housing and amenities obtained from Census 2001. This composite index is being computed by using following seven variables Percentage of Households having none of the specified assets (Television, Radio/Transistor, Bicycle, Two Wheelers, Four wheelers, Telephone)

i. *Percentage of Household living in Kuchcha or informal houses (Houses with kuchcha wall, kuchcha roof, kuchcha floor or mud floor)*
ii. *Percentage of household living without electricity*
iii. *Percentage of household having no access to banking service*
iv. *Percentage of household living in slums*
v. *Percentage of household living without access to safe cooking fuel or LPG*

Percentage of household using water sources away from the place of residence. The main finding is showing that in both the cities, wards recording highest index values are located in the peripheral parts not in the city core.

Introduction

Shelter or housing is one of the most important necessities of human beings that not only indicates a person's socio-economic status but also ensures safety and privacy. Thus housing deprivation or inadequate access to formal housing is synonymous to poverty and deprivation. Recent trend of rapid economic growth and globalisation in many developing countries may have increased per capita income, calorie intake and freed many million poor from consumption poverty or food crisis but have set new sets of challenges like housing crisis, energy shortage, expensive health care and education facilities. The urban poor and middle class in many developing countries are already showing increasing signs of discontent due to increase in electric bill, house rent, and medical bills. Subsidised housing is already a leftover in many Indian cities and housing crisis severely threatens to jeopardise the urban growth process. Unplanned urban growth and inappropriate use of vertical space have further intensified the crisis. This study focuses on the persistency of housing deprivation in Delhi and Kolkata. Calcutta or Kolkata, India's second most populated city with over 18 million inhabitants, just like other South Asian cities, is often portrayed as overcrowded, haphazardly grown and congested with seemingly insurmountable problems of inadequate shelter, lack of clean water, overwhelmed infrastructure, filthy air, unemployment and underemployment. Condition combined with inadequate resources, contribute to a feeling of despair and hopelessness for those confronting urban issues, yet within the same city one can find hope and opportunity along with misery and sorrow. Similarly, the influx of migrants after partition of the county in 1947 resulted in almost doubling the population of Delhi just in two months period. The total population of Delhi touched the mark of 14.4 lakh in 1951 from 6.96 lakh in 1941. Currently, Delhi has a large expatriate population, according to the new Indian census conducted in 2011, the city harbours 16,753, 235 people and its average population density is 11,297 persons per square kms. Thus, housing deprivation or shelter crisis is one of the most crucial issues in Delhi. intra-city disparity in housing and basic amenities within these two cities depict an interesting core-periphery disparity and difference between the former capital of India and its present capital; the former one is a colonial port city and the latter one is a historical city developed many thousand years ago.

Objectives

The paper has the following objectives:

- To identify intra-city concentration of slum locales within Delhi and Kolkata
- To analyse the various dimensions of housing deprivations
- To identify deprived wards within Delhi and Kolkata
- To draw a comparison between Delhi and Kolkata in terms of housing deprivation

Methodology

Following methodologies have been adopted for analysis:

- Extraction of data on urban growth, density, areal changes from the Census 2001; joining operations of spatial and Census data; **Query Building** (x>n%, where x = indicator / attribute) to find out the localities with haphazard urban growth and high slum population; and finally
- **Thematic mapping** using GIS technique.
- **Composite Index**: With the help of Z-score method composite index has been constructed and with the help of the average Z-score values ward level deprivation mapping has been done.

Formula used for this technique is

$$z = \frac{x - \mu}{\sigma}$$

Where μ is the mean of the population; σ is the standard deviation of the population.

The quantity *z* represents the distance between the raw score and the population mean in units of the standard deviation. *Z* is negative when the raw score is below the mean, positive when above. . In statistics, a **standard score** indicates by how many standard deviations an observation or datum is above or below the mean. It is a dimensionless quantity derived by subtracting the population mean from an individual raw score and then dividing the difference by the populationstandard deviation.

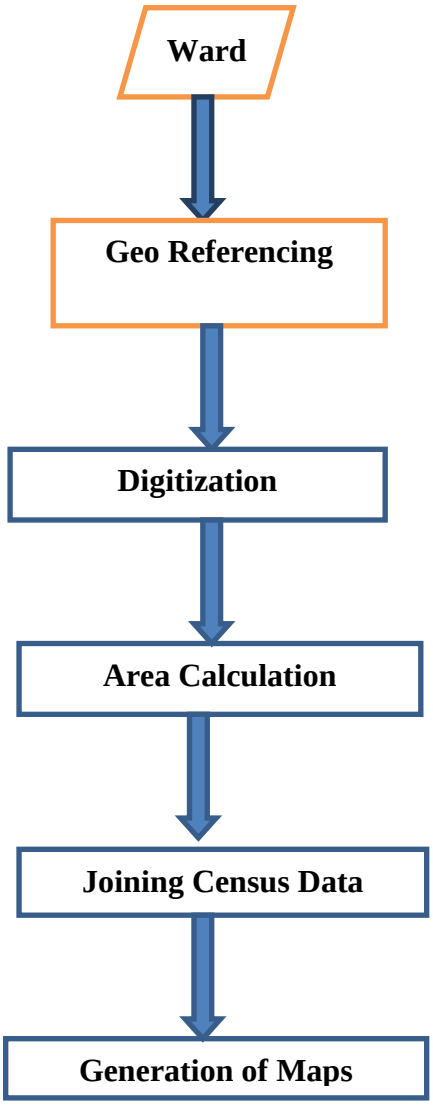


Diagram 1. Detailed Methodology for Merging Census Data with a Satellite Derived Map

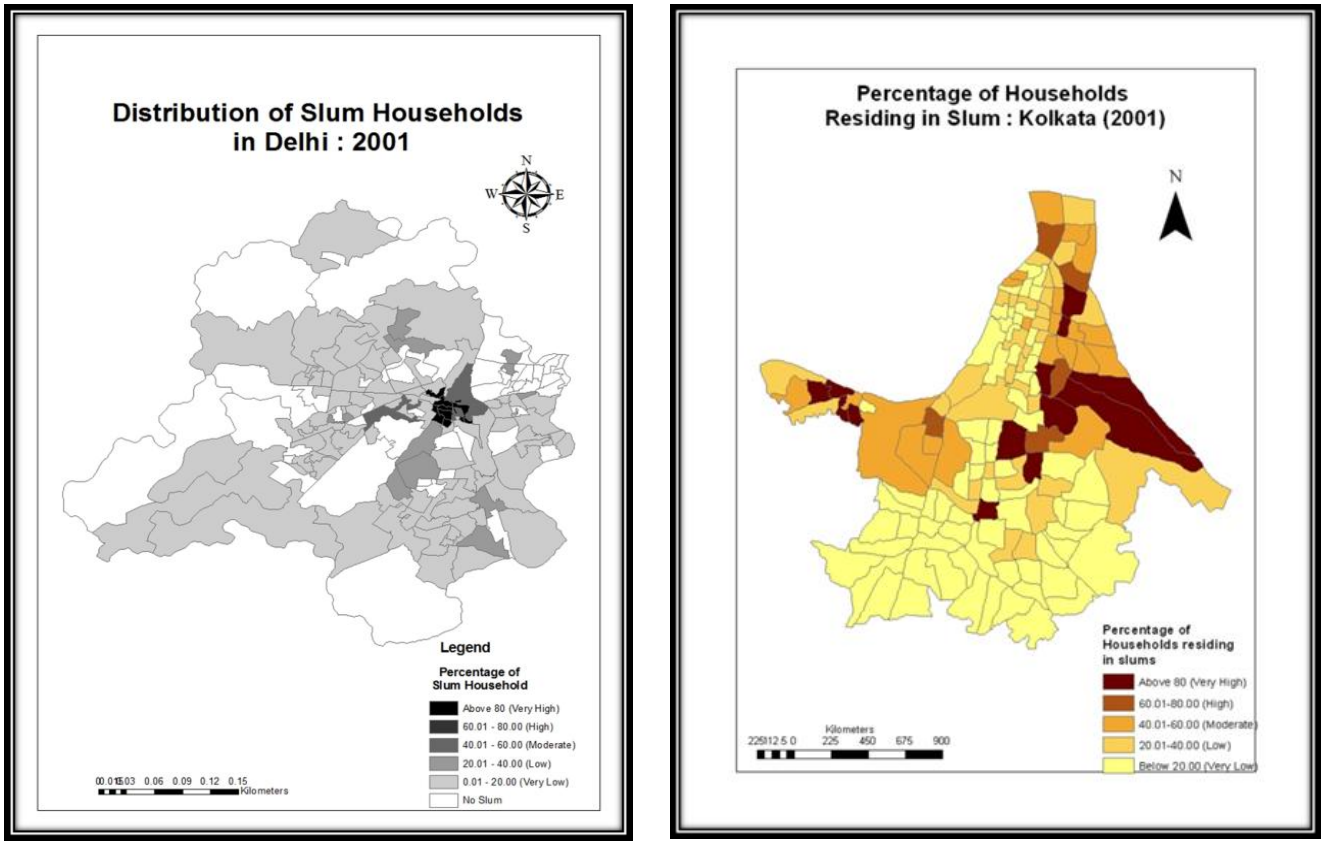


Fig. 1A and B: Location of Slum Wards in Delhi and Kolkata

Distribution of slum households in Delhi exhibits a unique pattern and characteristics, wards lying in the core city (Central and North Delhi) record highest percentage of households residing in slums. Concentration of slum households decreases from the city core to the periphery. Moderate concentration of slum household is found along the River of Yamuna and Trans Yamuna region in the East Delhi. In the periphery, South Delhi, R.K. Puram area especially exhibits maximum concentration of slum households in its different wards. Another uniqueness is that significant number of slum households are found everywhere from the city core to the periphery and they are found in every districts, not concentrated in a particular region.

Main Slum Locales in Delhi:

Zones	Wards	District	Location	Characteristics
Zone 1	Sadar Bazar (122), Quassabpura (112), Paharganj (108), DryaGanj (109), Manakpura (132), Qadam Sharif (131), Bazar Sitaram	Central Delhi and North Delhi	Core city	Highest percentage of households live in slums (more than 80 per cent)
Zone 2	Wards adjacent to zone 1 Ballimaran (111) etc	Central Delhi and North Delhi	Core city	60 to 80 per cent of the total households live in slums

Zone 3	South Patel Nagar (126), Ramesh Nagar (124), Jama Masjid (110), Civil Lines (114), some wards of NDMC etc	North Delhi, Central Delhi and parts of East Delhi	Core city	More than 40 but less than 60 per cent households live in slums
Zone 4	Jahangirpur (103), Shahdara (81)R.K Puram (15), Mustafabad(98), Yamuna Vihar (95), Srinivaspuri (8),	North West Delhi, North East Delhi, parts of South Delhi	Periphery (Trans Yamuna and Yamuna bank)	More than 20 to less than 40 per cent living in slums
Zone 5	Some wards of South West Delhi, South Delhi, South Delhi, East Delhi	South West Delhi, South Delhi, South Delhi, East Delhi	Peripheral part	Less than 20 per cent household live in slums

Kolkata exhibits a unique pattern of slum distribution; in this city, main slum pockets are located in the peripheral parts. The north-eastern periphery of Kolkata (Narkeldanga-Tangra-Tiljala-Tapsia region) harbours highest percentage of slum dwellers, followed by the Metiabruz-Garden Reach area in the west and Cossipore-Chitpore-Belgachia region in the extreme north. Slum locales are dispersedly found in the central and southern part of the city; but these parts do not have prominent slum wards.

Main Slum Locales in Kolkata:

Main Slum Locales	Location
Cossipore-Chitpur-Belgachia	North Kolkata (ward number 6, 3, 1, 12 and 5)
Tangra-Tiljala-Topsia	North eastern fringe of Kolkata, near the Eastern Metropolitan Bypass (ward number 58, 57, 56 etc.)
Metiabruz-Graden Reach	West Kolkata, near the port
Central and south	Scattered slum settlements in few wards

Various Dimensions of Housing Deprivations and Distribution of Deprived Locales:

Distribution of slum locales alone cannot explain the entire picture of housing deprivation in a particular city. Wards with very high percentage of slum population can be considered as the locales experiencing extreme point of housing deprivation. Other dimensions of housing deprivation cannot be assessed from this analysis; thus, other dimensions like basic amenities, services, quality of housing and other essential infrastructure should be computed. Following dimensions of housing deprivation have been calculated with various indicators listed below:

Asset based Dimensions	Housing infrastructure based Dimension	Amenities and basic service based Dimensions
Households not having access to • Television set, • Radio or Transistor • Telephone • Bicycle • Two wheelers (scooter, motor cycle, moped) • Four wheelers (car, jeep, van) • None of the specified assets.	Households not having access to formal housing- • Households using non-permanent materials as roof • Using grass, bamboo, wood, plastic, polythene, titles, slate, asbestos sheet etc as roof material • Households having mud floor, • Non permanent wall material (Grass, thatch bamboo, wood, plastic, polythene, mud/un-burnt brick, wood, asbestos sheet etc) • Adequate rooms	Households having lack of access to • Banking service • Electricity • Safe cooking fuel or LPG • Potable drinking water • Nearby source of drinking water • Adequate room • Separate kitchen • Closed drainage

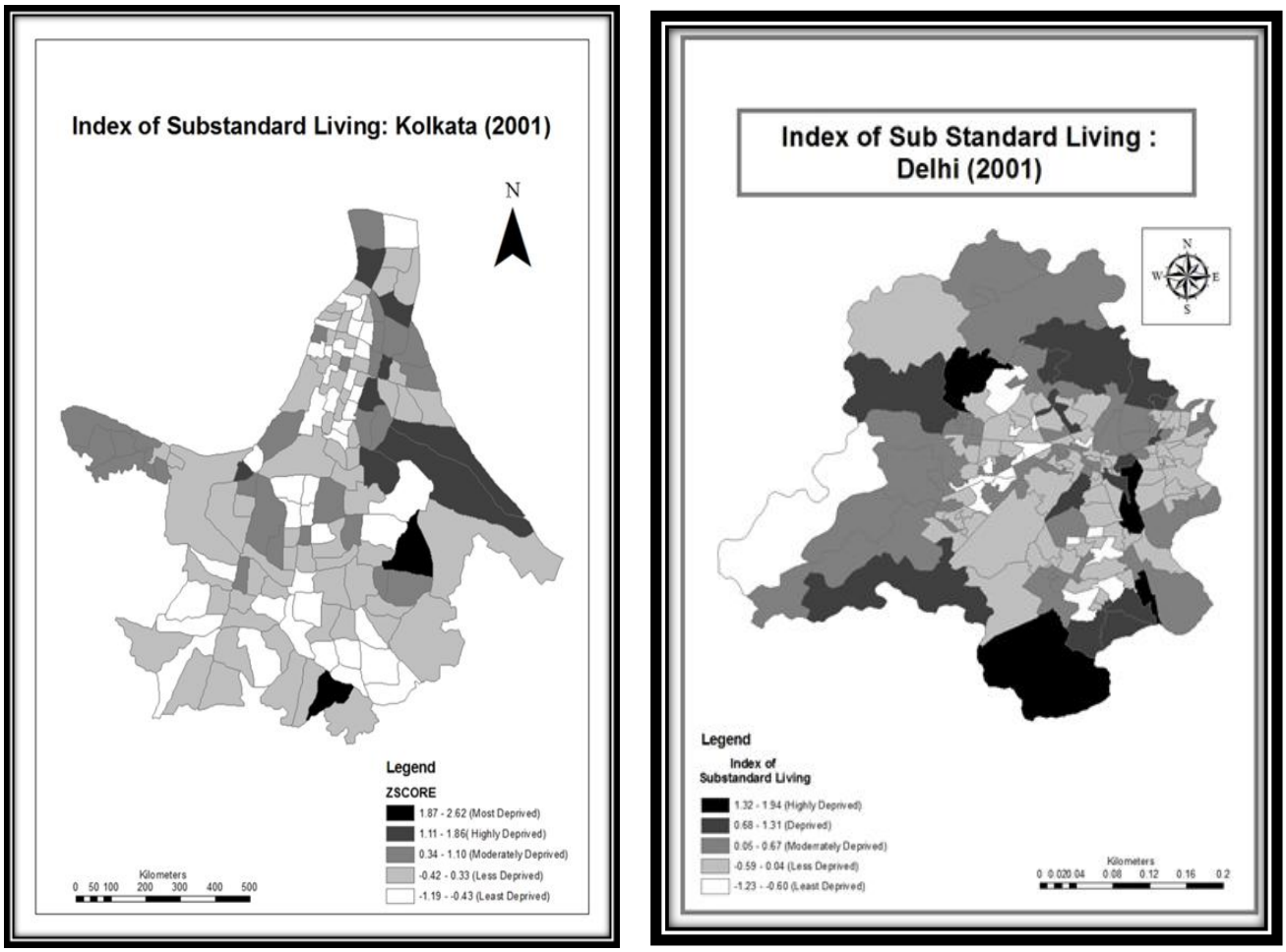


Fig. 2 A and **B:** Composite Index indicating standard of living in Kolkata and Delhi

Substandard Living in Delhi: The index of substandard living exhibits very high deprivation in terms of housing and amenities in Nizamuddin (ward 2), Sangam Vihar (64), Chattarpur (58), Harkesh Nagar (66) and Pahladpur Bangar (36). These areas are found in the peripheral part of the city, Chattarpur in the extreme south and others are located in the North-West and East Delhi (Trans-Yamuna region). Other deprived areas are Minto road, Kanjhawala, Karawal Nagar and Jama Masjid. Minto Road and Jama Masjid areas are located in the core city. Apart from these two wards, other wards do not record very high percentage of slum population. It should be kept in mind that the Census only provides data on registered slums and does not provide data on squatter settlements or other low income colonies. Thus, wards with very high percentage of population living in registered or authorized slums do not score high in the 'Sub Standard Living Index' indicating the fact that housing deprivation exists beyond slums and the peripheral wards can be treated as the 'epitome of housing deprivation' in Delhi.

Zones	Areas
Highly deprived	NIZAMUDDIN(2),PAHLADPUR, BANGAR(36), SANGAM VIHAR(64), CHATTARPUR (58), HARKESH NAGAR (66)
Deprived	MINTOROAD,KANJHAWALA,KARAWAL NAGAR,JAMA MASJID
Moderately Deprived	BIJWASAN,TUGLAKA BAD,SEEMA PURI,JAFFRABAD,MUSTAFABAD,JAHANGIR PUR,BURARI,ADARSH NAGAR,RANA PRATAP BAGH,ANAND PARBAT
Less Deprived	Rest of Delhi
Least Deprived	SAKET,GREATERKAILASH,DEFENCE COLONY, ROHINI, WARD 208 and 206 of NDMC area

Deprived Locales in Delhi

Deprivation Index	Score	Wards	location
Most deprived	1.87-2.62	110, 109	Eastern periphery, parts of Tiljala-Topsia-Kasba area
Highly deprived	1.11-1.86	58,57, 79,29, 13, 6, 36	North Tangra, Narkeldanga-Beliaghata, Ultadanga-Maniktola, Cossipore
Moderately deprived	0.34-1.10	1, 3,7,12, 14, 15, 21, 28, 31, 32, 39, 56, 59, 65, 80, 82,134, 135, 136, 137, 138, 139, 140, 141	Parts of Ultadanga, Cossipore, Tangra, Narkeldanga in north Kolkata Garden Reach Metiabruz, Ekbalpore area in south
Less deprived	-0.42 to 0.33	Wards are scattered in north, central and extreme southern part of Kolkata	
Least deprived	-1.93 to -.041	Central and south Kolkata	

Deprived Locales in Kolkata:

Kolkata exhibits more or less same picture; deprived locales are again fond in the peripheral parts of the city. Wards located in the eastern and northern periphery (North Tangra, Narkeldanga, Tiljala, Topsia, Beliaghata, Ultadanga, Maniktola and Cossipore) record highest score in the composite index followed by Garden Reach-Metiabruz area in the west. The most interesting thing is that, these wards are slum wards; here nearly 99 per cent people live in slums. These slums are registered slums and only slum wards score very high in this deprivation index.

The main differences between Delhi and Kolkata in terms of housing deprivation are mentioned below:
Delhi records very high percentage of slum households living in the city core, but highest deprivation value is found in the peripheral areas. Deprived wards of Kolkata are located in the north-eastern, western and northern peripheries of the city and these wards also record very high percentage of slum population. Therefore, in Delhi, housing deprivation exists beyond the legal definition of slums and it is very difficult to identify who are the worst sufferers of the housing deprivation, unless and until one can make a primary survey.

Findings and Conclusion

Being one of the busiest metropolises of the country Delhi stands as the symbol of old and new India where '*the stones whisper to our ears of the ages of long ago and the air we breath is full of the dust and fragrance of the past, as also of the fresh and piercing winds of the present*' (Jawaharlal Nehru). On the other hand, Kolkata often portrayed as the '*City of Joy'* acts as the beacon of hope for many million migrants coming to the city for economic betterment.

The first one acts as the soul of India or the threshold or Dahleez of the country and that is why this area remains one of the most contested regions in the recent past and still enjoys its supremacy as the administrative capital of India; the latter once enjoyed the pride of being the administrative capital of India during the colonial period and today it stands as the most important primate city of the eastern India. Thus, both of the cities attract job seekers and housing deprivation is one of the obvious outcomes of rural to urban in-migration. Both the cities are famous for slums and squatter settlements; but the basic nature of the housing deprivation differ. Delhi records very high percentage of slum households living in the city core, but highest deprivation value is found in the peripheral areas. Deprived wards of Kolkata are located in the north-eastern, western and northern peripheries of the city and these wards also record very high percentage of slum population. These two cities share different histories, socio-economic set up, planning and political attention; thus, these differences are the obvious outcomes of all these differences.

Mapping Morbidity Pattern in India: Opportunities and Challenges

Dr. Vinod Kumar Mishra
Associate Fellow, Indian Institute of Dalit Studies, New Delhi
E mail:vinodcsrd217@gmail.com

Abstract

India in course of her development has gone through epidemiological transition. The initial high burden of morbidity and mortality has declined with the development of technology. But with growth of population and consequent environmental degradation has increased the burden of communicable diseases. Despite high economic growth in last few decades, the social sector interventions particularly health has been dismally low in India. India still has largest proportion of communicable diseases in the world. Despite India's achievement in key health indicators since independence, inter-state and rural urban differential exists in health indicators. Measurement and identifications of important areas of communicable diseases is important for policy implications. Under development along with malnutrition and morbidity has negatively influenced the health indicators of some of the states in India. The present paper is based on Annual Health Survey (AHS) data of Empowered Action Group states in India. In the paper, cartographical approach has been adopted to map the morbidity pattern in India. Mapping of morbidity pattern helps to identify vital areas of communicable diseases. This cartographical technique of mapping morbidity in underdeveloped states has great implications on health related policies of government of India. Geographical pattern of prevalence of communicable diseases would help to utilize the limited resources of health care in India

Introduction

Like other developing countries India is also passing through epidemiological transformation. The pattern of disease and its distribution across various age groups have gone tremendous changes particularly after independence. Development of various modern technology and research and development in medical sector have brought revolutionary changes in disease pattern across the globe. Socio-economic development and emergence of welfare states have reduced the poverty levels in many countries. Access to basic amenities such as sanitation and safe drinking water has greatly reduced the occurrence of communicable disease not only in India but also in various other developing countries. The waves of epidemiological transformation have mainly come from the developed countries closely followed by developed countries. The improvement in access to basic amenities, nutrition level of population and revolution in health care service have caused increase in the life expectancy at birth.

But the impact of revolution in medical and health care service has not been uniform across various countries. There exists a clear distinction between developed and poor countries as far as pattern of health care service. Even within the same country large scale difference is observed between socio-economically well off and backward states of India. Even within the same states there exist great variations in the health indicators for various socio-economic groups. The people living below the poverty line particularly the vulnerable section of the society such as scheduled caste, scheduled tribes and religious minorities are far lagging behind in various indicators of health. The poor health indicator of these vulnerable groups is not because of economic deprivation but also social discrimination.

The cartographical approach has brought revolutionary changes in various spheres of human enquiry. Use of geographical information system can also be used in the mapping of the morbidity pattern in India. The mapping of morbidity pattern in India can be helpful in policy making in health such as identifying different morbidity prone. This will be helpful in making provision of health care facilities in those particular areas. The mapping of morbidity can also be useful for sustainable utilization of natural, human and financial resources of developing countries like India. By identifying the hotspots or the concentration zone of various morbidity will be immense helpful in concentrating our valuable resources in that particular area.

Objectives

The present paper tries to explore the following objectives-

A. To analyse the importance of cartographic techniques in studying morbidity pattern in India.
B. To analyse the morbidity pattern of acute respiratory infections in India.
C. To analyse the morbidity pattern of chronicle illness in India
D. To analyse the health seeking behavior patients in India

Data Source

The data source of the present study has been taken from the base line survey of Annual Health Survey 2010-11 conducted by the Registrar General of India in 9 EAG states that is Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh and Uttarakhand. The annual health survey which is the world largest survey aims to collect

comprehensive information on health and morbidity pattern of almost 48 percent of India population living in 9 above mentioned states. This is a three year survey. The data of the base line survey have been released and have been used in the present study.

Study Area

Annual Health survey has released data for all 9 states and in the present paper, the morbidity pattern of 9 states have been analysed. These states are – Chhattisgarh, Jharkhand, Madhya Pradesh, Uttar Pradesh and Uttarakhand Assam, Bihar, Rajasthan and Odisha. These states represent the morbidity pattern in the demographically lagging behind states.

Methodology

The present paper has adopted multiple methodologies for the clear understanding of the morbidity pattern in the study area states. The cross tabulation method has been used to present clear picture of the morbidity pattern in the states. Apart from this cartographic techniques such as use of Arc GIS method have been used to do cartographic presentation of the morbidity patterns in India.

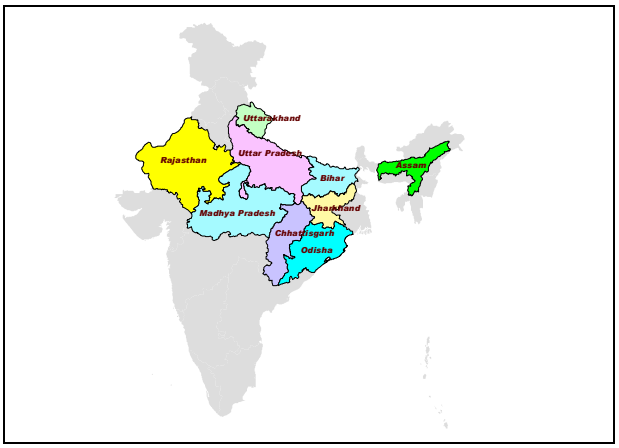


Fig. 1: Annual Health Survey States
Source: Annual Health Survey, Office of Registrar General of India

Analysis

Morbidity Pattern of Acute Respiratory Infection:

Annual health survey has extensively covered the data for the acute respiratory infection. The acute respiratory illness mainly includes fever, cold, sour throat and other respiratory related problems. Acute respiratory infection has been captured for the last 15 days preceding the survey. In the following table, persons suffering from acute respiratory infection per 100000 population have been given. If we see the data given in the table it becomes clear that situation of acute respiratory infection is very serious in Assam, Bihar and Uttar Pradesh. In these three states more than 3000 persons in 100,000 population were suffering with acute respiratory infection prior to 15 days of the annual health survey. In contrast to these three states, the situation is very good in Rajasthan, Jharkhand and Odisha where less than 1000 people in 100,000 have been suffering with any type of acute respiratory infection. Rajasthan is the best state where only 297 people out of 100,000 people were found suffering with acute respiratory infection in 15 days prior the survey.

There exits rural-urban differentials in the occurrence of the acute respiratory infection in 9 AHS states in 2010-11. The pattern given in the table clearly shows that acute respiratory infection is very high in rural areas of Jharkhand, Assam, Bihar, Odisha, Uttar Pradesh and Uttarakhand than in urban areas. While urban areas of Chhattisgarh, Rajasthan and Madhya Pradesh have more cases of acute respiratory infection in urban areas than in rural areas. There exist strong gender differentials in the morbidity pattern of acute respiratory infection in all nine states. All states report more number of women suffering from acute respiratory infection than their male counterparts. Various socio economic factors are playing important role in this case which need to be further explored.

Table 1: Persons suffering from acute illness (per 100,000 population) acute respiratory infections

Name of state	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	2877	2694	3536	2772	2627	3289	2985	2763	3799
Jharkhand	805	902	528	778	871	523	833	935	553
Assam	3182	3257	2833	3071	3154	2688	3299	3363	2990
Bihar	3048	3096	2727	3014	3075	2620	3084	3118	2847
Odisha	964	1027	638	910	970	611	1018	1084	666
Rajasthan	297	284	339	295	289	316	300	279	365
Uttar Pradesh	3017	3267	2133	2883	3116	2081	3159	3424	2190
Uttarakhand	1983	2004	1930	1861	1906	1759	2105	2100	2118
Madhya Pradesh	1341	1296	1533	1293	1271	1340	1392	1323	1537

Source: Annual Health Survey 2010-11

Acute illness of all types

If we see the morbidity pattern of all type of acute illness it becomes clear that three states Bihar, Uttar Pradesh and Assam are facing dangerous health problems where more than 10,000 persons have been found suffering with any type of acute illness 15 days before the survey. Among these states the situation is worst in Bihar which reports highest number of people suffering from acute illness during annual health survey. Among 9 EAG states the situation is far better in Chhattisgarh which reports lowest number of people reporting any type of acute illness closely followed by Rajasthan. Rural- urban differential exists in the case of reporting of any type of acute illness. All the states except Chhattisgarh reports higher morbidity in rural areas than the urban areas of the states. This supports the evidences in the literature on the morbidity that the rural areas are facing serious nature of health related problems than the urban areas because of prevailing low development and poverty along with the practically ineffective nature of health care facilities in rural areas.

Gender difference also exists in the morbidity pattern of any type of acute illness. Low level of nutrition along with gender discrimination poses serious challenges to the health of women in the tradition households. This has resulted into reporting higher case of any type of acute illness in all states in which annual health survey have been conducted.

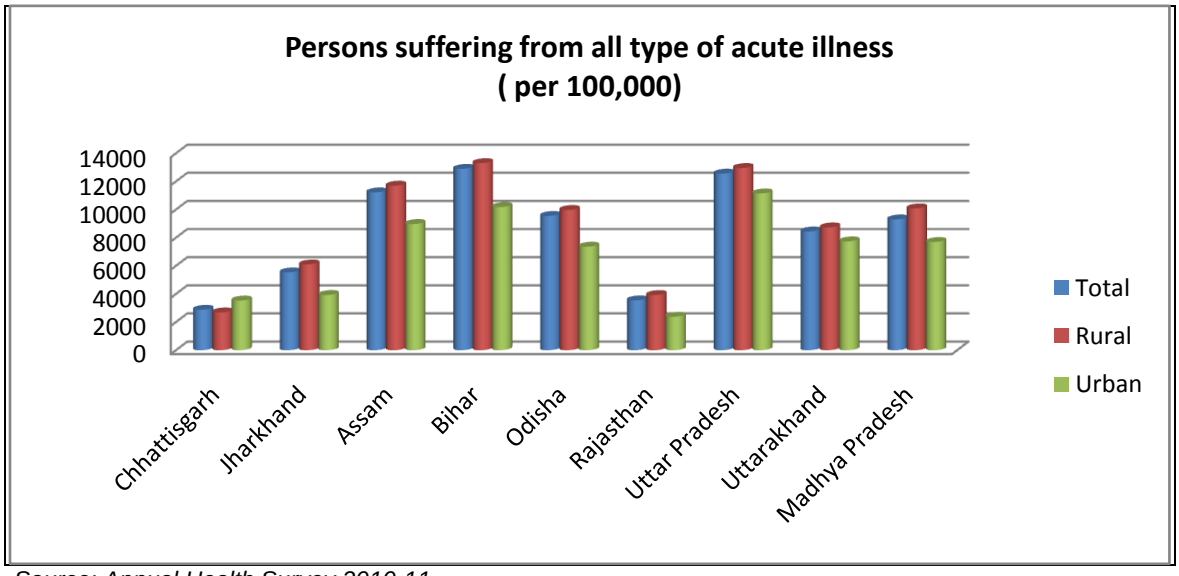
Access to Health care

The paper also analyses access to health care services by those suffering with acute illness of any type. The respondents were asked whether they have taken any treatment for acute illness. The table shows that quite a high proportion of persons suffering with acute illness have taken treatment from any source. Only Assam and Madhya Pradesh have less than 90 percent persons suffering with acute illness who have taken treatment from any source of health care facilities. The table also shows that other states have more than 90 percent of persons suffering with acute illness who have been taking any treatment.

Table 2: Persons suffering from acute illness (per 100,000 population) all type of acute illness

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	2877	2694	3536	2772	2627	3289	2985	2763	3799
Jharkhand	5537	6102	3931	5259	5801	3762	5832	6416	4118
Assam	11225	11704	8978	10687	11182	8413	11788	12248	9589
Bihar	12898	13306	10183	12340	12756	9661	13485	13879	10767
Odisha	9550	9976	7364	9309	9765	7031	9792	10186	7714
Rajasthan	3547	3926	2382	3377	3764	2205	3731	4100	2579
Uttar Pradesh	12561	12959	11151	12096	12491	10736	13053	13448	11611
Uttarakhand	8448	8736	7742	8029	8403	7163	8870	9060	8375
Madhya Pradesh	9304	10087	7697	8841	9642	7210	9812	10573	8236

Source: Annual Health Survey 2010-11



Source: Annual Health Survey 2010-11

Table 3: Persons suffering from acute illness and taking treatment from any source (%)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	93.9	93.5	95.8	94.5	94.1	96.5	93.4	93	95.1
Assam	86.5	86.4	87.3	86.6	86.5	87.5	86.4	86.3	87.2
Bihar	98.0	98.1	97.5	98.2	98.2	97.5	97.9	97.9	97.5
Odisha	95.9	95.9	96.2	96.0	95.9	96.6	95.8	95.8	95.8
Rajasthan	96.1	96.2	95.1	96.2	96.3	95.5	95.9	96.2	94.7
Jharkhand	99.3	93.1	94.2	93.6	93.4	94.6	93.1	92.9	93.8
Uttar Pradesh	97.8	97.7	98.4	97.9	97.8	98.4	97.8	97.6	98.4
Uttarakhand	96.4	96.1	97.5	96.7	96.3	97.6	96.3	95.8	97.4
Madhya Pradesh	87.9	85.8	93.5	87.2	85	93.4	88.6	86.7	93.7

Source: Annual Health Survey 2010-11

Table 4: Persons suffering from acute illness and taking treatment from government source (%)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	20.1	21.5	14.1	20.3	21.7	14.3	19.9	21.3	13.9
Jharkhand	11.3	10.3	13.4	11.4	10.9	13.7	11.1	10.1	13.2
Assam	36.1	37.1	29.6	35.9	37.0	29.0	36.2	37.2	30.2
Bihar	10.3	10.6	7.1	10.4	10.8	6.9	10.1	10.4	7.2
Odisha	52.0	54.0	38.0	52.7	54.9	38.1	51.2	53.1	37.8
Rajasthan	35.5	36.2	32.3	35.7	36.3	32.3	35.4	36.0	32.3
Uttar Pradesh	3.8	3.5	4.9	3.8	3.6	4.7	3.8	3.5	5.2
Uttarakhand	12.7	13.7	10.3	11.7	12.3	10.1	13.7	14.9	10.4
Madhya Pradesh	17.1	16.7	18.1	17.2	17	17.8	17	16.4	18.5

Source: Annual Health Survey 2010-11

It is shocking to notice that except Madhya Pradesh all the states have more men than who have been suffering with acute illness and taken any type of treatment. However, as shown in the table it is clear that proportion of persons suffering with acute illness having treatment in the government hospitals is very low except in Odisha where more than half of those suffering with acute illness have taken treatment in government health care service.

The figures do not necessarily indicate that the government health care situation is better in Odisha. The private health care institutions are not so effective and they are also very low in number that is why people who are suffering with acute illness are forced to go to government health care facilities for treatment. The situation of government health care facilities is very pathetic in Uttar Pradesh where only 3.8 percent of population suffering with acute illness takes treatment in government health care facilities. The situation of Jharkhand, Bihar and Uttarakhand is not very good.

Chronic Illness

The annual health survey provides data regarding chronic illness on the basis of symptoms related to a disease which persisted more than one month and related to illness which was diagnosed in any healthcare facilities as chronic illness even if it not recognized by the person concerned. Annual health survey had taken one year prior to the survey as the reference period. The household schedule had detailed information regarding type of chronic illness so that the correct information. Like acute respiratory illness the data for the chronic illness has also been given as number of persons per 100,000 suffering with the chronic illness.

The table given below shows the pattern of morbidity of chronic illness in 9 states. The incidence of chronic illness is highest in Assam and Bihar followed by Uttarakhand. Like incidence of acute illness the incidence of chronic illness is lowest in Rajasthan followed by Chhattisgarh. Madhya Pradesh and Jharkhand have just slightly more than 5000 incidence of chronic illness

Table 5: Having any kind of Symptoms of Chronic Illness (Per 100,000 Population)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	4083	3730	5362	3894	3596	4959	4278	3867	5788
Jharkhand	5290	5055	5959	4863	4643	5470	5743	5485	6502
Assam	11261	10894	12982	10509	10133	12238	12050	11686	13787
Bihar	10435	10777	8161	9091	9388	7177	11851	12226	9262
Odisha	7339	7093	8601	7073	6852	8181	7607	7335	9042
Rajasthan	2521	2427	2808	2358	2301	2533	2696	2563	3112
Uttar Pradesh	8380	8873	6633	7234	7656	5784	9593	10146	7575
Uttarakhand	9656	9530	9967	7826	7604	8340	11499	11403	11749
Madhya Pradesh	5646	5608	5726	5065	5124	4944	6284	6135	6593

Source: Annual Health Survey 2010-11

Table 6: Having diagnosed for any kind of chronic Illness and sought Medical Care (%)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	82.0	78.6	90.6	82.4	79.0	91.3	81.6	78.2	89.9
Jharkhand	53.4	45.6	69.0	53.6	46.0	69.0	53.1	45.2	69.0
Assam	90.7	90.3	92.5	91.2	90.5	93.6	90.3	90.1	91.5
Bihar	82.6	82.4	86.7	83.4	82.9	87.4	82.3	81.9	86.2
Odisha	91.0	90.1	94.7	91.1	90.1	95.1	90.8	90.0	94.4
Rajasthan	85.4	83.0	91.7	85.8	83.8	91.4	85.0	82.2	92.0
Uttar Pradesh	90.8	90.5	92.1	90.6	90.2	92.2	90.9	90.7	92.0
Uttarakhand	60.7	54.3	73.6	63.6	57.1	75.5	58.5	52.4	72.0
Madhya Pradesh	54.5	46.6	66.4	55.3	47.4	68.2	53.7	45.9	64.9

Source: Annual Health Survey 2010-11

The rural - urban differential of morbidity pattern shows a very different picture. In all states except Bihar and Uttar Pradesh, urban areas have reported higher incidence of chronic illness than the incidence reported from the rural areas. As far as, gender differentials in the incidence of chronic illness is concerned, the incidence is lower than the male in all states though the gender gap is not very high except in Uttarakhand.

If we analyse the data given in the table, which shows the percentage of persons diagnosed with any type of chronic illness and sought medical care it clearly shows more than 90 percent of those diagnosed for chronic illness in Odisha, Assam and Uttar Pradesh have sought medical care. The situation is very worrisome in Jharkhand, Uttarakhand and Madhya Pradesh were slightly more than half of those diagnosed for chronic illness have sought medical care. This clearly shows that access to health care is very in above mentioned states. Gender differential of seeking medical care behavior in case of chronic illness is clear ill states except Uttar Pradesh where nearly equal proportion of male and female suffering with chronic illness have sought medical care.

However, if we analyze percentage of people diagnosed for chronic illness and seeking treatment from government sources, we find that Bihar and Uttar Pradesh less than 10 percent have been getting regular treatment form government sources. This shows that the government source of health care services are not available and either people are unable to access to health care or they are force to take medical treatment from private service providers.

Table 7: Having diagnosed for any kind of chronic Illness and getting Regular Treatment from Government Source (%)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	23.4	25.6	19.2	24.8	26.9	20.5	22.1	24.3	18.0
Jharkhand	15.9	14	19	17.6	15.9	20.5	14.3	12.3	17.7
Assam	39.0	41.2	31.4	38.5	40.8	30.2	39.5	41.5	31.8
Bihar	8.8	8.5	11.1	9.6	9.2	12.0	8.2	7.9	10.3
Odisha	51.9	57.2	32.3	52.6	58.1	32.4	51.4	56.4	32.2
Rajasthan	46.7	47.5	44.9	48.5	49.7	45.9	44.9	45.3	43.9
Uttar Pradesh	9.9	8.9	13.8	11	10.1	14.8	8.9	8	13
Uttarakhand	26.4	29.2	21	25.5	28.4	20.5	27	29.7	21.5
Madhya Pradesh	24.7	24.3	25.4	25.8	25.5	26.4	23.7	23.1	24.6

Source: Annual Health Survey 2010-11

Table 8 Persons suffering from Acute Illness of Diarrhoea/ Dysentery (Per 100,000 Population)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	1107	1213	723	1024	1133	635	1193	1296	815
Jharkhand	429	458	346	423	455	334	435	461	358
Assam	1310	1401	881	1276	1362	879	1345	1441	883
Bihar	2093	2249	1056	2057	2221	1003	2131	2278	1115
Odisha	836	900	511	820	880	523	853	920	498
Rajasthan	647	719	427	628	703	402	668	737	453
Uttar Pradesh	1187	1258	934	1203	1282	931	1170	1234	937
Uttarakhand	675	767	447	646	742	424	703	791	473
Madhya Pradesh	1256	1473	812	1254	1476	804	1259	1470	822

Source: Annual Health Survey 2010-11

Morbidity pattern of water borne diseases:

incidence cases of diarrhea is very high in Bihar. If we compare the morbidity pattern of diarrhoea in Bihar with other annual health survey states, this become clear that Bihar reports almost three times more than Rajasthan and Uttarakhand while Jharkhand had reported less than one fourth incidences of dysentery than Bihar

Water borne diseases are essentially outcome of unavailability of access to safe drinking water. Despite various efforts taken by Government to improve the accessibility to water and sanitation both in rural areas and in urban areas, quite a large proportion of population is unable to access safe drinking water. So far recognized sources of drinking water such as hand pump, tube well and tap water have also become polluted resulting into high incidence of water borne disease. Above is also true because of unable to access to sanitation facilities. Despite total sanitation campaign by the government, more than half of India's population goes open for nature's call (Census of India 2011). This is manifested in the form of higher number of cases of water borne diseases like dysentery which is directly linked with the personal hygiene. Gender differential is again manifested in all states except Uttar Pradesh, Madhya Pradesh and Uttarakhand. All other states reports higher incidence of morbidity in women than in men.

If we see the morbidity pattern of communicable and water borne diseases it becomes clear that number of

Incidence of fever of all type

In the present paper all types of fever have been clubbed together to analyze the pattern of incidence of fever in 9 AHS states. As it is clear from the table given below that the incidence of fever is highest in Uttar Pradesh, closely followed by Bihar and Odisha. Among all AHS states Rajasthan has reported lowest cases of fever of all types which is also less than one third of the total number of incidence in the Uttar Pradesh. Jharkhand also reports quite a low number of incidences of all types of fever in comparison to other states.

Table 9: Persons suffering from Acute Illness of Fever of all types (Per 100,000 Population)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	5193	5606	3696	4977	5401	3467	5415	5817	3938
Jharkhand	3856	4294	2612	3652	4072	2494	4072	4526	2743
Assam	4978	5219	3848	4830	5089	3635	5133	5354	4078
Bihar	7111	7296	5881	6733	6913	5575	7510	7696	6224
Odisha	6689	6990	5141	6577	6911	4906	6802	7070	5389
Rajasthan	2165	2489	1169	2068	2389	1096	2270	2598	1249
Uttar Pradesh	7571	7672	7217	7282	7394	6896	7878	7961	7574
Uttarakhand	5225	5366	4877	5004	5199	4552	5447	5529	5234
Madhya Pradesh	5699	6355	4352	5338	5975	4042	6094	6770	4695

Source: Annual Health Survey 2010-11

Rural urban differential is again manifested by above table with high number of cases reported in rural areas than the urban areas. The table clearly shows that the gap between rural and urban areas is very high in all states. Rural areas of Jharkhand, Rajasthan and Madhya Pradesh have almost double incidence of all type of fever than the urban areas of these states. Rural urban difference is very low in case of Uttar Pradesh where both urban areas and rural areas have reported very high incidence of fever of all types. As far as gender differential is concerned the incidence of any type of fever is higher in case of women than the men in all states. This clearly manifests the socio-economic condition of women. The incidence of all type of fever is higher in the case of women living in rural areas than the women living in urban areas. The women living in rural areas faces more problem than the women living in urban areas that clearly manifests the problems faced by the rural women.

Morbidity Pattern of life style diseases in India

India has witnessed epidemiological transformation in last few diseases. With the growth of medical health care along with general growth in the access to hygiene, basis amenities and sanitation facilities the incidence of communicable diseases have gone down in last few decades specially after the independence. The life style of Indian population has changed in last few decades. Sedentary life style with practically no exercise along with increase stress related activities has given rise to incidence of non communicable diseases in the last few decades. In the present section of the paper morbidity pattern of non-communicable diseases have been analysed.

Hypertension: This is a life style disease which has increased not only in urban population but also in rural areas in the last few decades. The table given below clearly indicates that the number of persons per 100,000 persons is very high in Assam. Odisha is far located behind Assam. Uttar Pradesh also has more than 1000 persons reporting hypertension per 100,000 persons.

Table 10: Having any kind of Symptoms for Chronic Illness of Hypertension (Per 100,000 Population)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	574	330	1456	480	263	1253	670	398	1672
Jharkhand	486	283	1062	458	261	1000	515	305	1132
Assam	1738	1488	2910	1504	1231	2758	1983	1754	3075
Bihar	699	662	944	597	555	873	806	774	1024
Odessa	1185	980	2239	923	720	1934	1450	1239	2560
Rajasthan	277	190	541	215	151	409	343	233	687
Uttar Pradesh	498	409	815	368	295	621	636	527	1030
Uttarakhand	1005	664	1843	798	520	1442	1214	804	2283
Madhya Pradesh	687	348	1382	504	258	1006	887	446	1799

Source: Annual Health Survey 2010-11

The incidence of morbidity is significantly low in Rajasthan which has reported only 277 persons out of 100,000 suffering with the hypertension related problems. There exists very high rural urban differential in the case of hyper tension. As mentioned earlier hypertension is a life style based non communicable disease the people living in urban areas faces high stress and life style related problems that the people living in rural areas.

The findings of the annual health survey clearly indicates that incidence of hypertension is very high among urban population than the rural population in all states where survey have been conducted. Rural urban difference is very high in Chhattisgarh, Assam, Uttarakhand, Odisha and Madhya Pradesh where the incidence of hypertension is two to three times higher than the incidence of hypertension in the rural areas.

Gender –differential in the incidence of hypertension clearly indicates that women have higher number of incidence of hypertension in all 9 states. The table clearly shows that the established notion that women are generally engaged in the households activities which are often not so stress thus leading to lesser cases of hyper tension than their male counter parts. The findings of annual health survey clearly break this notion. Now women are also coming up in big way and taking the stressful works. But, unfortunately very women are still very less in numbers in all spheres of public life than the men. In this case higher proportion of cases of hypertension clearly indicated the changing morbidity pattern in India as far as gender differentials are concerned.

Tuberculosis

The medication pattern of the tuberculosis has undergone tremendous change after much medical development. Though, tuberculosis is curable but number of cases of incidence of tuberculosis is very high in many states. The government has launched various medical health interventions to deal with the ever persisting disease of tuberculosis. The tuberculosis treatment is fully provided by the government. But with the rising pollutions and increasing additions are still reporting many states. The incidence of tuberculosis has been given in the preceding table. The table 11 clearly shows that incidence of tuberculosis is highest in Bihar. Other states are much behind Bihar as far as incidence of morbidity is concerned. The incidence of tuberculosis is lowest in Rajasthan followed by Odisha. Assam and Uttar Pradesh has nearly 300 incidence of tuberculosis in 100,000 persons. The table 11 clearly shows that the gender differential of incidence of tuberculosis does not show any uniform pattern. Tuberculosis is more in male than the females in all states.

Conclusion

To conclude we can say that cartographic techniques are very useful in mapping morbidity in India. Annual health survey data has been utilized to map the morbidity pattern in India; the mapping of morbidity has great policy implication as with mapping of morbidity we can concentrate our scarce health resources in the more problematic areas. Thus more and more research and development is required in this field which can bring revolutionary changes in the field of health care facilities.

Table 11: Having any kind of Symptoms for Chronic Illness of Tuberculosis (Per 100,000 Population)

Name of State	Persons			Male			Female		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Chhattisgarh	195	196	191	251	262	213	137	128	168
Jharkhand	260	283	193	335	382	206	180	180	180
Assam	288	306	199	354	381	228	218	229	168
Bihar	479	505	307	546	581	321	409	426	292
Odisha	139	148	92	174	189	104	103	107	81
Rajasthan	108	115	86	134	146	96	80	82	75
Uttar Pradesh	290	303	243	327	347	260	250	257	225
Uttarakhand	189	189	187	219	223	210	158	156	163
Madhya Pradesh	169	185	138	200	224	152	135	142	122

Source: Annual Health Survey 2010-11

Changing Pattern of Sex Ratio and Child Sex Ratio in India: A GIS Based Analysis of Urban and Rural Areas

Dr. Rajesh Yadav and Dr. Pankaj Kumar
Government of India, Ministry of Home Affairs
Office of the Registrar General, India

Abstract

Present paper analyses the changing pattern of Sex Ratio and Child Sex Ratio in India. Census year 2001 and 2011 are selected to analyse the pattern. The findings are based on secondary source of data which mainly derived from Census of India. District is considered as basic unit of the study at Total, Rural and Urban levels. The study of Sex Ratio is of great interest to researchers because of the contrasting roles played by to sexes in economy and society. The overall sex ratio of the country as per Census 2011 has improved by seven points to 940 against 933 in Census of 2001. This is the highest sex ratio at the national level since Census 1971. However, the area of grave concern remained the lowest ever child sex ratio of 941 as per Census 2011. The Census data indicates decline of 13 females per 1000 males in age group 0-6 years from 927 in 2001 to 914 in 2011. The changing pattern of sex ratio at district level would result in negative trend of sex ratio in coming decades.

Introduction

Population of any society is divided into two segments on the basis of gender, they are males and females. Both the sexes are complementary to each other and play their distinctive roles in the social and economic activities of the community. The ratio between the two sexes has its bearing on the other demographic characteristics of the region (Shryock, 1976). Therefore, the study of sex composition becomes very significant for the socio-economic planning and for the analysis of other population characteristics in a region. Sex Composition of a population is expressed in terms of sex ratio and calculated as the 'number of females per thousand males'. Sex ratio can be computed at the time of conception, birth and enumeration termed as primary, secondary and tertiary sex ratio respectively (Chandana, 1992). But most often sex ratio at the time of enumeration is taken into consideration. There are three major factors which determine the sex ratio in an area. These are the sex ratio at birth, difference in the mortality rates of the two sexes and the sex composition of the migrants. In the developed countries sex ratio is generally in favour of females because of higher mortality rates among males. Contrary to this, in the developing countries sex ratio is skewed towards males as in younger age-groups, more male health care facilities for the females. But in older age groups, more females survive being biologically stronger than males. It is attempted in this paper to analyse the changing pattern of sex ratio and child sex ratio in India taking district as unit of analysis.

Objective

The main objective is to examine and analyse the changing pattern of sex ratio and child sex ratio and to compare the declining sex ratio and child sex ratio during 2001-2011 Census year at Total, Rural and Urban level in India.

Database and Methodology

The study is based on the secondary data obtained from the Census of India. For comparing the data between Census 2001 and 2011, the data related to Census 2001 has been re-casted based on administrative units as per Census 2011. District is taken as a unit of study for analysis and mapping purpose. Data thus collected was interpreted and represented cartographically by using the Choropleth technique. All maps are prepared by using ArcGIS 10 software. The changing pattern emerging from the maps were analysed and interpreted by correlating the sex ratio and child sex ratio.

Changing Pattern of Total Sex Ratio (TSR)

Total Sex Ratio (TSR) as per Census 2011 is 940, which shows an increase of seven points from the TSR of 933 as per Census 2001. The TSR varies from one region to another. Out of 640 districts of the country, 200 districts have the TSR ranging from 901 to 950, which are closer to the country's average of 940 in 2011. 21 districts fall in the range of 850 and below in 2011 in comparison to 54 districts in 2001 and 98 districts have TSR above 1001 in 2011 in comparison to 76 districts in 2001 (Table 1) indicating the improvement in TSR. The belt of highest TSR is found along the western coastal region and in contiguous pockets consisting of few districts in Chhattisgarh, Odisha, Eastern U.P., Uttarakhand and Himachal Pradesh.

Table 1: Sex Ratio

Range (Sex Ratio)	2011 (No. of Districts)			2001 (No. of Districts)		
	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN
850 and Below	21	19	39	54	42	104
851-900	124	108	164	129	109	207
901-950	200	191	224	207	196	187
951-1000	197	215	144	174	187	82
1001 and Above	98	98	66	76	97	42

Source: Computed by Researchers

Out of 640 districts, 147 districts show a decline of up to 240 females per 1000 males. Among the districts which have shown the decline,form contiguous pockets in Jammu & Kashmir, Uttarakhand, Maharashtra, parts of Eastern U.P., Bihar and southern part of Tamil Nadu (Fig. 1) and 10 districts have shown no change in TSR.

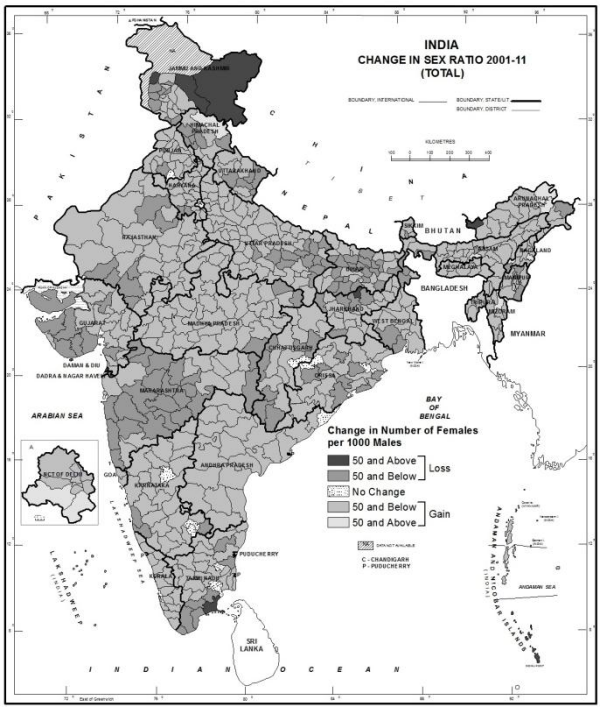


Fig. 1.

Changing Pattern of Rural Sex Ratio (RSR)

Out of 640 districts of country, 191 districts in 2011 and 196 districts in 2001 are placed in the range from 901 to 950 which is closer to the country's average of 947 in 2011. 19 districts in 2011 and 42 districts in 2001 have RSR of below 851 while 108 districts in 2011 and 109 districts in 2001 are placed in the range from 851 to 900. 215 districts in 2011 and 187 districts in 2001 fall in the range from 951 to 1000 while98 districts in 2011 and 97 districts in 2001 have the RSR over 1000 (Table 1), indicating no major change in the pattern in RSR.

Out of 640 districts, 189 districts show a decline of up to 294 females per 1000 males. Among the districts which have shown the decline, form almost the same pattern of spread as of TSR across the country (Fig. 2) and 19 districts have shown no change in RSR.

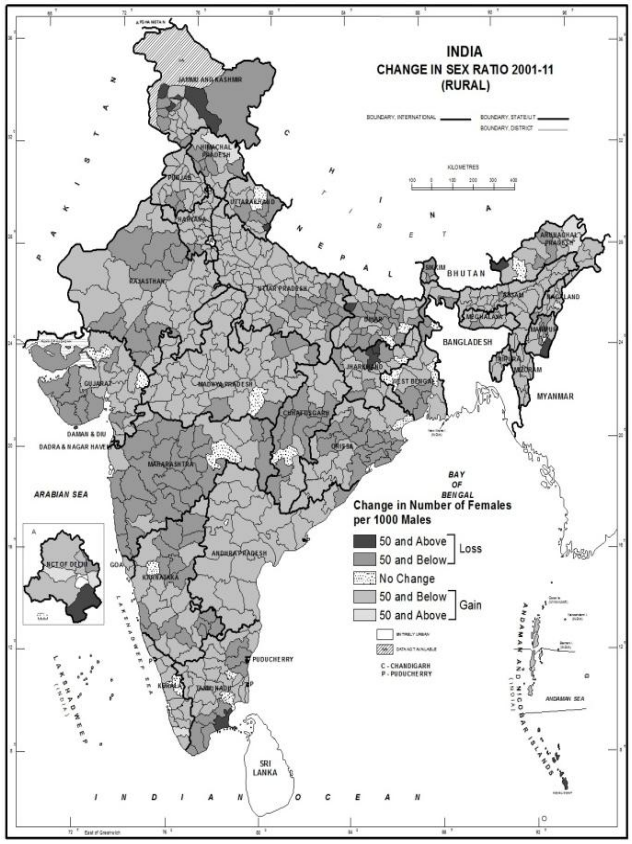


Fig. 2.

Changing Pattern of Urban Sex Ratio (USR)

Out of 640 districts of the country, 224 districts in 2011 and 187 districts in 2001 have the USR between 901 and 950 which is closer to the country average of 926 in 2011. 39 districts in 2011 and 104 districts in 2001 have USR below 851. Of the remaining districts 164 in 2011 and 207 in 2001 fall in the range from 851 to 900 and 144 in 2011 and 82 in 2001 fall in the range from 951 to 1000. 66 districts in 2011 and 42 districts in 2001 have USR of over 1000 (Table 1).

Out of 640 districts, 44 districts show a decline of up to 434 females per 1000 males. Districts which have shown the decline do not show concentration in any part of the country. 589 districts show improvement in USR which are spread in all parts of the country. The concentration of contiguous patches of the districts with the improvement in USR of more than 50 points is in northern and north eastern parts of the country and 4 districts have shown no change in USR (Fig. 3). This indicates towards improvement in USR.

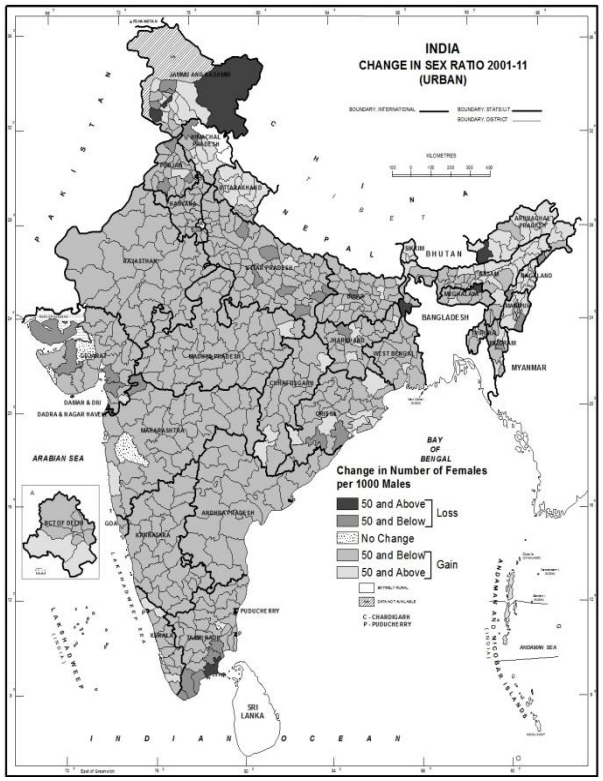


Fig. 3.

Changing Pattern of Total Child Sex Ratio (TCSR)

Child Sex Ratio is an important determinant of TSR and an indicator of the status of reproductive health care, medical services, institutional deliveries and male-female differentials in terms of nutrition level and mortality rates at early years of life. Proportion of females to males among children determines the future number of females in reproductive age-groups, thus affecting the SR of total population in the long term. Though, the changing pattern of SR in the country determines an improving trend but the data related to CSR (in age group of 0-6) shows more alarming trends.

Out of 640 districts of the country, 268 districts have the TCSR between 901 and 950 which is closer to the country average of 914 in 2011. 61 districts in 2011 and 57 districts 2001 have TCSR of below 851 while 136 districts in 2011 and 70 districts in 2001 fall in the range from 851 to 900. 172 districts in 2011 and 109 districts 2001 fall in the range of TCSR from 951 to 1000 while 3 districts in 2011 and 12 districts in 2001 have TCSR of over 1000 (Table 2). This distribution indicates the deteriorating situation of TCSR in the country.

Out of 640 districts, 461 districts show a decline of up to 210 females per 1000 males and 159 districts show an improvement in TCSR. Districts which have shown the improvement do not show concentration in any part of the country with exception in the neighbouring states of Punjab, Haryana and Himachal Pradesh. Districts with decline in TCSR are spread in all parts of the country. The concentration of contiguous patches of the districts with the decline in TCSR of more than 50 points is in Jammu & Kashmir and parts of Maharashtra and 20 districts have shown no change in TCSR (Fig. 4). This indicates towards a deteriorating situation of TCSR and reproductive TSR.

Table 2: Child Sex Ratio

Range (Child Sex Ratio)	2011 (No. of Districts)			2001 (No. of Districts)		
	TOTAL	RURAL	URBAN	TOTAL	RURAL	URBAN
850 and Below	61	59	76	57	54	86
851-900	136	123	191	70	61	110
901-950	268	255	252	226	219	284
951-1000	172	191	109	275	281	134
1001 and Above	03	03	09	12	16	08

Source: Computed by Researchers

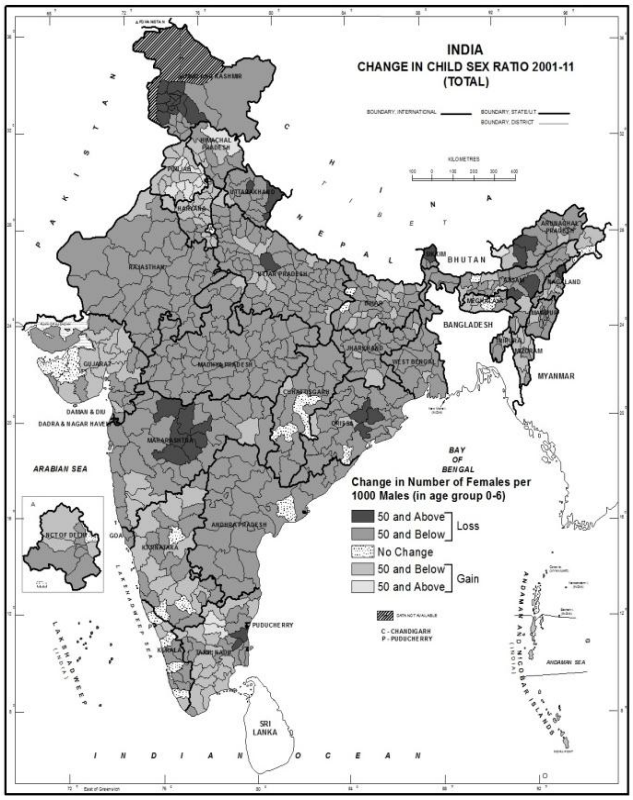


Fig. 4

Changing Pattern of Rural Child Sex Ratio (RCSR)

Out of a total of 640 districts, 255 districts recorded a RCSR fall in the range from 901 to 950 which is closer to the country average of 919 in 2011 whereas, only 219 districts fell in this range during 2001. 59 districts in 2011 and 54 in 2001 are found below 850 and 123 districts in 2011 and 61 in 2001 are found in the range of 851 to 900 which clearly indicates towards the declining trend in the RCSR. 191 districts in 2011 and 283 districts in 2001 are found in the range of 951 to 1000 and3 districts in 2011 and 16 in 2001 have RCSR above 1000 (Table 2).

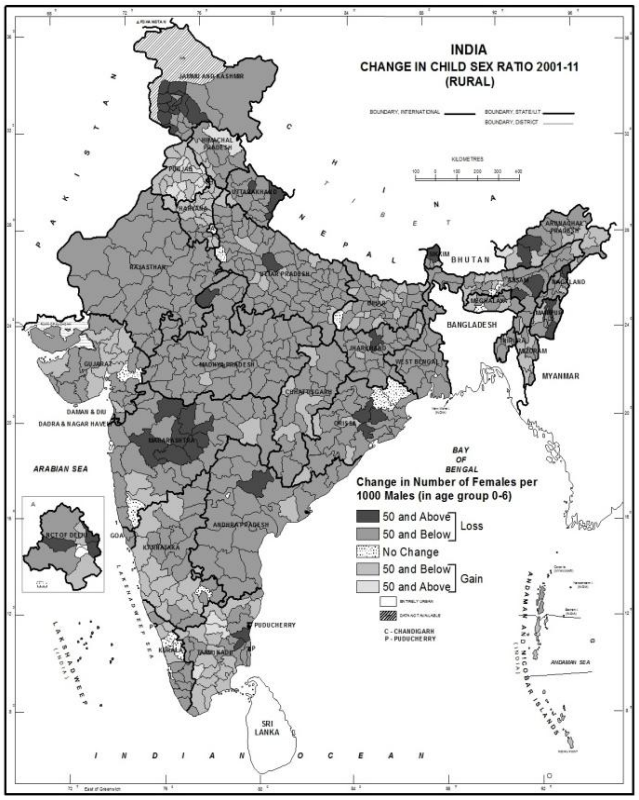


Fig. 5

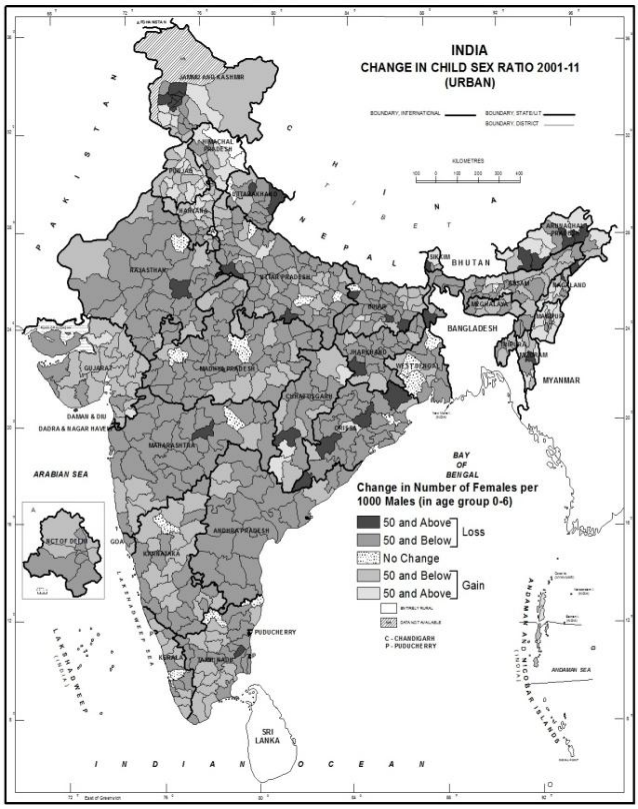


Fig. 6

Out of 640 districts, 492 districts show a decline of up to 231 females per 1000 males. Districts which have shown the declineare spread all over the country.The concentration of contiguous patches of the districts with the improvement in RCSR is seen only in Himachal Pradesh, Punjab, Haryana and parts of Karnataka, Kerala and Tamil Nadu and 12 districts have shown no change in RCSR during 2001-2011 (Fig. 5). This indicates towards a deteriorating situation of RCSR and reproductive RSR.

Changing Pattern of Urban Child Sex Ratio (UCSR)

Attitudinal change in urban society leading to somewhat greater attention towards the girl child in recent years could also contribute to higher urban child sex ratio to some extent (Sangwan and Sangwan, 2008).

Out of 640 districts of the country, 252 districts have the UCSR between 901 and 950 which is closer to the country average of 902 in 2011 and 284 districts fell in the same range in 2001. 76 districts in 2011 and 86 in 2001 fall in the lowest range of UCSR i.e. 850 & below. 191 districts in 2011 and 110 districts in 2001 are found in the range from 851 to 900, while 109 districts in 2011 and 134 districts in 2001 fall in the range from 951 to 1000. 9 districts in 2011 and 8 in 2001 districts fall in the highest range of UCSR i.e. 1001 and Above (Table 2).

Out of 640 districts, 492 districts show a decline of up to 391 females per 1000 males. Districts which have shown the decline are spread all over the country. The concentration of contiguous patches of the districts with the improvement in UCSR is seen in Himachal Pradesh, Punjab, Haryana, Gujarat and parts of Jammu & Kashmir, Karnataka, Kerala, Tamil Nadu and north eastern states and 19 districts have shown no change in UCSR during 2001-2011 (Fig. 6). This indicates towards a deteriorating situation of UCSR and reproductive RSR but in comparison to RCSR, UCSR shows a better change in trend.

Conclusion

Though, the change in sex ratio in India especially in urban areas has shownamoderate improvementduring the study period,but the negative change in the proportion of females per thousand males in age group 0-6 (Child Sex Ratio) is not a good indication for India. This positive change has probably taken place due to the fear of the laws imposed by governments in favour of girl child in previous decades.

But, due to non-enforcement or improper monitoring these laws, at the end of different government bodies and the attitude for the preference of male child in comparison to female child resulted in this type of imbalance. Improving situation in urban parts of the country indicates that state machineries have been

able to enforce laws to some extent, only in urban area. The current analysis also reveals that this changing pattern ofCSR in the country would result in more worst conditions related to sex ratio in forthcoming decades than existing.

Acknowledgement

Authors are grateful to Registrar General and Census Commissioner of India and Dr A. P. Singh, Deputy Registrar General, India, O/o the Registrar General, India for their valuable suggestions and comments in improving the quality of this paper.

References

1. Shryock, H. S. (1976): "*The Method and Materials in Demography,"* Academic Press, New York.
2. Chandana, R.C. (1992): *"A Geography of Population: Concepts, Determinants and Pattern",* 2nd Edition, Kalyani Publishers, New Delhi.
3. *Office of the Registrar General & Census Commissioner, 2011*, Government of India, New Delhi.
4. Sangwan, S. And Sangwan, R.S. (2002): "*Spatial Pattern of Rural – Urban Differentials in Sex Ratio of India,*" Population Geography, Vol.24, Nos. 1 and 2, pp. 47-58.

Geomagnetic Reversal: A Myth or Truth!

Rajiv Kumar Srivastava and Raman Verma
Geodetic & Research Branch, Survey of India, Dehradun

Abstract

Earth has had a magnetic field for at least 3.5 billion years and is generated by a self-sustaining dynamo effect caused by the fluid motions of the outer core. The outer core of the earth is an electrically conduction fluid and acts as a generator (or dynamo). The outer core rotates relative to the earth's rotation along its axis and moves across existing lines of magnetic force. The magnetic field is thus regenerated, using the fluids energy of motion.

A 'geomagnetic reversal' is a change in the Earth's magnetic field such that the positions of magnetic north and magnetic south are interchanged. In the early 20th century geologists first noticed that some volcanic rocks were magnetized opposite to the direction of the local Earth's field. When lavas are deposited on the Earth's surface, and subsequently freeze, and also when sediments are deposited on ocean and lake bottoms, and subsequently solidify, they often preserve a signature of the ambient magnetic field at the time of deposition. This type of magnetization is known as 'paleo-magnetism'. Careful measurements of oriented samples of faintly magnetized rocks taken from many geographical sites allow scientists to work out the geological history of the magnetic field. Most estimates for the duration of a polarity transition are between 1,000 and 10,000 years. However, last reversal, had been estimated to have occurred about 780,000 years ago. Studies of lava flows on Steens Mountain, Oregon, also indicate that the magnetic field could have shifted at a rate of up to 6 degrees per day about 15 million years ago.

Geodetic & Research Branch of Survey of India has been doing magnetic observations on uniformly distributed 183 repeat stations (178 stations in India and 5 stations in adjoining countries). Horizontal force, Total force & Declination have been observed on these stations periodically every 5 years and Magnetic Declination Chart at different epochs (latest epoch 2010.0) have been prepared. This chart is very useful for Mariners, Armed Forces, Civil Aviation Organisation & general users for finding direction of true north using magnetic compass. In this study, Magnetic Declination Charts from epoch 1965.0 onwards have been studied and it is found that magnetic declination contours are showing an oscillating motion which gives an opportunity to understand above postulate.

Introduction

Earth has had a magnetic field for at least 3.5 billion years and is generated by a self-sustaining dynamo effect caused by the fluid motions of the outer core. A geomagnetic reversal is a change in the Earth's magnetic field such that the positions of magnetic north and magnetic south are interchanged. In 1906 the French Physicist Bernard Brunhes discovered that some volcanic rocks were magnetized opposite to the direction of the local Earth's field. When lavas are deposited on the Earth's surface, and subsequently freeze, and when sediments are deposited on ocean and lake bottoms, and subsequently solidify, they often preserve a signature of the ambient magnetic field at the time of deposition. This type of magnetization is known as 'paleomagnetism'. Careful measurements of oriented samples of faintly magnetized rocks taken from many geographical sites allow scientists to work out the geological history of the magnetic field. Most estimates for the duration of a polarity transition are between 1,000 and 10,000 years. However, last reversal, had been estimated to have occurred about 780,000 years ago. According to John Tarduno, professor of geophysics at the University of Rochester, USA the strength of Earth's magnetic field "has been decreasing for at least 160 years at an alarming rate, leading to speculation that we are heading toward a reversal." However, it is also estimated that geomagnetic intensity has declined almost continuously from a maximum achieved approximately 2000 years ago. So far the strength of the Earth's field has decreased by 10 to 15 percent over the last 150 years, and approximately 35% over the last 2000 years.

Causes of reversal

Scientific opinion is divided on what causes geomagnetic reversals. Many scientists believe that reversals are an inherent aspect of the 'dynamo theory' of how the geomagnetic field is generated. Dr. Peter Olson, Geophysicists from Johns Hopkins University believes in part, geomagnetic reversals are not spontaneous processes but rather triggered by external events such as increased solar activity like solar flare, sun storms etc. which could have a chain reaction to the flow in the Earth's core. Following pre-cursors are also supposed to happen in the event of reversal:

1. An escalation of severe weather storms (water and wind), an increase in number and size of earthquakes (dirt), and an increase in volcanic eruptions (fire).
2. Continuous weakening of geomagnetic field.

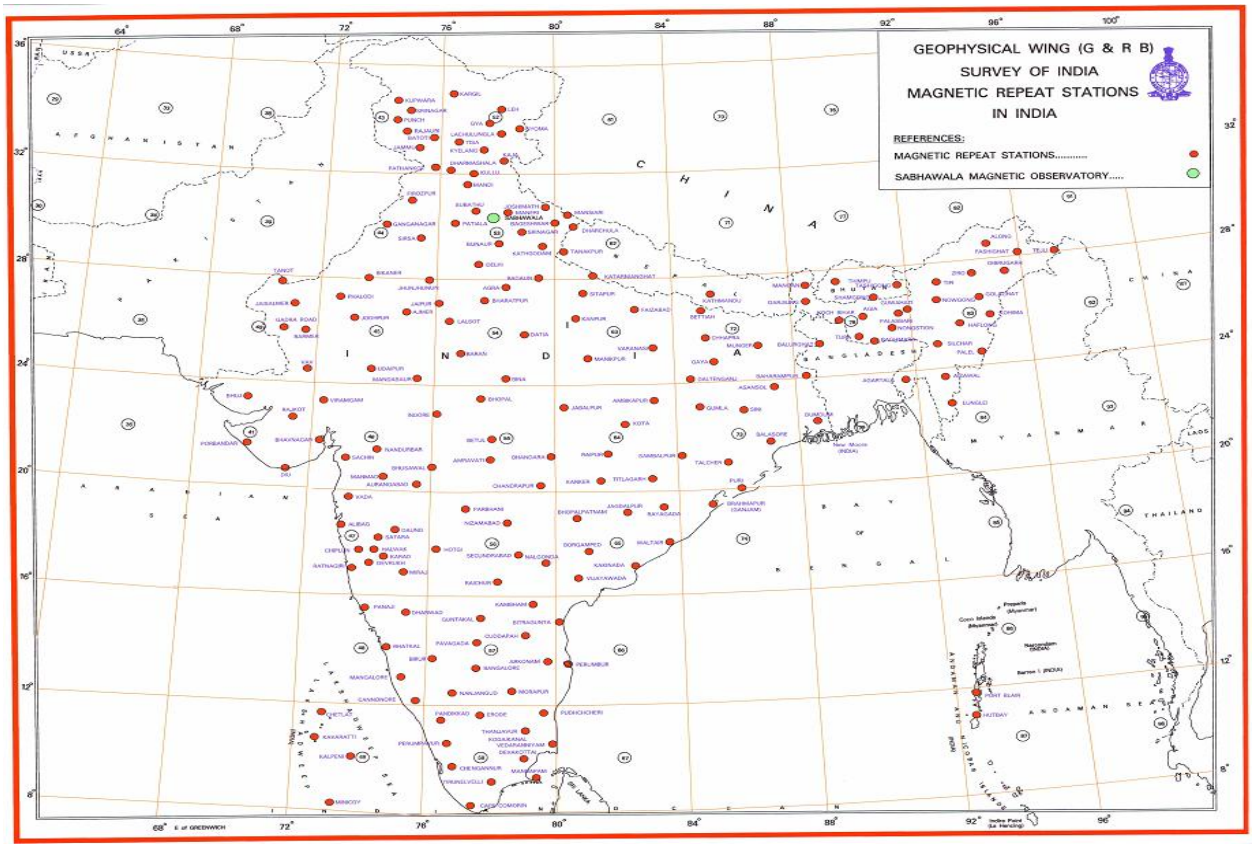
3. Swaying of geomagnetic north from geographic north i.e. continuous increase in value of Magnetic Declination due to enhanced secular variation.

Role of Survey of India

Magnetic Survey of India was proposed in 1896 by Sir John Eliot, Meteorological Reporter to the British ruled Government of India, and General C. Strahan, R.E. Surveyor General of India, and was recommended by the Astronomer Royal Sir W. H. M. Christie and by Sir J. Norman lockyer, both of whom visited India in 1898, in connection with the total eclipse of the sun which took place in January of that year. There was at first some uncertainty as to whether the Meteorological department or the Survey of India should conduct the operations. It was eventually decided that the work should be carried out by the Survey of India.

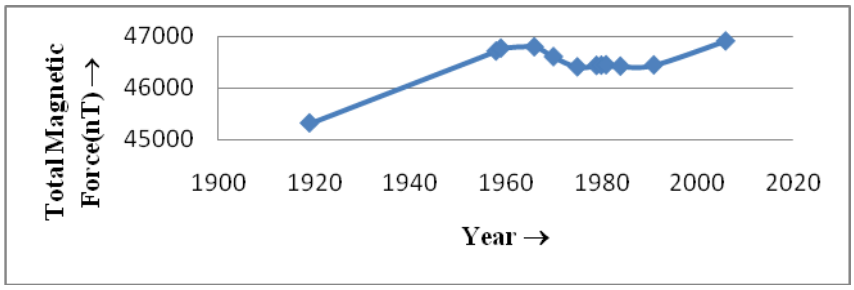
The aim of Magnetic Survey has been to determine the three magnetic elements- Declination, Dip and Horizontal Force, at repeat stations uniformly distributed over whole of India, Burma (now Myanmar) and Ceylon (now Srilanka), and to obtain from these the actual course of the true isomagnetic lines. The values of each element carefully plotted on a map of India and the lines of equal Declination, Dip, Horizontal Force & Total Force have been drawn to conform as closely as possible to the plotted values. These lines depict the actual magnetic conditions of the country and represent the true course of the isomagnetics as obtained from actual observations corrected as above and reduced to epoch. Declinations were drawn at the interval of 15'.

Many of the observations were made between the year 1902 and 1913 with only 55 repeat stations. Thereafter, due to World War I, it was suspended and from 1920, it again started but observations were not regular due to various reasons. Gradually, no. of repeat stations was increased to 183 including 3 in Bhutan & 2 in Nepal. Survey of India prepared isomagnetic charts at epochs 1909.0, 1920.0, 1942.0, 1946.0, 1953.0 & 1960.0 and after recommendation of IAGA (International Association of Geomagnetism and Aeronomy) it has been preparing isomagnetics charts regularly at the interval of 5 years since epoch 1965.0 to latest being 2010.0.

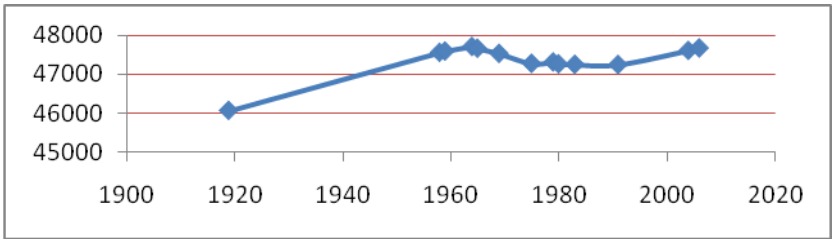


Locations of Repeat Stations

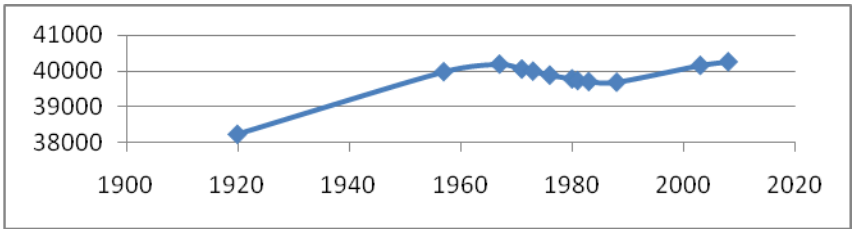
Our study is focused on variation of geomagnetic field & magnetic declination from the data available with G & RB. Weakening of geomagnetic field is cited as one of the causes which indicate reversal of poles. We have selected those repeat stations which reflect an overall picture of India with approx. 100 year data. Variation of total geomagnetic field/force (in nanotesla, nT) on these stations is shown in following charts:



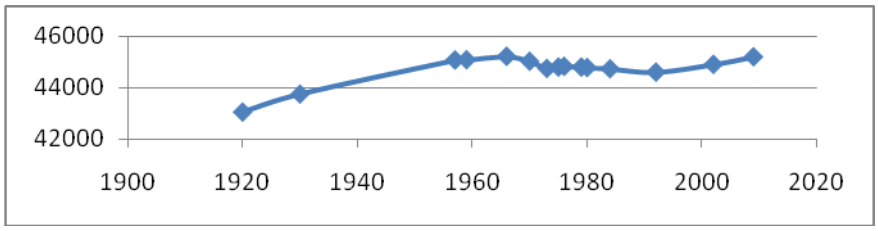
SILCHAR (1919-2006)



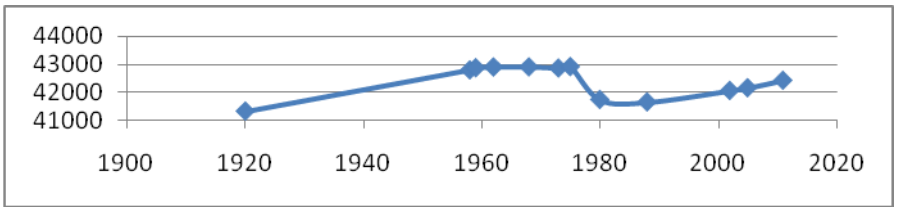
DARJEELING (1919-2006)



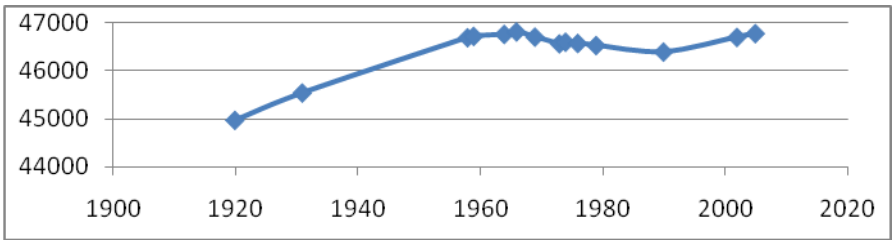
TIRUNELVELLY (1920-2008)



UDAIPUR (1920-2009)



WALTAIR (1920-2011)



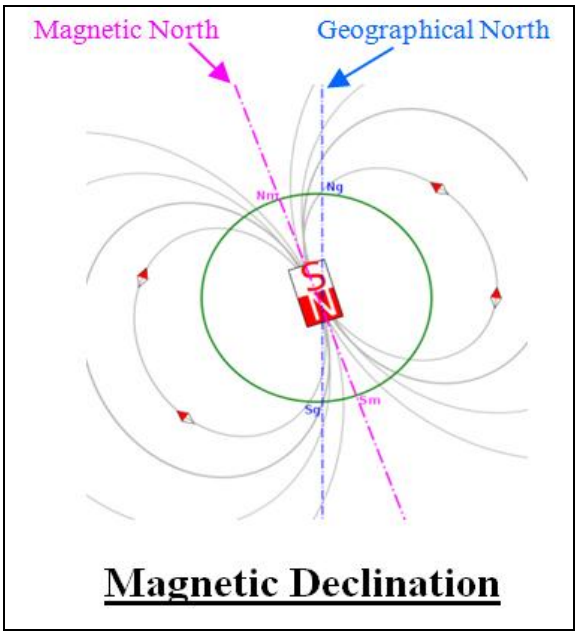
KANPUR (1920-2005)

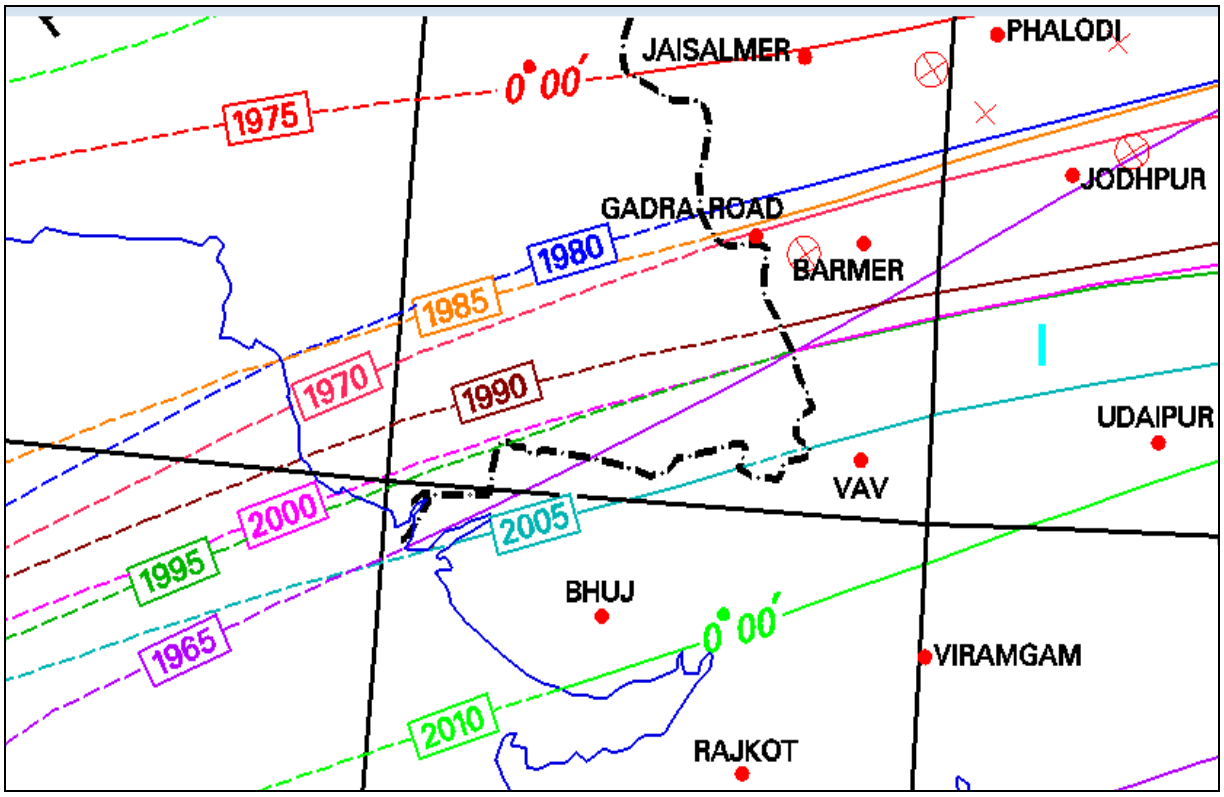
In the above charts, nowhere geomagnetic field seems to weakening in the last approx. 100 years. Also, as stated above, secular variation will be enhanced to such a level that it will cause geomagnetic reversal.

Change in the value of Magnetic Declination is caused by secular variation. It means Magnetic Declination will keep on increasing till the reversal.

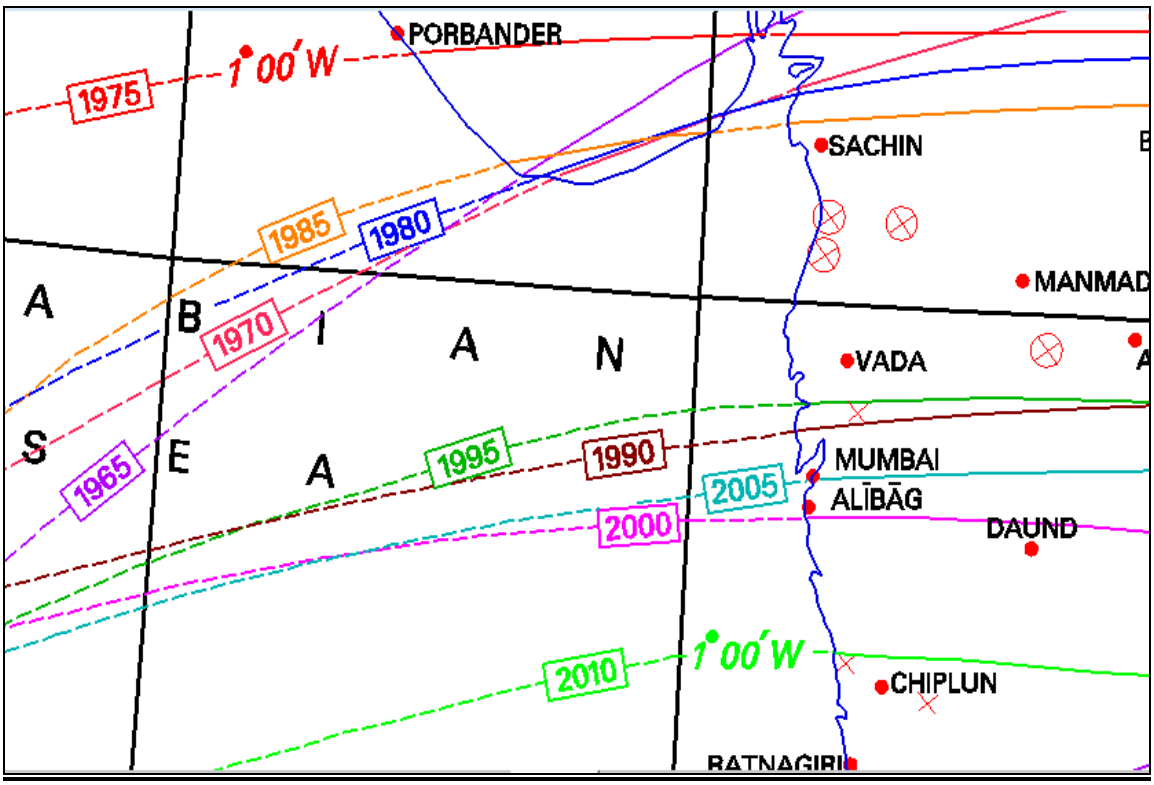
Magnetic Declination can be defined as the angle between Geographical north (or true north) & Magnetic north. It is considered positive when eastward and negative when westward.

For study of variation in Magnetic Declination, isomagnetic lines charts from epoch 1965.0 to epoch 2010.0 (approx. 50 years) have been considered as these are prepared regularly. Year-wise equal magnetic declination lines of some values are illustrated below:

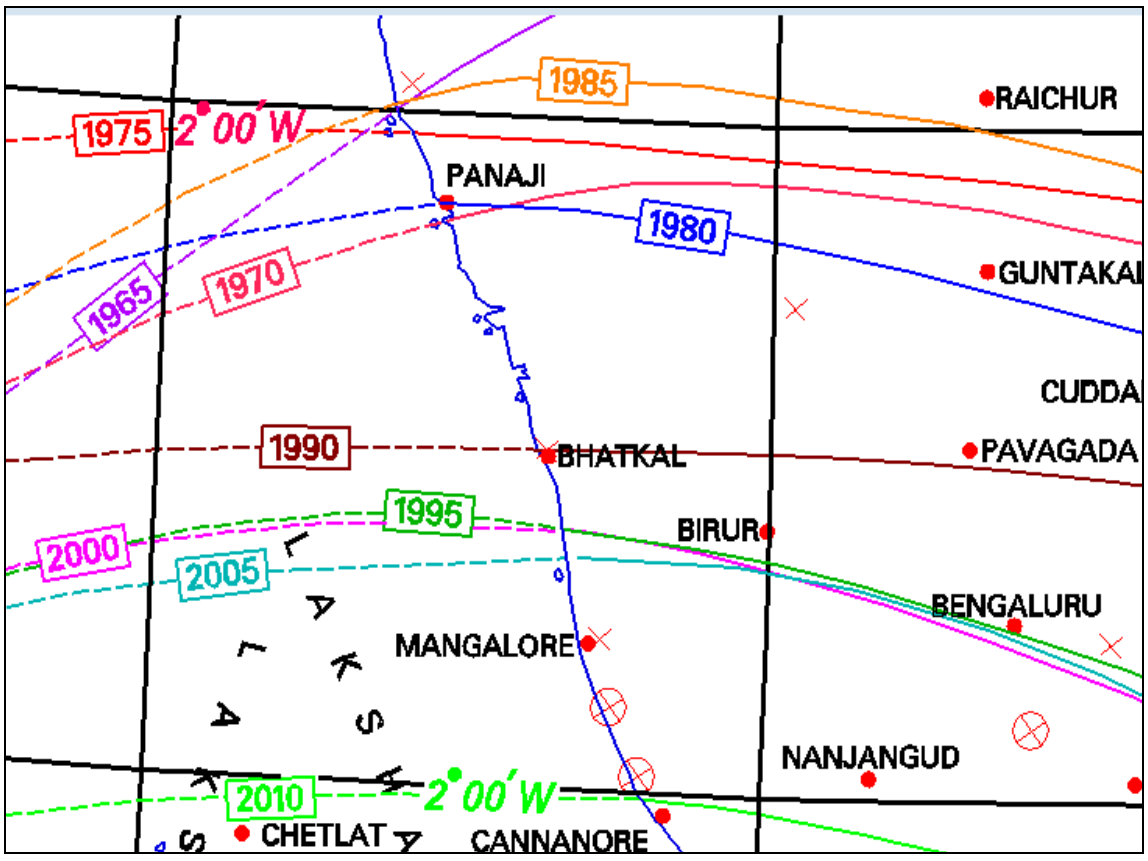




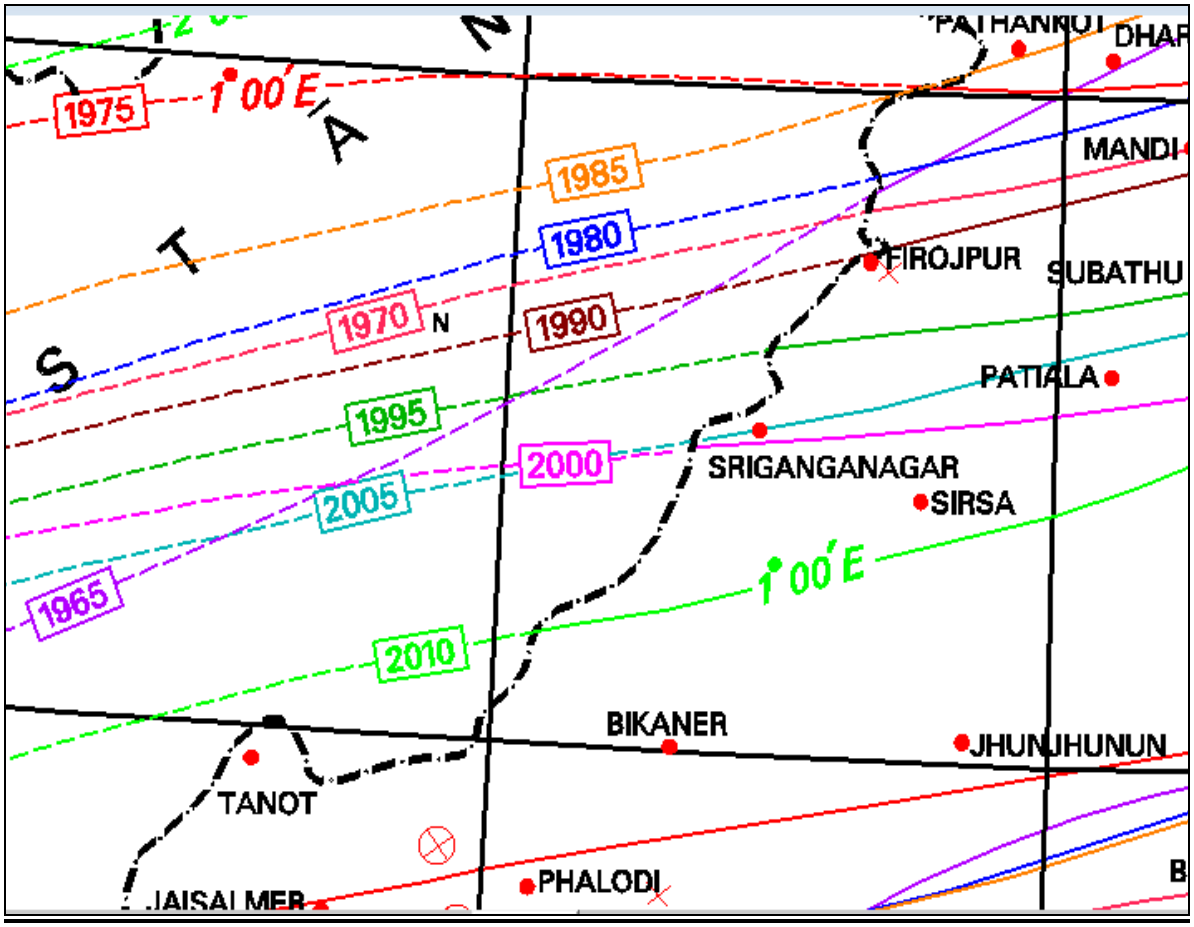
Magnetic Declination lines of value 0° 00' in epochs charts 1965.0 to 2010.0



Magnetic Declination lines of value 1° 00' West in epochs charts 1965.0 to 2010.0



Magnetic Declination lines of value 2° 00' West in epochs charts 1965.0 to 2010.0



Magnetic Declination lines of value 1° 00' East in epochs charts 1965.0 to 2010.0

It is clearly visible from the above diagrams that though declination is increasing from epoch 1965.0 to 1975.0 but it started decreasing and at epoch 2010.0 it has gone below epoch 1965.0 and considering its oscillating trend, it has the tendency of bounce back in future epochs.

Conclusion

1. After analyzing the behavior of geomagnetic field, there is no sign of its weakening in Indian Subcontinent which does not synchronize with the general belief.
2. Moreover, pattern of magnetic declination is also not indicating its sway in one direction in the last approx. 50 years. Rather, it is oscillating without definite periodicity.
3. Therefore, with the above findings, evidence of an imminent Geomagnetic Reversal is weak in Indian Subcontinent.

Resource Mapping for Sustainable Agricultural Planning in Nagalar Sub-Watershed using Geospatial Technology

Bhaskaran G, Gobinath K and Rajalakshmi K
Department of Geography
University of Madras, Chennai
Email : grbhaskaran@gmail.com

Abstract

Resource mapping and management is most required for a region's sustainability and economic stability. Now a day's geospatial technology has emerged as a powerful tool to identify, analyze and predict the natural resources at different level in a reliable spatial format. An attempt has been made in the present study to evaluate both land and water resources for providing site-specific action plan for sustainable development of Nagalar sub-watershed. Individual Thematic layers on 1:50,000 scale for land resources and water resources have been prepared from remote sensing satellite data duly filed-checked and relevant collateral data. By combining both Land Resources with Water Resources using GIS techniques, a composite map on the Resources Potential Zones (RPZ) is derived and correlated with the existing Land use Classes (LC) to bring out another map showing Resources Potential Utilization Zones (RPUZ), which gives information on the extent of current land utilization levels of the study area. The RPUZ clearly shows that the three levels of resource utilization i.e. excessively utilized, underutilized and normally utilized in the study area. Action Plan for Sustained Agriculture Development has been arrived by considering the resources availability of the sub-watershed. The farmer's acceptability for implementing the Action Plan at field level has been studied with large, medium and small farmers. The large farmers readily accepted the scientific results, but the medium and small farmers accepted with some restrictions. The level of acceptability can be correlated with lack of fund, inability to cope with the modern techniques and societal framework. The study proves that the modern geospatial technology is more helpful to identify, analyze the natural resources for the sustainability of any region.

Introduction

The rapid expansion in technology, population and economic activities has also featured the rapid and unsustainable exploitation and depletion of natural resources. In many countries fresh water availability is approaching crisis point; 1.3 billion people do not have access to clean water. It is estimated that 5 million people die annually from water borne diseases. The last 30 years have witnessed a growing understanding that the earth cannot sustain current levels of pollution and utilisation of natural resources. A need for their management has arisen. This is only possible through a continuous effort to survey and monitor the quantitative and qualitative characteristics of the environmental conditions.

The present study attempts to understand the natural resources availability through an integrated approach using Remote Sensing (RS) and Geographic Information System (GIS) and also to understand the role of various terrain parameters in such analysis. A small watershed is taken for the study since it is a basic unit for the interactive parameters such as erosion, slope, soil formation etc., which determine the genesis and type of landuse practice. Moreover, watershed approach for land use management is currently preferred by the union and State Governments for planning purposes.

Natural Resources Studies requires a comprehensive analysis of the terrain conditions (geology, landforms, soil, slope, rainfall and groundwater) and an assessment of natural resources potential, which broadly encompasses land resources and water resources. The integration of remote sensing and GIS paves way for dynamic analysis of thematic layers and information so as the condition of wastelands and resources available in the study area may be identified for wasteland reclamation studies at various levels. The present study, integrating both remote sensing and GIS for sub-watershed level land use management analysis, could be applied to similar problematic areas and terrain conditions.

Study Area

Nagalar sub-watershed, which lies in Theni District of Tamil Nadu, has been selected for the present analysis on Land use management processes. This sub-watershed comprises both agricultural lands and forest area. Nearly 45% of area is covered with wastelands of one category or the other. Majority of the land is covered with permanent fallow lands, salt-affected land, sandy area, scrubs, stony, waste and degraded forests (Fig. 1).

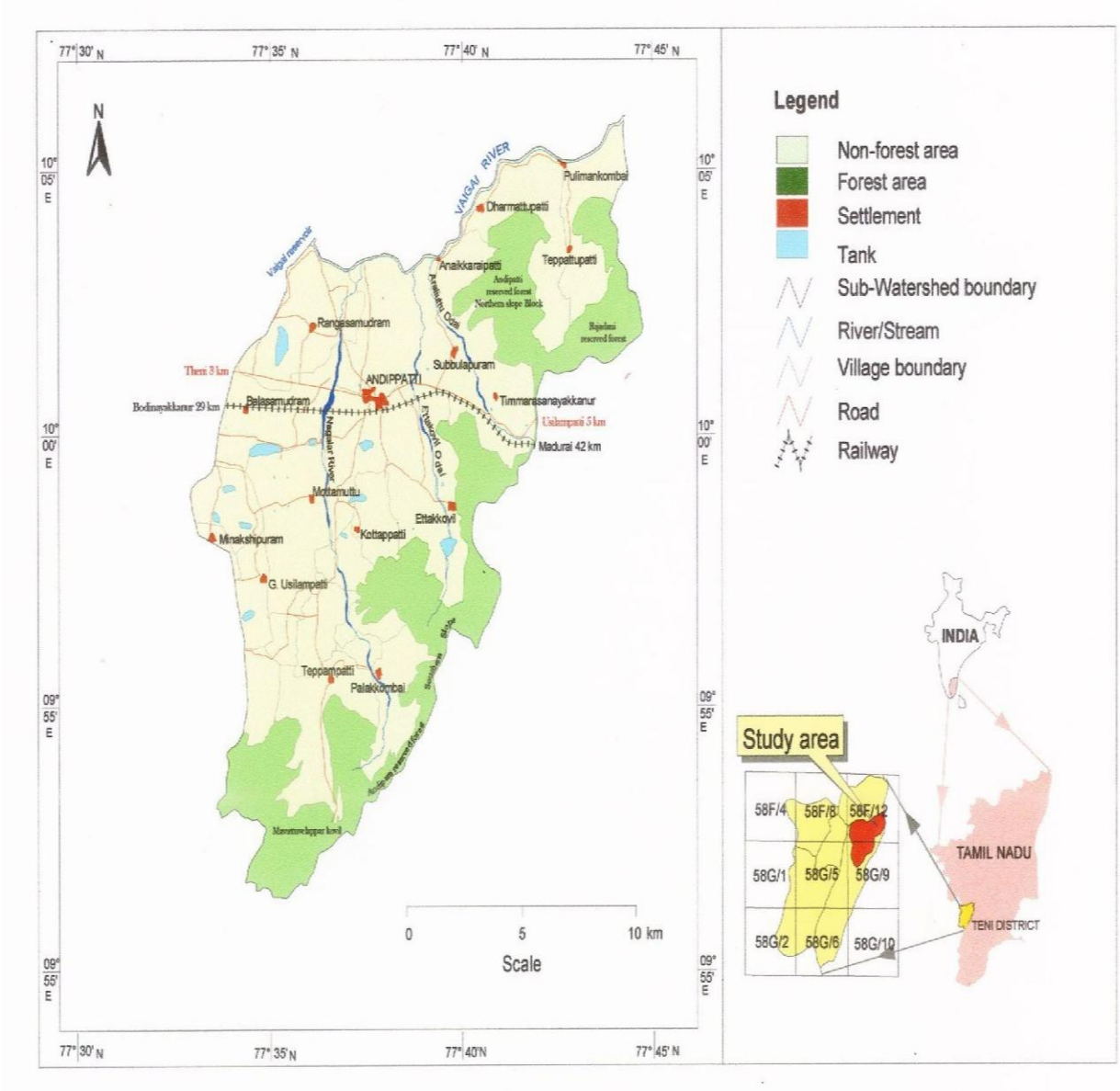


Fig. 1: Study Area – Nagalar Watershed

Nagalar sub-watershed is a typical and individual sub-watershed lying in the Varaha Watershed of Vaigai River. Basin in Southem Tamil Nadu. The areal extent of the watershed is 338.1 sq.km. It lies in the North-eastern part of Andlpattl Taluk them District of Tamil Nadu (Fig. 1). It extends between 9°49'N and 10° 06'N latitudes and 77° 32'E and 77° 45'E longitudes. The length of the watershed is approximately 28 kms. In southwest to northeast direction and the width ranges between 2 and 15 kms in the east-west direction. The watershed comprises 19 revenue Villages, of which 6 villages fall partly and the rest fully, Andipatti Panchayat Union.

The Nagalar sub-watershed appears to be boxed in by the surrounding hills. The altitude varies from 240 meters in the north-eastern part of the study area and steadily increases towards east (298m), south (125m) and southwest (133m). The plains occupy about 54% of the total area of the sub-watershed. The uplands of the study area extend continuously from plains towards southeast and southwest with an average width of 5 kms. The elevation of uplands varies between 320m and 400m above mean sea level. The hilly regions cover nearly 31 % of the total area of the basin and rims around south, southeast and eastern parts of the study area. The hilly region is observed with a few cliffs and escarpments.

The rainfed Nagalar river, Ettakovil Odai and Araliuttu Odai (ephemeral streams) take their sources from Andipattii Hills, descend down along the slopes of these hills and enter the palani. The streams flow towards north and northeast directions in the study area. Along the northern boundary, the Vaigai main river drains the plains. !he entire plain has few rainfed tanks and well, which are the prime source of irrigation in the sub-watershed. There are 12 tanks and 9 small tanks occupying an area of 279.65 ha accounting for 0.83% of the total watershed area. Nearly 1876 dug wells and 475 tube wells were used for irrigation purpose in the study area.

Semi-arid climatic condition prevails in the study area. The study area enjoys seasonal precipitation during southwest and northeast monsoons. The northeast monsoon is more predominant and brings relatively a large amount of annual rainfall (435 mm in average) while the southwest monsoon records an average precipitation of 175 mm. December is the month the lowest temperature(24.7°) is observed. After December, the temperature steadily increases and reaches the maximum during the summer months of April and May.

Since the basin is experiencing varied environmental characteristics such as climate, geology, soil, and drainage, it although smaller in extent, sustains a variety of vegetation, which is one of the great advantages for the introduction of various types of crops. A variety of field plantation crops and trees to sustain soil erosion have been introduced in the area over the years. In general, the cropping pattern of agricultural wetland is paddy, followed by cotton, pulses, banana and sugarcane. In dry lands, only single crop of cotton or mixed cropping of either millet with pulses, sunflower or groundnut with pulses is cultivated. In few areas, fruit trees are also raised with the help of Department of Horticulture.

More than 70% of the total population in the study area is engaged in agricultural activities, either directly or indirectly. Industries services account for a very low employment level. The distribution of agricultural land holding is asymmetrical, marked by sharp inequalities. This is the main reason for the people, as they do not have adequate land or gainful employment year round, to fall back upon the forest resources for earnings. Inconsistency in the onset of monsoon adds another dimension to the problem, rendering most of the agricultural laborers jobless. Seasonal unemployment and fluctuation of income are important economic factors responsible for lowering the standard of living for the inhabitants in general and cultivators in particular.

The present study describes the remote sensing and GIS analysis for evaluating resources potential of the sub-watershed. Creation of thematic layers using remote sensing, field and collateral data is the first step. Second step is Land Potential Zone (LPZ) and Water Potential Zone (WPZ) identification through overlaying analysis using GIS. These two are then combined to arrive at Resource Potential Zone (RPZ) is the third step. Overlaying the Resource availability on cadastral map on 1:8,000 scale and provide suggestion for sustainable agricultural development is the final step. Stepwise process is discussed in details as below:

Resources Potential Assessment at Macro-Level

The information derived from remote sensing data are combined with collateral data such as groundwater details (well yield, resistivity, and borehole logs), to derive information on land and water resource potentials of the study area using GIS techniques. The Land Resources are analyzed to obtain Land Potential Zone (LPZ) and secondly water resources are analyzed to obtain Water Potential Zone (WPZ). These two are then combined to arrive at Resource Potential Zone (RPZ).

Land Potential Zone (LPZ)

To understand the potentiality of Land Resources in the study area, GIS overlay analysis is carried out. Various thematic layers such as geology, geomorphology, soil and slope are considered for the analysis. These layers are the indicators of physical conditions of a terrain or land. Geology of the terrain is considered as a basic unit and accordingly, the significance of slope and landform units of the particular lithological environment are related. This relationship forms the basis for zonation of land potential. For example, a landform of a particular slope may develop certain soil type under a palticular lithologic and climatic condition, which may be used for some specific land use (Majid Ghiassi Far, 2001). Based on this principle, categories in each thematic layer are given proper weightage according to their landuse capability significance and are added to derive the Land Potential Zone map (Fig. 2).

Based on the above analysis, the GIS derived LPZ map is categorized into five zones viz., LPZ-I, LPZ-2, LPZ-3, LPZ-4, and LPZ-5. The *Excellent* degree of land potential is shown as LPZ-I; *very good* degree of land potential as LPZ-2; *good* degree of land potential as LPZ-3; *moderate* and *poor* as LPZ-4 and LPZ-5 respectively. In the LPZ map, the LPZ-I category is located in the eastern part of the study area, where buried pediment (deep and moderate) and flood plains with a gentle slope to flat terrain are observed. Soil condition of this area also indicates very good land use capability and irrigability.

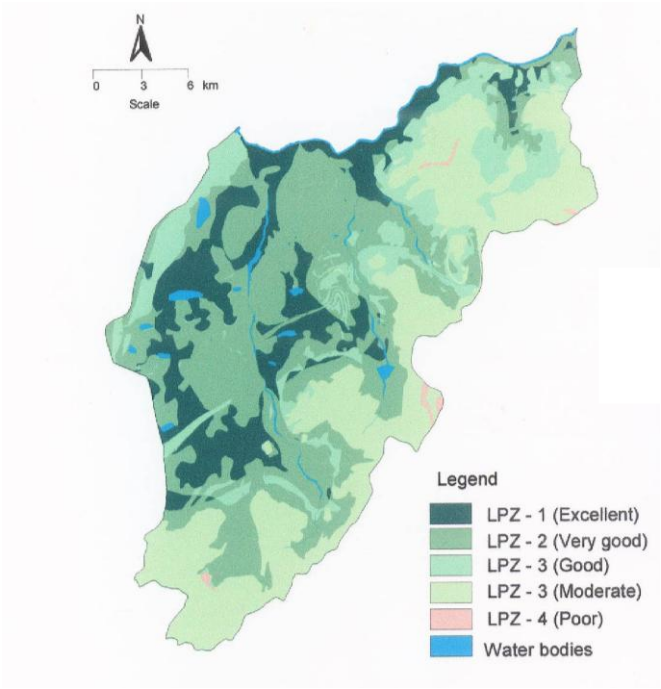


Fig. 2: Land Potential Zone (LPZ)

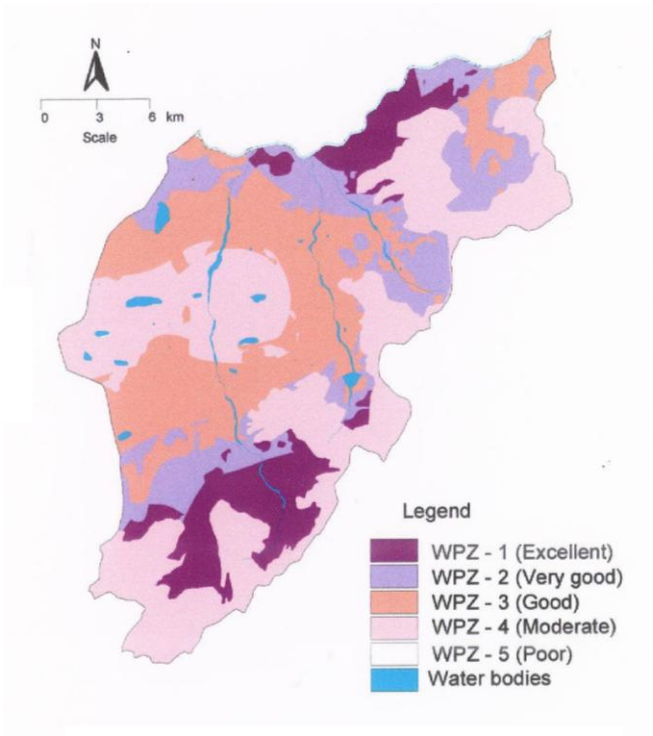


Fig. 3: Water Potential Zone (WPZ)

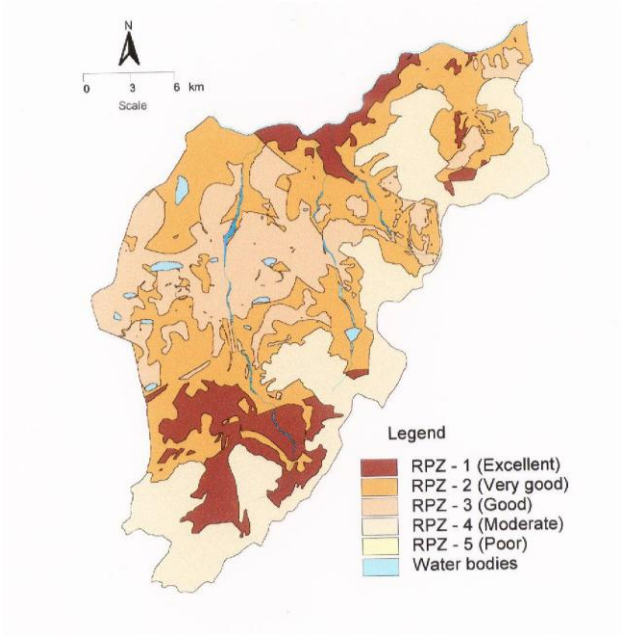


Fig. 4: Resource Potential Zone (LPZ)

This covers an area of 4633.35 ha. (13.7%) of the study area. The LPZ-2 is observed in the central part of the study area, where similar condition as that of LPZ-1, is noted. This covers an areal extent of 13953.60 ha. (41.3%).The LPZ-3 is observed as patches in the eastern, northern and the northwestern parts of the study area. This zone is characterized with pediments, buried pediments of medium and shallow depth, sandy areas and a slope condition ranging from gentle to moderate degree. This covers an area of 5519.3 ha. (16.3%). The LPZ-4 is mainly confined to the western part study of the area, which is covered by structural

hills. This covers an areal extent of 9646.90 ha. (28.5%). The LPZ-5 is seen as few small patches in the western, northern and northwestern parts of the study area and as an isolated patch in the southern part as well. This covers an area of 61.3 ha. (0.2%).

Water Potential Zone (WPZ)

The method adopted in GIS analysis for water potential assessment of the study area is almost similar to that of land potential. The procedures for water potential assessment involved generation of maps showing Water associated with buried pediments of medium and shallow depth, and pediments. Land capability ranges from very good to moderate with certain limitations. This covers an areal extent of 9490.42 ha. (28.1%). An area showing *moderate* (WPZ-4) degree of water potential is mostly restricted to a large patch in the western part and structural hills in the eastern part. They cover an areal extent of 13839.4 ha. (40.9%) of the study area. *Poor* (WPZ-5) degree of water potential is almost negligible and found as smaller patches in the northeastern parts of the study area (Fig. 3). This covers an areal extent of 13.2 ha of the study area.

Resources Potential Zone (RPZ)

It is required to have an overall picture of both land and water resources potential to relate their degree of association with resources utilization. Hence, resource potential of the study area is carried out (combining both LPZ and WPZ) to understand the existing availability of such resources and their subsequent utilization for agricultural practices.

Resources potential of the study area includes both land and water resources. Analysis and discussion of these two resources in the previous sections helped to understand their individual relationships to landuse practices of the study area. In practice, it is essential to understand their cumulative effects and their influence on land utilization (Douglas, 1994). The resources potential of the study area is derived from the GIS overlay analysis of both LPZ and WPZ and the resultant map is categorized into RPZ-I *(excellent), RPZ-2 (very good),* RPZ-3 *(good),* RPZ-4 *(moderate)* and RPZ-5 *(poor).* Among these RPZ-I indicates zone having excellent land potential and excellent water potential. The RPZ-2 as very good land potential and very good water potential and so on (Fig. 4).

Zones showing *excellent* resources potential (RPZ-I) are observed in the flood plains in the northern part and bazada zones in the southern and northeastern parts of the study area. This covers an aerial extent of 5412.35 ha. (16 %). The *very good* resource potential zone (RPZ-2) covers a vast area of 10128.52 ha. (29.95%) and observed throughout the study area except the central and eastern parts. *good* degree of resource potential (RPZ-3), is seen in the central part, covering 8639.2 ha. (25.54 %) of the study area. Resources potentials of both *moderate* and *poor* degrees are conformed to the eastern part along the forest area covering 9608.32 ha. (28.41%) and 26.12 ha. (0.07%), respectively.

The spatial pattern of resources potential map shows that the *excellent* potential tract is mostly associated with fallow lands in the southern and northeastern parts and double crop area in the northwestern (flood plain area) parts. The RPZ-2 *(very good)* is mostly associated with double crop, plantation and fallow lands. It is predominantly associated with double crop and plantation categories in the southern and central pat1s than the western part. It is also seen with a few patches of fallow lands in the northeastern part adjoining the foothills. The RPZ-3 *(moderate)* is associated with double crop and plantation in the central part. This is correlated well with the above analyses (LPZ and WPZ), again indicating its association with tank irrigation. It is also seen with single crop area indicating certain limitations to the agricultural practices, mostly pertaining to utilization of water potential available in the area. Similarly, fallow land is also seen in this area indicating lesser utilization of both land and waters potentials. The RPZ-4 and RPZ-5 are observed in the eastern parts (forest predominant) of the study area.

GIS Analysis for Micro-Level Planning Of Wastelands

After careful observation of the Nagalar sub-watershed on medium scale (1:50,000), a smal1er Pulimankombai mini-watershed (4A2A5a2) has been selected for the large scale GIS analysis. Pulimankombai mini-watershed is located in the northeastern part of the study area. It occupies an area of 4212.36 ha. It is surrounded by Andipatti RF Northern hills on all its three sides and bound by Vaigai Main River in the north. The mini-watershed truly represents the entire study area as it has all types of priority zones available in the study area and also all the land use units such as permanent fallow, salt affected. Land with or without scrub, and degraded forest. There are seven micro watersheds within this mini-watershed from which one mini-watershed (4A2A5a2e) has been selected for the cadastral level analysis (Fig. 5). For detailed investigation and analysis larger scale informations are required and hence, information obtained from large-scale remote sensing data is combined with field data.

The remotely sensed derived thematic map has been taken as input for GIS. It contains only theme information and areal extent. But the details such as field division and ownership are required so that suggestions could be verified in the field. Such details are obtained from the Village Administrative Officer (VAO) of the selected village. Large-scale field sub-division map from Field Measurement Book (FMB) sketch (on 1:8,000 scale) and the respective field

details from the Adangal register available with the VAO are taken as GIS input after transforming the scale to 1: 12,500. Digitized cadastral map derived from remotely sensed data showing land use (1: 12,500) is matched with the above map. This exercise is attempted to create a map using both field divisions and land use categories extracted from satellite image, on 1: 12,500 scale, which is currently treated as 'acceptable' scale by the planners and planning agencies.

Map showing field sub-divisions are compared with the remote sensing derived land use map. During such analysis, a field sub-division occupied by more than 75% of a particular wasteland unit (for example permanent fallow or salt affected) is categorized as the same wasteland unit. Similarly, a permanent fallow land occupying 75% of a field sub-division may be identified as a permanent fallow. This method is adopted for all the land parcels and in this way, field sub-divisions are categorized to show various wasteland units. It also helps in updating wasteland information.

The Resource Potential Zone of *excellent* category has some areas in Permanent fallow of wasteland map, and some in Salt-affected land domain. These are termed as Pf1 and Sal, and they occupy an area of ll.02 ha. 9.76 ha. *very good* Zone of RPZ occurs over Permanent fallow *(Pf2),* Salt-affected land (Sa2) and Land with / without scrub (Sc2) occupying an area of 104.48ha., 5.35 ha., and 59.2 ha. In *good* Zone of RPZ, Permanent fallow (Pf3), Land with / without scrub (Sc3) and Stony waste (Sw3) are formed to occur, occupying an area of 12.13 ha., 74.81 ha., and 323.17 ha. *moderate* Zone of RPZ occur over Permanent fallow (Pf4), Degraded forest (Df4) and Stony waste (Sw4) category of wasteland, occupying an area of 2.88 ha., 439.87 ha., and 4.72 ha. This classification brings out the Potential Zones Available for Wasteland Development, indicating the potentiality in a priority.

Action Plan for Sustainable Agricultural Development Using GIS

Suggestions for reclamation are given under six major categories such as "improved agricultural activities, agro-horticulture, agro-forestry, horticulture, fodder / fuel wood plantation and forest gap plantation. According to the above categories, "improved agriculture activities" include intense agriculture activities with already available soil and water resources or by adopting soil conservation measures. Cropping pattern may include paddy, sugarcane, cotton, millets, ragi and cholam. The term "agro-horticulture" includes mixed agricultural practices with horticultural species.

This may include growing mangoes or citrus fruit trees along with cultivation of dry crops. "Agro-forestry" includes growing of trees (teak) along with cultivation of millets and pulses. This activity is most preferred for wastelands development in areas adjoining croplands (Sankaranarayan, 1988). The term "horticulture" mainly indicates growing of fruit trees such as pomegranate, guava, and mango, citrus fruits apart from vegetables, flowers and herbs.

The above categories may be recommended to reclaim various wasteland units with either "minimal effort" or "maximum effort". Here, the minimal efforts mainly indicate physical constraints such as soil suitability and availability of water for irrigation. Many of the farmers in this area depend upon either monsoon for irrigation or tanks. This may be fruitful during rainy season but during summer many of the lands are left without any cultivation due to lack of enough surface storage for irrigation. Thus, many of the farmers adhere to traditional cropping pattern (cultivating only a particular type of crop) instead of crop rotation causing the land loose its soil nutrients. This may be remedied by crop rotation, soil conservation and use of modem farming techniques, which requires investment from the farmers' side and come under the purview of "maximum effort". The maximum effort also includes digging of bore wells, drip irrigation, crop management (nurseries, manures and pesticides), market potential, trade and transp0l1, and investment for long-term produces such as agro-forestry and agro-horticulture. Based on the above descriptions and combining with the information derived from GIS techniques, suggestions for reclamation of wastelands in both the cadastral sites have been discussed in the following sections.

Pulimankombai mini-watershed-1

The selected site is farming orient with 178.98 ha. of land under cultivation and 40.21 ha. under forest. Suggestions for Sustainable Development based on the available resources in the area, soil condition, slope condition and groundwater potential are arrived at giving two options as discussed (Fig. 6).

Permanent fallow

Permanent fallow is found to occur in all the resources potential zones (from zone 1 to zone 3) except in zone 4. Thus, Pf 1 in *excellent* zone has Pulimankombai and Maravapatt soils series. Slope is flat to gently undulating with *very good* groundwater potential. Soil type and availability of groundwater indicates that Pf1 could be easily reclaimed. The land potential is as good as the cropland; it remains as permanent fallow due to some socioeconomic constraints. During field investigation it was found out that lack of fund was the main reason. Hence, this category of wasteland can be developed into productivity by bringing it under cultivation. The area under this category is 11.02 ha. and a percentage of 7.6 to the total wasteland area.

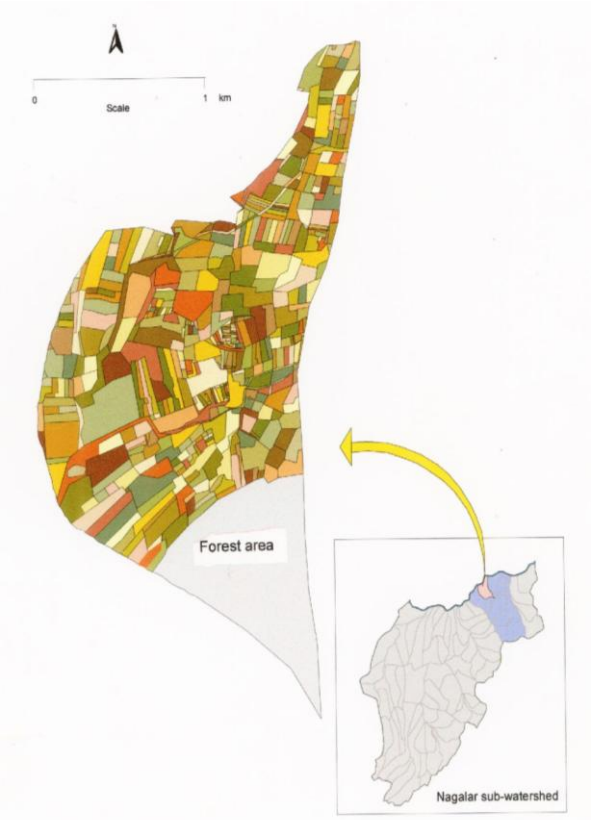


Fig. 5: Study Area - Pulimankombai Mini-watershed (Micro-level study)

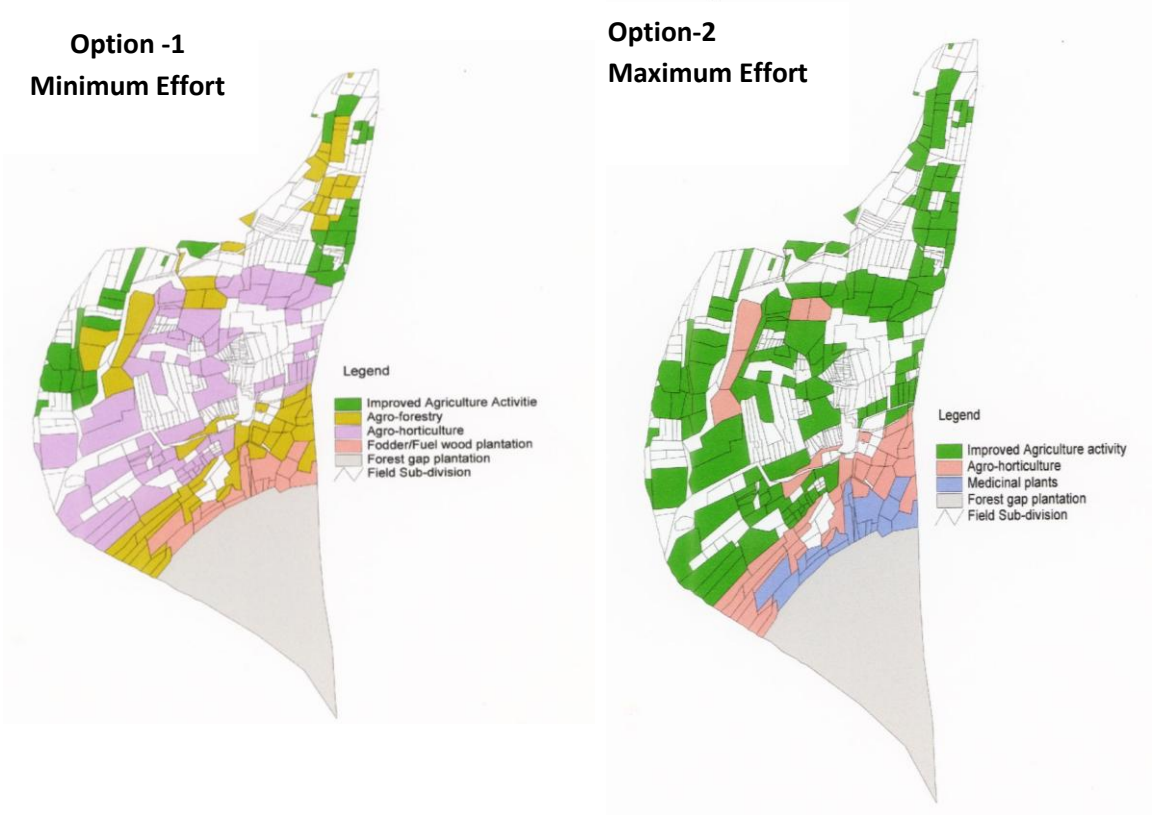


Fig.6 Action Plan for Sustainable Agricultural Development

Permanent fallow falling in zone2 (Pf2) has both Maravapatti and Rajagopalanpatti soil series with a slope percentage ranging from 1 to 5. Groundwater resource is *very good* to *good.* The wastelands falling in this zone may be improved by practicing agro-horticulture method effort and could also be used for improved agricultural activities after adopting adequate conservation measures. The area under this category is 55.98 ha. and a percentage of 38.6 to the total wasteland area. Permanent fallow falling in zone3 (Pf3) has Pudur soil series and moderate slope having *moderate* groundwater resource. This wasteland unit is" suitable for agro-forestry and could be reclaimed for agro-horticulture after applying meticulous conservation measures. Area under this category is 12.13 ha. and a percentage of 8.4 to the total wasteland area. Hence, restoration of cultivation is the chief mode of reclamation suitable for this zone.

Salt-affected

Salt-affected land is a wasteland category, which has lost its productivity only temporarily. If proper measure of reclamation is applied, they condition may be reversed. Salt-affected land is mostly confined to resource potential zone 1 and zone 2. The cause for salinity of the soil may be due to lithology (calcareous in nature) and excessive surface erosion. Salt-affected land that is observed in *excellent* resource potential zone (Sal) has predominantly Pulimankombai soil. The terrain is flat with gentle undulations and the groundwater resource is *very good.* The land may be used for agro-forestry and could be utilized for improved agricultural activities after adopting soil conservation measures. Area under this category is 9.76 ha. and a percentage of 6.7 to the total wasteland area.

Similarly, Sa2 is observed to be associated with Maravapatti and Rajagopalanpatti soils series with *good* groundwater potential. The land may be used for agro-forestry with soil improvement but could also be utilized for agro-horticulture practices when sufficient conservation measures are applied. Soil conservation is the main problem in these units and when appropriate measures are adopted, the land may be well used for growing fruit trees. Area under this category is 5.35 ha. and a percentage of 3.6 to the total wasteland area.

Stony waste

Stony waste falling in zone-3 (Sw3) and observed with Valuttu soil series and steep slope. Ground water potential is also ranging from *good* to *moderate.* This is not suitable for any meaningful land use practice and fodder and fuel wood plantation trees and plants may be grown. Area under this category is 3.47 ha. and a percentage of 2.4 to the total wasteland area. This necessitates another step in verification by interacting with the local people in the cadastral sites. For this purpose counselling was held with the farmers who have been selected from the ownership details pertaining to the problem lands. The villagers are interviewed about adopting suggested reclamation activities in their lands.

Assessing the Level of Acceptability

The attribute data of cadastral site is used to identify farmers and their land holding capacity, which is used in the assessment of level of acceptability. Farmers are categorized into large, medium, small and marginal based on their land holding capacity and has been interviewed for their acceptability of the suggestions for Sustainable Development. The Action Plan for Sustainable Development may be carried out either with minimum effort or by adopting conservation measures (maximum effort) and accordingly these two suggestions have been forwarded to each farmer. Totally, 47 farmers have been selected covering the entire micro-watershed. Among them, large farmers constitute 4 numbers, 6 medium farmers, 12 and 25 numbers of small and marginal farmers respectively.

Summary

There is a clear distinction in suggestions for reclamation of wasteland categories observed in both the sites. The selected cadastral site, which is agriculture predominant, people are more inclined to growing traditional crops. When conditions such as monsoon, do not favor them, they work as agricultural laborers. At the same time, lack of fund and lack of awareness cause the local community to look for alternatives for subsistence instead of agriculture, leaving their land barren. Though the local farmers agreed to the suggestions, they are reluctant in adopting conservation activities, which involves money and intensive labour. The government and other voluntary organizations should help in restructuring the land use practice and thus avoid further degradation of land. The present study clearly proves the need of large scale natural resource information which has been generated from geomatic toll is very much useful for sustainable planning.

References

1. Douglas P.S.(1994), 'Resources Management Perspective; Practical consideration for using GIS and remote sensing at the field level', Remote sensing and GIS in ecosystem management Isand Pres, Washington, pp.140-156.

2. Majid Ghiassi Far (2001).'Land use/ Landcover mapping by integrating remote sensing and Geographical Information Techniques', ICORG, pp.99-107.

Spatial Variation of Cropping Intensity in Kerala - A Case Study

Lekshmi G.S, Dani V, Veena Surendran and E Saravanan
Centre for Earth Science Studies, Training and Extension Division, Akkulam, Thiruvananthapuram-695031
E-mail: girijalekshmi@yahoo.co.in

Abstract

Agriculture is the most important sector in the economy of India. Any development or underdevelopment in this sector will affect other economic activities of the country. Agriculture will continue to remain India's leading economic activity both in its contribution towards Gross National Product and employment opportunities in the rural areas.

Kerala state lies at the south-western part of India covering an area of 38863 sq. kms. is basically an agrarian state. The density of population is 859 sq.km. (Census 2011). The state is blessed with 44 rivers having the water resources rich in its potential. It is one among the state in India where canals, tanks and wells are the major source of irrigation. Kerala's agriculture economy has undergone to such a transformation which can be measured in terms of its cropping intensity.

The present paper is an attempt to study the extent of intensification of agriculture in the state and to find out the factors responsible for increase and decrease in cropping intensity. To analyse the cropping intensity of the state, ten years data (2001-2010) were used. Thematic maps were prepared using GIS (Arc Gis software version 9.3) to show the cropping intensity. The study shows that cropping intensity is very high in Wayanad District and very low in Kasargod District. In the present study an attempt is made to highlight the factors that influence the cropping intensity in the state. Finally suggestions were made in terms of short and long term measures to improve the cropping intensity of the state.

Introduction

Agriculture plays an important role in the present stage of the development of India's economy. For a well planned agricultural development a sound national policy covering both the location specific and people specific aspects in a coordinated manner is a prior requirement. Crops are the major index of agricultural typology. Agriculture is the mainstay of the rural masses in Kerala. Nowadays, the traditional mode of agricultural production with low output from cultivated land has failed to support the overwhelming majority of rural population. Cultivated land is over crowded by the surplus agricultural workers along with their dependents. Population pressure on agricultural land has a tendency to intensify the cultivation of the limited land with two or more crops in an agricultural year in order to compensate the decrease in land/man ratio. Intensity of cropping refers to the number of crops raised on a field during an agricultural year. Intensive utilization of the net sown area for more than one crop is beneficial for increasing agricultural production. Multiple Cropping is necessary in order to increase the production of crops in the region sufficiently so that the needs of the increasing number of people are satisfied.

Study Area

Kerala lies between 8°.8' to 18^0.48' North latitude and 74°.4' to 77°.50' East longitudes (Fig.1). The topography of the state varies from the hilly ranges of Western Ghats in the east to presence of lakes and coastal plains in the western region. Physiographically the area has been divided into highlands, midlands and lowlands. The state is blessed with forty one west flowing and three east flowing rivers.

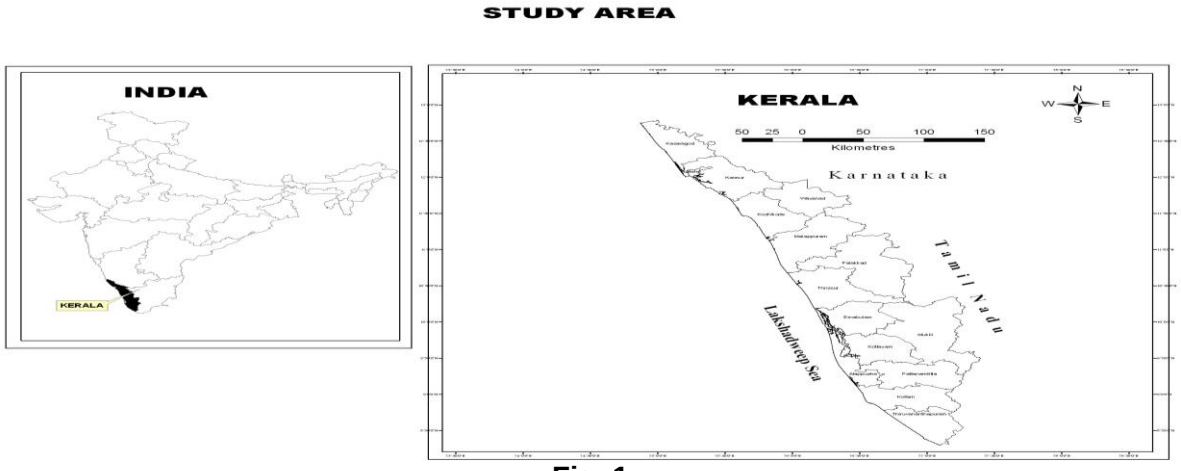


Fig. 1

Aims and Objectives

- To assess the cropping intensity of Kerala.
- To find out relation between population pressure and cropping intensity.
- To measure the factors responsible for increase and decrease in cropping intensity in the state.

Review of Literature

Similar type of work has been carried out in this field. Das M.M (1979) examined the population pressure and intensity of cropping in the state of Assam. Das Sarbeswar and Das M.M (1994) studied about the Intensity of Cropping in the South Bank Region of Kamrup District in Assam. Ishrat Saeed Khan M (1996) assessed about the Cropping Intensity in Village Sia-Khas.

Data Sources

Secondary Source of Data collected from Department of Economics and Statistics, State Planning Board, Census of India 2011, Survey of India Toposheets.

Methodology

The present study is based on secondary data. Here the average area and production of 10 consecutive years (2001-2010) have for taken to calculate the cropping intensity of the state. For measuring the intensity of cropping, standard statistical techniques were used. To know the relationship between cropping intensity and population correlation co-efficient techniques has been used. Arc Gis 9.3 version is used for the preparation of thematic maps.

Results

Intensity of Cropping (Fig. 2) is high in Wayanad (173.84). Wayanad is the major producer of plantation crops, spices, fruits and vegetables etc…Palakkad stands next to Wayanad with an index of 158.41, where rice cultivation is dominant. Medium cropping intensity districts are Kollam (137.83), Kozhikode (139.49), Malappuram (136.50), Thrissur (136.65), Ernakulam (126.78), Alleppey (133.67), Idukki (133), Trivandrum (125.85), Kottayam (128.73) and Pathanamthitta (128.80). In most of the above districts, coconut is the major crop followed by rice, rubber, spices, fruits and vegetables. Intensity of Cropping is low in Kasargod with an index of 110.28. Kannur (123.31) stands next to Kasargod. Less irrigation facilities and environmental problems are the major problems in these districts for utilization of crops.

An attempt has been made to test the hypothesis that there exists a positive correlation between total rural population and cropping intensity. The correlation between the two variables is found to be 0.19 which is very insignificant. The correlation coefficient between the percentage of rural population in all districts of the state and cropping intensity is found to be 0.40. It shows the positive correlation. The correlation coefficient between the percentage of rural population in the state and cropping intensity is found to be 0.20, where it is insignificant.

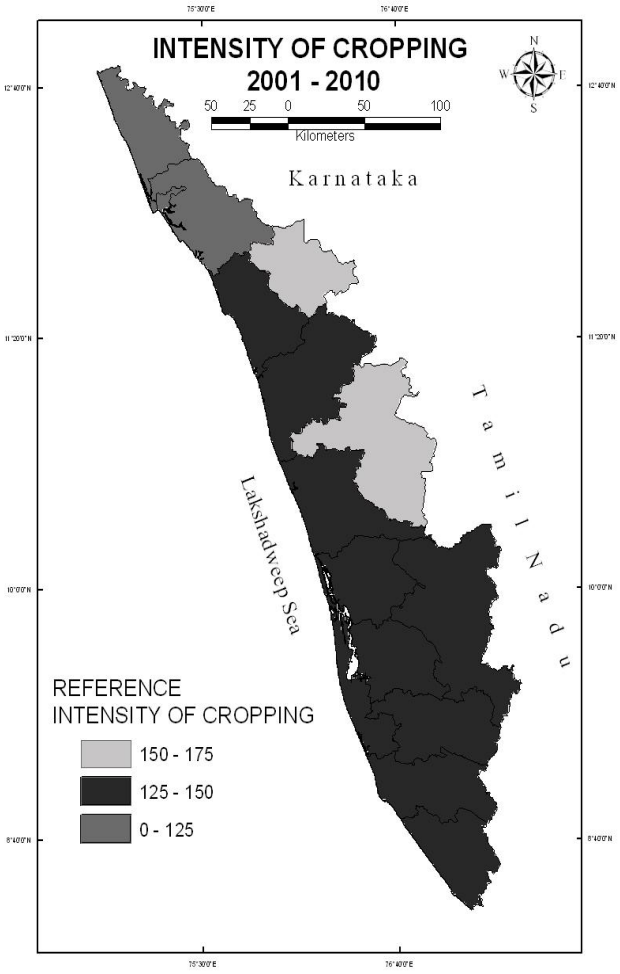


Fig. 2.

Irrigated Area is other factor which affects the intensity of cropping in the region. Therefore an attempt has been made to test the hypothesis that there exists a positive correlation between percentage of irrigated area and cropping intensity. The correlation coefficient between the percentage of irrigated area and cropping intensity is -0.05, which is negative is found to be very insignificant. An attempt has been made to test the hypothesis that there exists a correlation between percentage of area sown more than once and cropping intensity. The correlation coefficient between the percentage of irrigated area and cropping intensity is 0.80, which is highly significant.

Conclusion and Suggestion

From these above results, it is inferred that there exists a positive correlation between cropping intensity and rural population, percentage share to rural population of the state, percentage share to rural population of the district and area sown more than once. Negative correlation is seen between cropping intensity and area irrigated. The availability of farm labourers and irrigation projects facilitated high cropping intensity in Wayanad. Similarly high cropping intensity recorded in Palakkad is due to good irrigation facilities. Other districts like Thiruvananthapuram, Malappuram, Ernakulam, Kottayam, Kollam, Thrissur, Alappuzha are having medium cropping intensity. Inadequate irrigation facilities and serious environmental problems viz.pesticides are responsible for the low cropping intensity in Kasargod.

From the above study it is clear that there is considerable scope for increasing the area under double or multiple cropping, though there is physical limitation of cultivable land in Kerala. In some rural areas as the population is more, the peasants are forced to intensify their agriculture by their own traditional methods of cultivation. Fertilizers, improved seeds, pesticides and insecticides are the modern inputs for the development of agriculture in the state. By applying these modern inputs in agriculture, real development can be achieved. All kinds of efforts will increase the intensity of cropping in the region in order to achieve higher level of agricultural production and productivity.

References

1. Department of Economics and Statistics, Agricultural Statistics 2001-2010, Government of Kerala, Thiruvananthapuram.
2. State Planning Board, Economic Review 2010, Government of Kerala, Thiruvananthapuram.
3. Das M.M (1979*), Population Pressure and Intensity of Cropping in Assam*, Geographical Review of India, Vol. 41, pp105-114.
4. Das Sarbeswar and Das M.M (1994), *Intensity of Cropping in the South Bank Region of Kamrup District*, Geographical Review of India, Vol. 56, pp34-42.
5. Ishrat Saeed Khan M (1996), *An Assessment of Cropping Intensity in Village Sia-Khas: A Case Study*, Geographical Review of India, Vol. 58, pp153-161.
6. Department of Economics and Statistics, Statistical Hand Book Kerala (2005), Government of Kerala, Thiruvananthapuram
7. Census of India 2011, Series1, India, Provisional Population Totals: Rural and Urban Distribution, Paper 1 of 2011.

Crop Combination Regions of Kerala

Lekshmi G.S, Dani V, Veena Surendran and E Saravanan
Centre for Earth Science Studies, Training and Extension Division, Akkulam, Thiruvananthapuram-695031
E-mail: girijalekshmi@yahoo.co.in

Abstract

Studies of crop combination regions nowadays play a significant role in the discipline of Geography of Agriculture. It provides a good basis for regional planning. This type of study will vary from small region to the entire country. Five years (2005 to 2010) average of crop data, district wise were used for the study. The present paper is an attempt to study and to delineate the patterns of crop combination regions in Kerala, by applying the arbitrary choice method, the minimum deviation method advocated by Weaver and the maximum deviation method advocated by Rafiullah. The findings of crop regions will determine the regional frame work of agricultural activities and specialization of crops in the study area. In this study, seventeen important crops of Kerala have been selected. The crop data were analysed, and delineated the crop combinations of the state. It was found that the arbitrary choice method and both Weaver's and Rafiullah's method and was best suitable to demarcate the crop combination regions of Kerala which is truly fitting with the physiographic conditions prevailing in this region.

Based on the analysis, thematic map was prepared using GIS (Arc GIS Software Version 9.3) and the different crop combination regions were identified in the fourteen districts of Kerala. The study reveals more number of crop combinations (9) which can be seen in Malappuram, Kozhikode and Kannur. In these districts, coconut is the major crop followed by fruits and vegetables as second ranking crop. Three crop combinations can be seen in Wayanad and Alappuzha districts. Plantation is the first ranking crop and Spices is the second major crop in Wayanad district. Coconut is the first ranking crop and Rice is the second major crop in Alappuzha district. The statistical methods used in the delineation of crop combination regions of Kerala highlight the important crops that enter the crop association. The maximum deviation method by Rafiullah's method gives better precision in the demarcation of crop regions as it simplifies the maps of crop association.

Introduction

The study of crop combination regions provides a good basis for agricultural regionalization. The crops are generally grown in combinations. Crop combination analysis is one of the vital methods for studying agricultural patterns and it provides a comprehensive basis for basic regional planning for rural areas. In the recent trends in agricultural geography greater attention is paid towards the study of crop combination. It is more useful and problem oriented aspect to find out the causes of certain crop combination in some environmental conditions and to see how far the physical as well as socio-economic conditions influence a specific crop combination. The study of crop combination regions constitutes important aspects of agricultural geography. With the development of better irrigation facilities, high yielding varieties of crops will improve the agricultural system.

Study Area

Kerala is the south western most state in India (Fig. 1). The state covers a total geographical area of 38863 sq.kms. It had a population of 33.3 crores. The state is wedged between the Lakshadweep Sea and the Western Ghats. The state has a coastal length of 590 kms. The width of the state varies between 11 and 121 kms. Geographically Kerala can be divided into three regions: the eastern highlands, the central midlands and the western lowlands. Forty one west flowing rivers and three east flowing rivers originate in the region of Western Ghats. Periyar, Bharathapuzha, Pamba are the major rivers in the state. The eastern part consists of high mountains, gorges, valleys etc.

The western part consists of lakes, estuaries and lagoons. The geological setting of Palakkad Gap is favourable for cotton cultivation. Anaimudi, the highest peak in South India is situated in this state. Kerala has a wet and maritime tropical climate influenced by the seasonal heavy rains of the south west and north east monsoons. The average rainfall of Kerala is 3107 mms. Coconut is the most dominant crop grown. Kerala stands first in the production of spices and rubber.

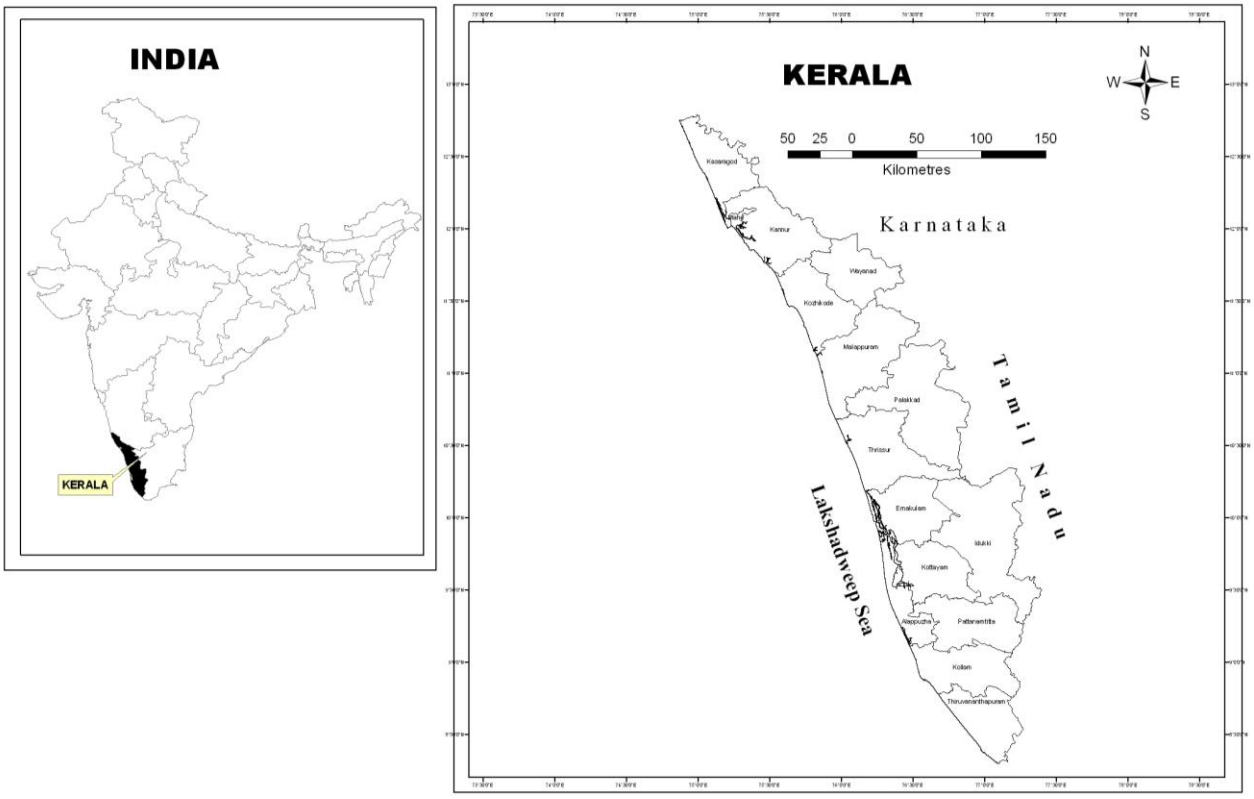


Fig. 1: Study Area

Aims and Objectives

- To assess the crop combination regions of Kerala by using the arbitrary choice method, the minimum deviation method advocated by Weaver and the maximum deviation method advocated by Rafiullah.
- To know the general crop statistics in the state.
- To delineate the crop association in all districts of Kerala.

Review of Literature

Similar type of work has been carried out in this field. Majid Hussain (1972) examined the crop combination regions of Uttar Pradesh. Sangeeta Bhatt and Harsh.P.Bhatt (1999) studied about the crop diversification and crop combination in Uttar Kashi. Neeraja.K, Krishna Reddy.B and Ramanaiah.Y.V (2004) explained the crop regions, crop combinations and crop diversification in Nellore District in Andhra Pradesh. Singh Surendra (1987) studied about the hierarchical crop regions of Uttar Pradesh. Krishnakumari.A and Swaminathan (1999) explained the Changing Farming Scene in Nellore District in Andhra Pradesh. Teli B.L (1989) also studied about crop combinations in India. Todkari G.U, Suryawanshi S.P, Suryawanshi M.V and Patil B.D (2010) examined about the agriculture landuse pattern in Solapur District of Maharashtra.

Methodology

The present study is based on secondary data. Here the average area and production of 5 consecutive years (2005-2010) was used to know the crop combination regions in the state. District has been taken as the areal unit of study. To study the crop combination regions of the state arbitrary choice method, the minimum deviation method by Weaver and the maximum deviation method by Rafiullah were used. Arc Gis 9.3 version is used for the preparation of thematic maps.

Results

Seventeen major crops like coconut, fruits& vegetables, rubber, spices, arecanut, rice, other non food crops, cashew, tapioca, tubers, plantation, palmyrah, pulses, oilseeds, cereals, sugarcane, cotton etc. were considered for crop combination analysis. Maps were prepared by using Arc GIS 9.3 software. Crop combination maps were prepared on the basis of

Arbitrary Choice Method (Fig. 2), Weaver's and Rafiullah's method.

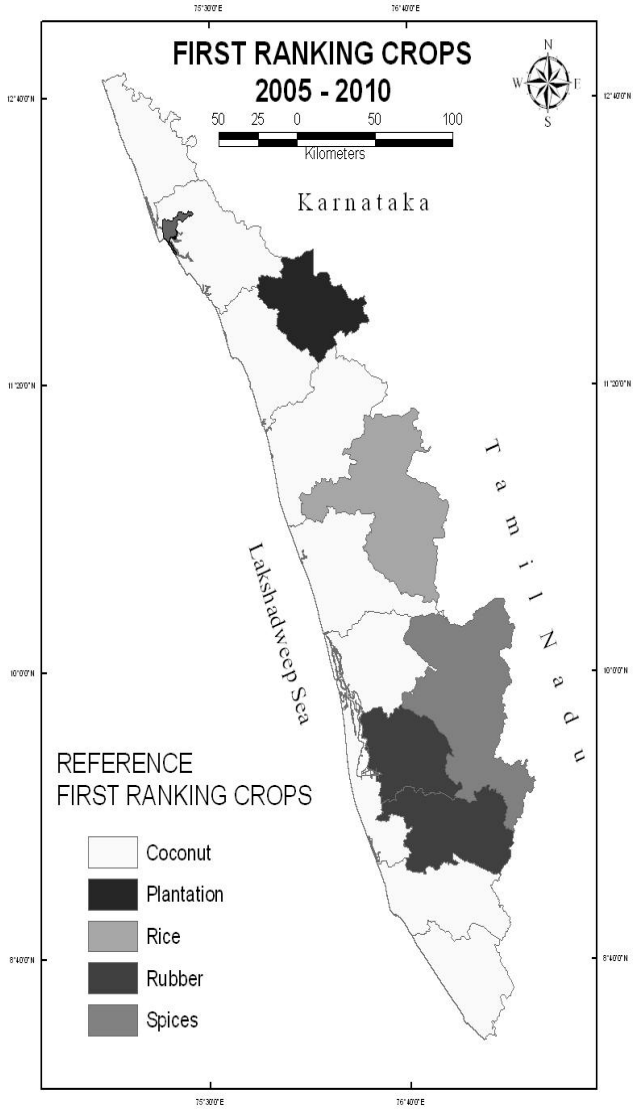


Fig. 2: Map from Arbitrary Choice Method

Based on Weaver's method (Fig. 3) there are three to nine crop combination regions were identified in the state. Malappuram, Kozhikode and Kannur are having the highest crop combination regions (9) where coconut is the first ranking crop. The results derived from Weaver's method shows that Trivandrum, Kollam, Kottayam, Thrissur and Kasargod districts having 8 crop combination regions, where coconut is the major crop. Palakkad and Idukki districts have 6 crop combinations, where rice is the dominant crop in Palakkad and spices in Idukki. Ernakulam and Pathanamthitta have 4 crop combinations where rice is the major crop in Ernakulam and rubber in Pathanamthitta. Alappuzha and Wayanad is having the least crop combination regions (3) where coconut is the first ranking crop in Alappuzha and plantation in Wayanad.

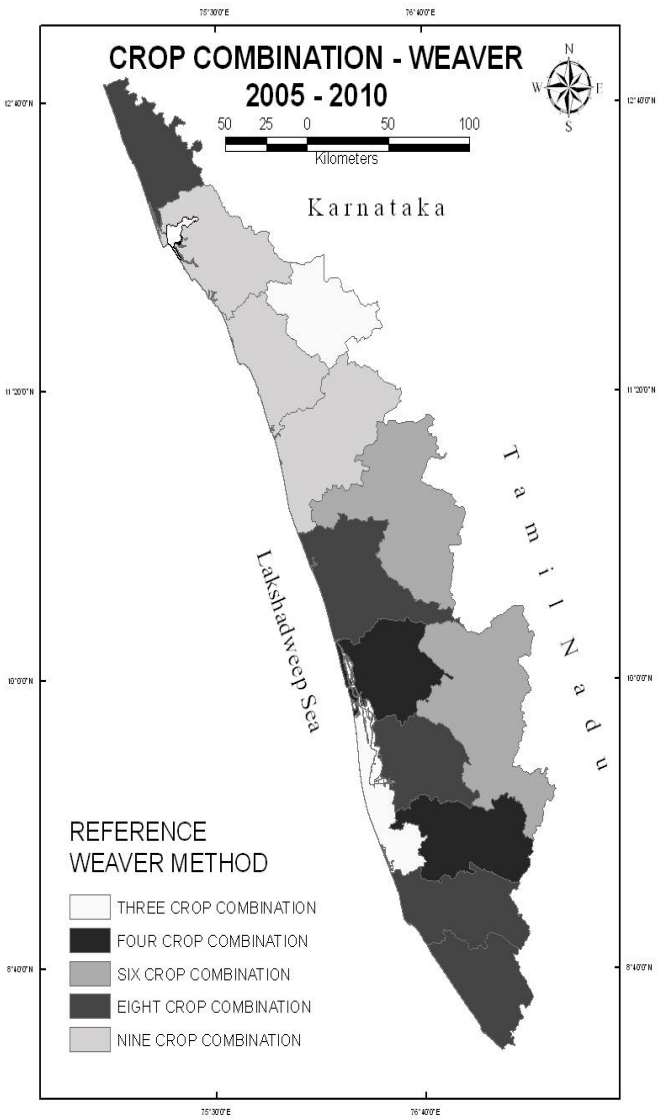


Fig. 3: Map from Weaver's method

The results derived from Rafiullah's method (Fig. 4) shows only monocrop and two crop combinations. Trivandrum, Alappuzha, Kottayam, Thrissur and Kozhikode are having two crop combinations. Kollam, Pathanamthitta, Idukki, Ernakulam, Palakkad, Malappuram, Wayanad, Kannur and Kasargod are having only monocrop. Coconut is the major crop in Trivandrum, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasargod. Rubber is the dominant crop in Kottayam and Pathanamthitta. Rice is the major crop in Palakkad. Spices are the first crop in Idukki and Plantation is the major crop in Wayanad.

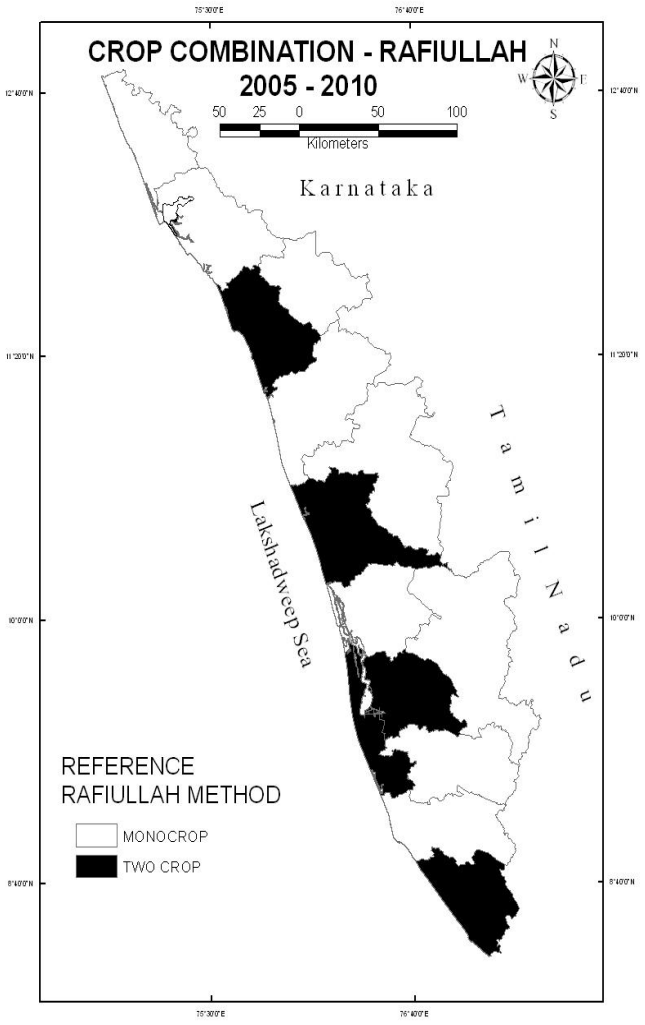


Fig.4: Map from Rafiullah's method

Conclusion and Suggestion

The aim of the present paper is been to delineate the crop combination regions of Kerala by using the arbitrary choice method, the minimum deviation method by Weaver and the maximum deviation method by Rafiullah. The application of the arbitrary choice method e.g. first crop only, first two crops or first three crops is not judicious as by doing so the rest of the crops are being excluded without any consideration of their percentage weightages. The demarcation of crop combination regions reveals that coconut is the major crop in the state. It shows that the area under rice is decreasing. Rubber is the second major crop in districts like Trivandrum, Kollam, Ernakulam, and Kasargod districts.

The above study reveals that the high crop combination districts indicate the impact of institutional and technological factors in the region. The districts characterized with low crop combinations need special attention on priority basis so that their production level could be raised. The statistical approaches applied in the delineation of crop regions of Kerala bring to light the major crops which enter the crop associations. The maximum positive deviation method gets ascendancy over weaver's method as it reduces the number of crops in the combination and thus simplifies the crop association maps.

References

1. Department of Economics and Statistics, Agricultural Statistics 2001-2010, Government of Kerala, Thiruvananthapuram.
2. State Planning Board, Economic Review 2010, Government of Kerala, Thiruvananthapuram.
3. Hussain Majid (1972*), Crop Combination Regions of Uttar Pradesh a Study in Methodology*, Geographical Review of India, Vol 34, pp134-156.
4. Sangeeta Bhatt and Harsh.P.Bhatt (1999), *Crop diversification and Crop Combination in Uttar Kashi*, Geographical Review of India, Vol 61, pp398-404.
5. Neeraja. K, Krishna Reddy. B and Ramanaiah.Y.V (2004), *Crop Regions, Crop Combinations and Crop Diversification in Nellore District, Andhra Pradesh*, The Indian Geographical Journal, Vol 79, pp45 – 50.
6. Singh Surendra (1987), *Hierarchical Crop Regions of Uttar Pradesh*, Indian Journal of Regional Science, Vol 10, 1978, pp57 – 62.
7. Krishnakumari. A and Swaminathan (1999), *Changing Farming Scene in Nellore District, India,* The Indian Geographical Journal, Vol 65, pp123-129.
8. Teli B.L (1989), *Crop Combinations in India*. The Indian Geographical Journal, Vol 64, pp 96-98.
9. Todkari G.U, Suryawanshi S.P, Suryawanshi M.V and Patil B.D (2010), *Agriculture Land use Pattern in Solapur District of Maharashtra.* International Journal of Agricultural Sciences, Vol 2, pp 01-08.

Application of Geospatial Technology in Change Detection of Snow Cover Area of Great Himalayan National Park, Himachal Pradesh

Ansul Sood
Research Scholar, Dept. of Geography
North-Eastern Hill University
Umshing, Mawlai, Shillong, Meghalaya
Email: meetme_anshul@yahoo.co.in

Abstract

The Great Himalayan National Park, the newest National Park of India, was notified in 1999. The snow bound area of the National Park covers about 18,825ha which is approximately 16% of the total land cover of the Park. The permanent snow cover provides the natural boundaries on the northern, eastern and southern extent of the Park.The snow cover plays an important role in maintaining the ecology of the Park as it provides habitation to most of the unique faunal species like snow leopard, blue sheep, Himalayan musk deer etc. Beside the biological significance, it also has hydrological significance as the National Park is the origin of four major rivers viz., the Tirthan, Sainj, Jiwa Nal and Parvati which add water to the Beas River flowing through Kullu Valley. The rivers are main source of water for the rural and urban settlements of the Valley. Nowadays, climate change is affecting the snow cover the world over including the Himalaya, The availability of geospatial technology like remote sensing and GIS is helpful in examining the effect of climate change on the snow cover area of the National Park. The present study is based on the satellite imageries of two different seasons for the identification of snow cover area of two periods. The identification of snow cover area is based on NDSI which is calculated using TOA reflectance value instead of image DN. The accuracy of the classified image is satisfactory. The study reveals that the snow cover area has reduced largely which may affect the ecology of the National Park.

Introduction

Study of snow cover is very important in this era of global climate change. As the snow cover is a key indicator of the regional and global climate (Hall et al. 1995). The glaciers in snow cover areas are the major source of fresh water and give birth to various rivers. The mapping of snow cover area is also useful in modelling of snowmelt runoff and avalanche forecasting, which claims lives and property each year (Sharma et al. 2004). In high altitude protected forests and National Parks snow cover area also plays an important role in maintaining the ecology by providing habitation to unique flora and fauna found in these areas (Keller et al. 2005). The study of change detection of permanent snow cover in these areas is also helpful to monitor these fragile habitats.

With the advancement of geospatial technology and techniques like remote sensing, GIS etc. the monitoring and mapping of snow cover change become possible in less time, with low cost and with high accuracy. The satellite image provides information pertaining to spatial distribution of snow having various parameters of hydrologic importance, which is of great importance for snow hydrologists (Dozier, 1984). The spectral signature of snow is high in visible part (0.4μm-0.7μm)of electromagnetic spectrum because of its high albedo, which makes it easily detected by the satellite sensors. However, the limitation of cloud cover is always there as the spectral signature of both snow and cloud are high in visible region of electromagnetic spectrum. Another difficulty in mapping of snow cover area in rugged mountainous terrain is hill shadow, under which the snow appears to be dark. Identifying the snow signature under shadow is a tedious task which can be possible only through geospatial technology.

In the light of above discussion an attempt has been made in this paper to show the change detection of snow cover area in the Great Himalayan National Park area of Himachal Pradesh using geospatial technology.

Study Area

The Great Himalayan National Park, the newest National Park of India, was notified in 1999. Administratively it lies in Kullu district of Himachal Pradesh (Fig. 1). Its geographical extent lies between 31° 38' 15" & 31° 56' 41" North latitudes and 77° 20' 00" to 77° 52' 11" East longitudes. The total area of Great Himalayan National Park Conservation Area is 1171 sq.kms. its aerial estimation consists of GHNP-754 sq.kms, Sainj Wildlife Sanctuary-90 sq.kms., Tirthan Wildlife Sanctuary-61 sq.kms. and Ecozone-265 sq.km. The altitudinal range is between 1700-5800 meters above mean sea level. The snow

bound area of the National Park covers about 18,825 ha which is approximately 16% of the total land cover of the Park. The permanent snow cover along with



Fig. 1: Great Himalayan National Park Conservation Area

some steep ridges provides the natural boundaries on the northern, eastern and southern extent of the Park. The open and non snow area at the western and north-western boundary of the Park provides the accessibility to the Park which is declared as Ecozone (Srivastav, 2010).

The snow cover plays an important role in maintaining the ecology of the Park as it provides habitation to most of the unique faunal species like snow leopard, blue sheep, Himalayan musk deer etc. Beside the biological significance, it also has hydrological significance as the National Park is the origin of four major rivers viz., the Tirthan, Sainj, Jiwa Nal and Parvati which add water to the Beas River flowing through Kullu Valley.

Database and Methodology

The database for the present study consists of satellite imagery of Landsat-5 Thematic Mapper with the path and row of 147 and 038 respectively. For the change detection two different geo-referenced satellite imagery of different time period has been acquired. The first imagery is of March 1999 as at that time although the winter season is over but the large part of study area remains under snow cover, also the possibility of cloud is less in this month. The second imagery is of October 2011, this month is characterised by pleasant weather with clear and sunny sky having minimum snow cover. Thus, the month is chosen to obtain better results. For the processing of satellite imageries and map composing the Erdas Imagine 9.1 and ArcGIS 9.3 softwares has been used respectively.

The area of interest (AOI) is then created using a prepared map of study area and then extracted from above imageries using subset tool of Erdas Imagine 9.1 for further classification. The classification of imageries has been done after converting the Digital Number (DN) into Top of Atmosphere (TOA) Reflectance for optimum detection of snow cover (Hall et al. 1995; Chander et al. 2009). The conversion of DN into reflectance has done using two step processes as describe by Irish (2008).

The first step is the conversion of DN into Spectral Radiance. According to Jensen (2000) Radiance(L_λ) is defined as the radiant flux (time rate of flow of energy onto, off or through the surface) per unit solid angle leaving an extended source in a given direction per unit of projected source area in that direction. It is measured in Watts per meter squared per steradian (W m^{-2} sr^{-1}). The conversion has been done using following formula:

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda) / (QCALMAX - QCALMIN))*(QCAL - QCALMIN) + LMIN_\lambda$$

Where:

L_λ= spectral radiance at the sensor's aperture

QCAL= the quantized calibrated pixel value in DN

$LMIN_\lambda$= the spectral radiance scaled to QCALMIN in watts/(meter squared * ster * μm)

$LMAX_\lambda$= the spectral radiance scaled to QCALMAX in watts/(meter squared * ster * μm)

QCALMIN= the minimum quantized calibrated pixel value (corresponding to $LMIN_\lambda$) in DN 1 for LPGS products, 0 for NLAPS products

QCALMAX= the maximum quantized calibrated pixel value (corresponding to $LMAX_\lambda$) in DN = 255

The second step involves the conversion of calculated radiance into TOA Reflectance. According to Adams and Gillespie (2006) reflectance is defined as the ratio between measured radiance from a scene and the radiance reflected from an ideal, smooth diffuse reflecting surface oriented at the same mean incidence angle to the sun. The reflectance is calculated using following formula:

$$\rho_p = \pi * L_\lambda * d^2 / ESUN_\lambda * \cos(\vartheta)_s$$

Where:

ρ_p = unitless TOA or planetary reflectance

L_λ = spectral radiance at the sensor's aperture

d = earth-sun distance in astronomical units on Julian day of year

$ESUN_\lambda$= mean solar exoatmospheric spectral irradiance

$\cos(\vartheta)_s$ = solar zenith angle in degrees

The values of most of the parameters have been obtained from the metadata associated with the imageries and Chander (2009).

The high albedo of snow makes it possible to visually interpret it through the visible bands i.e.1, 2 and 3 of the Landsat Thematic Mapper. However the band 5 which lies in 1.57-1.78 µm of the electromagnetic spectrum has been consider very useful in identification of snow cover area as it has capability to distinguish cloud from snow as in band 5 the pixel value of cloud is higher than that of snow which makes it more brighter then snow in imagery **(**Fig. 2 and Fig. 3) (Dozier 1984; Dozier 1989).

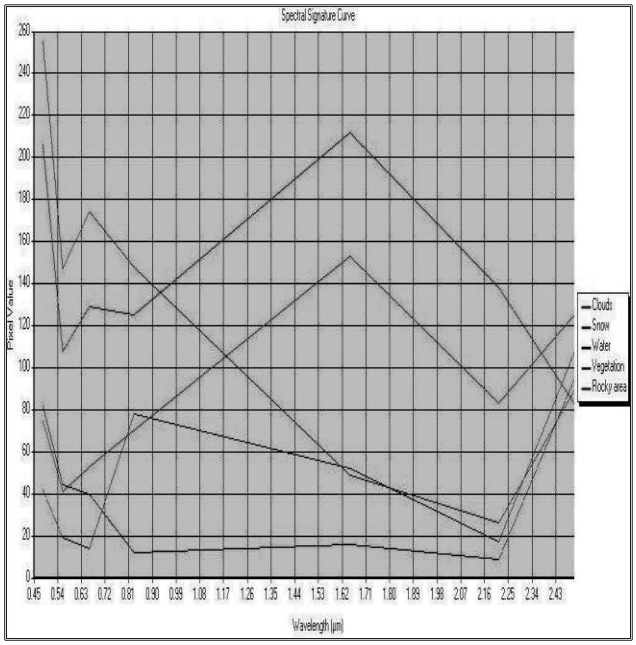


Fig. 2: Spectral Signature Curve

The identification of snow cover in both the imageries have been based on an index known as Normalized Difference Snow Index (NDSI) which is based on band rationing technique (Dozier 1984; Dozier 1989; Hall et al. 1995; Kulkarni et al. 2002). The NDSI is can be estimated using Green (0.53-0.61 µm) and Shortwave infrared SWIR (1.57-1.78 µm) part of electromagnetic spectrum. It is calculated by following formula:

NDSI=Green – SWIR/ Green + SWIR

In terms of Landsat Thematic Mapper:

NDSI = B2 – B5/ B2 + B5

The NDSI is very useful in distinguishing snow from bright soil, rocks and clouds. As the pixel value of snow has been found to be >0.4 whereas the pixel value of other class has found to be ≤0.The NDSI is also useful to identification of snow cover area under mountain shadow. However, one limitation of NDSI is the separation of water from snow as the pixel valued of water found to be same as that of snow i.e. >0.4. This limitation has been solved by taking reference of pixel value in Band 4 (0.78 – 0.90 µm) of the Landsat Thematic Mapper. The reason of this reference is that the water absorbs Near Infrared band radiation which makes it easily distinguishable from land surface. For the identification of snow cover another condition of pixel value >0.11 in Band4 has also been considered along with the NDSI value of >0.4 (Hall et al. 1995; Hall et al. 1998). Another limitation is the identification of snow cover under vegetation. This limitation has been overcome by using Normalized Difference Vegetation Index (NDVI) in identification of vegetation covered under snow. Although the pixel value of forest in NDVI is found to be between -1 to +1 but in reality it is 0.6 for the area of highest photosynthetic activity (Hall et al. 1995). The area with higher NDVI under snow cover has been marked as vegetation.

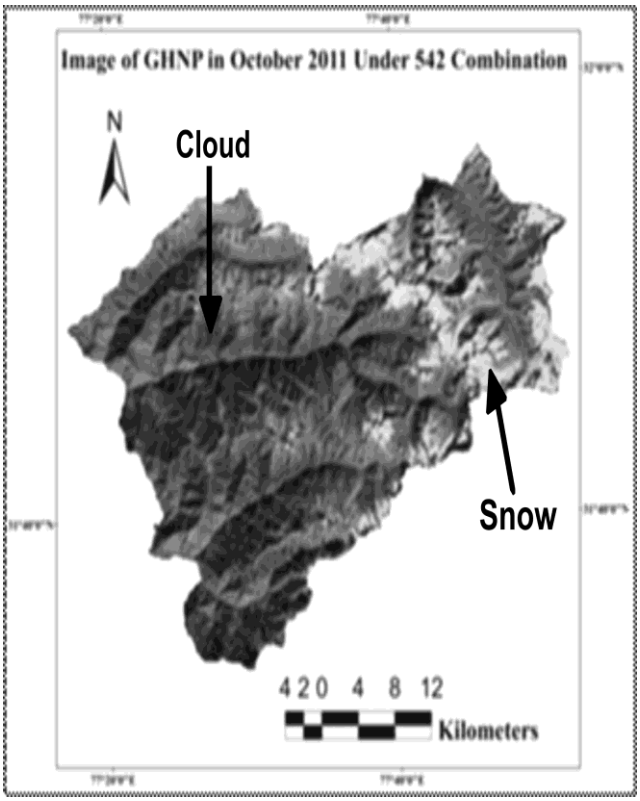


Fig. 3: Cloud and Snow Distinction

Considering the above mentioned criteria the imageries has been classified using knowledge engineer tool of Erdas Imagine 9.1 for the identification of snow cover area. For the sake of convenience and requirement the imageries are only classified into snow cover area and vegetation. The third class which has neither fall under snow cover nor it has marked as vegetation has been classified into unidentified class. After the classification the accuracy assessment has been done using same software so that the classification can be validated. After the accuracy assessment the change detection analysis has been done to see the changes in snow cover area and vegetation cover.

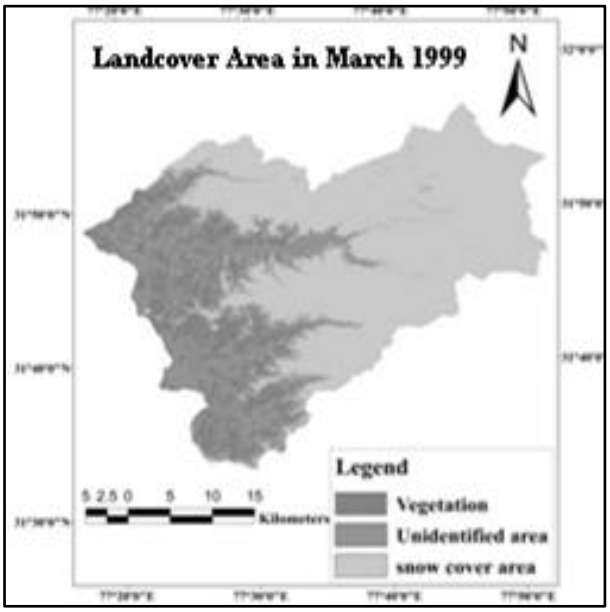


Fig. 4: Classified Image of March 1999

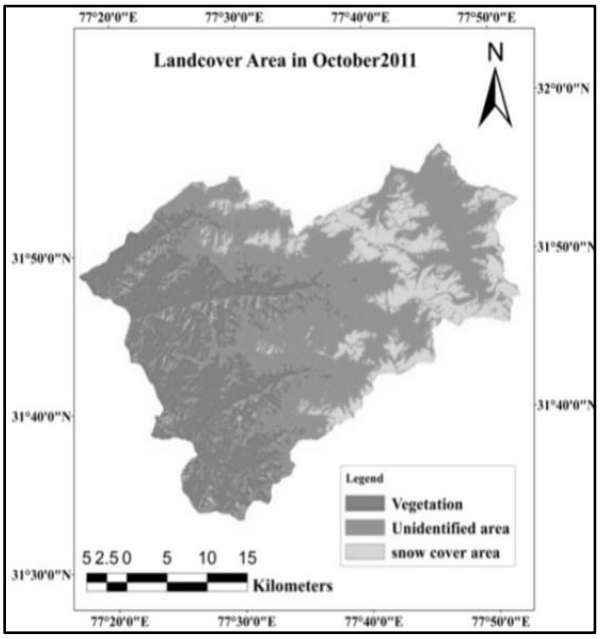


Fig. 5: Classified Image of October 2011

Results and Discussion

Status	Change(Ha)	Change%
Increased	58221	46.49
Decreased	18625	14.87
Unchanged	48396	38.64
Total	**125242**	**100.00**

Table 4. Change Detection

Fig. 2 shows the spectral signature of some land cover area. Based on the spectral signature of cloud and snow the NDSI image has been generated from the two imageries for further classification. The results of accuracy assessment of March and October imageries has shown the high accuracy of 96.15% and 94.49%, respectively with the Kappa coefficient value of 0.92 and 0.89 respectively (Table 1)

Indicator	March 1999	October 2011
Accuracy%	96.15%	94.49%
Kappa	0.92	0.89

Table 1. Accuracy Assessment Report

The classified image of March 1999 (Fig. 4) shows that maximum area (61.04 Ha) is under snow cover followed by unidentified area (24.25 Ha) which consists of rivers, rocks, soil, agriculture land, some amount of vegetation which does not match with the NDVI criteria of ≥0.6 as the value depicts the presence of healthy and dense forest which has covered 14.72 Ha of the total area (Table 2).

Class	Area (Ha) in March 1999	Area in %
Snow cover area	76446	61.04
Vegetation	18431	14.72
Unidentified	30365	24.25
Total	**125242**	**100.00**

Table 2. Land Cover of March 1999

On the other hand the snow cover area in the classified image of October 2011 (Fig. 5) decreased to 16.20 Ha. However, the area under vegetation has increase to 29.65 Ha (Table 3) which shows that about 14.93 Ha vegetation area was under snow cover. From the Table 3, the increase in unidentified area (54.15 Ha) can be seen. It means that 37,453 Ha area was covered with seasonal snow which covers29.9 Ha of the total area. The remaining 20291 Ha of snow cover area consist of permanent snow cover and those areas where the sunlight is very less which affects the melting of snow.

Class	Area(Ha) October 2011	Area in %
Snow cover area	20291	16.20
Vegetation	37133	29.65
Unidentified	67818	54.15
Total	**125242**	**100.00**

Table 3. Land Cover of October 2011

The change detection (Fig. 6) of two imageries depicts the major increase in unidentified area (46.49 Ha) (Table 4) as that area was cover with snow in March 1999. The unchanged area of 38.64 Ha consists of area of permanent snow and some forest cover which was not covered in snow cover in March 1999. A little decreased area of 18625 Ha consists of forests, agricultural fellow land and fields as in October the agricultural lands and fields contain crops which are ready to be harvested.

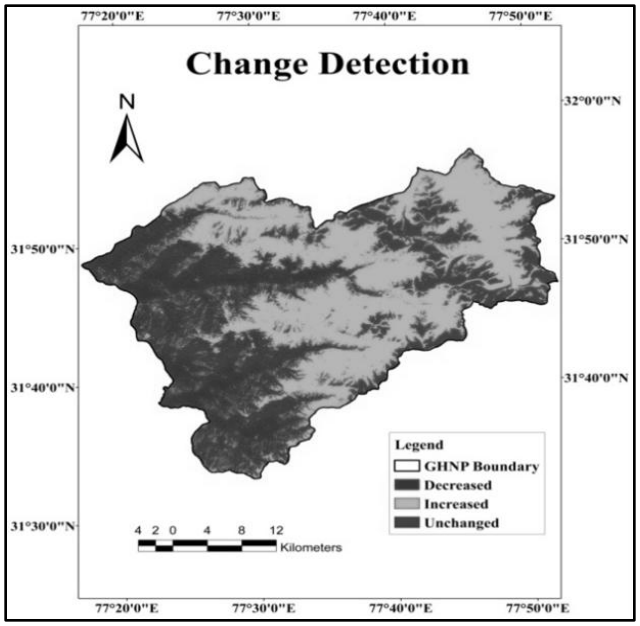


Fig. 6: Change Detection

Conclusion

The paper shows that geospatial technology is very helpful in study of snow cover change detection. It would be very difficult to study the snow cover change without it. It has been evaluated that the snow cover area has been reduced to 29.9 Ha over time. The ecology of the park is highly dependent on the snow cover. The decrease in this would not only affect the ecology but also the livelihood of local people residing near the Park area as their livelihood is highly dependent on the forest resources like collection of medicinal plants, mushrooms etc. Thus, the socio-economic life of local people is also indirectly depending upon the snow cover.

The paper has some gaps like it doesn't mention the nature of snow as old or new, it also hasn't distinguish between snow and ice, the classification on the basis of snow grain size is also missing in this paper. The further study of these gaps will be interesting to study as it may reveal some interesting facts.

References

1. Adams, J.B. and Gillespie, A.R. (2006), *Remote Sensing of Landscapes with Spectral Images A Physical Modeling Approach*, Cambridge University Press, UK, 345.
2. Chandler, G. et al, (2009), *"Summary of current radiometric calibration coefficients for Land sat MSS, TM, ETM+, and EO-1 ALI sensors"* Remote Sensing of Environment, 113, 893-903.
3. Dozier, J.(1984), *"Snow Reflectance from LAN DSAT-4 Thematic Mapper"* IEEE Transactions On Geoscience and Remote Sensing,GE22(3), 323-328.
4. Dozier, J.(1989), *"Spectral Signature of Alpine Snow Cover from the Landsat Thematic Mapper"* Remote Sens. Environ, 28, 9-22.
5. Hall, D.K. et al., (1995), *"Development of Methods for Mapping Global Snow Cover Using Moderate Resolution Imaging Spectroradiometer Data".* Remote Sensing for Environment, 54, 127-140.
6. Hall, D.K. et al. (1998), *"Assessment of Snow-Cover Mapping Accuracy in a Variety of Vegetation-Cover Densities in Central Alaska".* Remote Sens. Environ, 66, 129-137.
7. Irish, R. (2008), *"Calibrated Landsat Digital Number (DN) to Top of Atmosphere (TOA) Reflectance Conversion"* Remote Sensing Basics, NASA.
8. Jensen, J.R. (2000), *Remote Sensing of Environment: An Earth Resource Perspective*, Prentice Hall, New Jersey, 47.
9. Keller, F. et al., (2005), *"Sensitivity Analysis of Snow-cover to Climate Change Scenarios and Their Impact on Plant Habits in Alpine Terrain"* Climate Change, 72, 299-319.
10. Kulkarni, A.V. et al., (2002), *"Field Based Spectral Reflactance Studies to Develop NDSI Method for Snow Cover Monitoring".* Journal of Indian Society of Remote Sensing, 30(1&2), 73-80.
11. Sharma, S.S. et al.,(2004), *"Change Detection Analysis of Avalanche Snow in Himalayan Region Using Near Infrared and Active Microwave Images"* Advances in Space Research, 33, 259-267.
12. Srivastav, A. (2010), *"Great Himalayan National Park Management Plan (April 2010-March 2020)"* Great Himalayan National Park.

Impact of Indira Gandhi Nahar Pariyojana Stage-II on Agro-Ecological Environment and Livelihood in Arid Rajasthan

Balak Ram and J.S.Chauhan
Central Arid Zone Research Institute, Jodhpur – 342 003
E.mail: dr.brmayank@gmail.com

Abstract

The impact of canal irrigation on agro-ecological environment has been assessed in IGNP Stage-II command area covering Bikaner and Jaisalmer districts. The pre-canal period land use map of Bikaner (1976) and Jaisalmer (1986) prepared at CAZRI were updated by using IRS LISS-III data of 2005-06 and limited field check and further verified with IRS P6 LISS-III data of 2010-11. Land records and other relational data from 1970-71 to 2009-10 are analyzed to bring out changes in cropping pattern, crop productivity, land holdings, ownership, occupational pattern, settlement, livestock, economic and infrastructure development. The introduction of canal irrigation brought green and granary by putting 3.2 lakh ha area under irrigated farming and 1.83 lakh ha active dune complex into forestry. The expansion of agriculture has led to increase net sown area by 310%, built up area by 260%, pastures by 34% and guar-moth-bajra based cropping system into mustard-wheat-gram-groundnut system. The dormant and silence region is now became a hub of greater human activities and mobility. Measures are suggested for efficient use and management of land, water, human and livestock resources.

Introduction

Introduction of irrigation through Indira Gandhi Canal system in Arid Rajasthan caused enormous changes in land use and socio-economic life of settlers. Change in land use and land cover when coupled with climate variability and change, are likely to affect ecosystem and environmental quality particularly when affected lower quality lands are environmentally sensitive. This necessitates critical appraisal of the drivers and consequences of land use changes in order to formulate a long term sustainable land use plan. The pre-canal period land use map of Bikaner (1976) and Jaisalmer (1986) prepared at CAZRI were updated by using IRS LISS-III data of 2005-06 and supported with limited field check and further verified with IRS P6 LISS-III data of 2010-11. The impact of canal irrigation and Command Area Development on land use has been assessed in IGNP Stage-II command area covering Bikaner and Jaisalmer districts. Land records and other relational data from 1970-71 to 2009-10 are analyzed to bring out changes in cropping pattern, crop productivity, land holdings, ownership, occupational pattern, settlement, livestock, economic and infrastructure development. Besides, the impact of canal system on terrain characteristics, land cover and inward & outward migration of population are also analyzed. The introduction of canal irrigation brought green and granary by putting 3.2 lakh ha area under irrigated farming and 1.83 lakh ha active dune complex into forestry. The expansion of agriculture has led to increase net sown area by 310%, built up area and transport network by 260%, pastures by 34% and guar-moth-bajra based cropping system in to mustard-wheat-gram-groundnut system. Negative impacts are also highlighted. Strategies are given for efficient use and management of water resources, development of sustainable land use system, economic use of native wealth, development of animal husbandry and enhance livestock production.

Study area and environment

Out of the total 1.41 mha culturable command area of IGNP Stage-II, 75.46% (10,64,000 ha) is lying in Bikaner and Jaisalmer districts. These two districts together constitute 68,77,369 ha total geographical area. The region forms core of the '*Thar*' or the 'Great Indian desert' and extends from 69° 29' 00" E to 74° 21' 35"E longitudes and between 26° 01' 00"N to 29° 02' 44" N latitudes (Figure 1). It is bounded by Pakistan international boarder towards west and north; Ganganagar and Hanumangrh districts towards north east; Churu district towards east and Barmer, Jodhpur and Nagaur districts towards south. The region is dominated with moderately high to high sand dunes, sandy plains, rocky/gravelly pediment and few saline depressions. The region support 3.04 million human and 5.41 million livestock population.

The climate is hot arid with high erratic rainfall, extremes of seasonal temperatures, high wind speed and high evaporation loss. The mean annual rainfall varies from 300 mm in the east to less than 100 mm in the extreme west. The average annual rainfall of Bikaner district is 263.4 mm and that of Jaisalmer district 191.8 (1979-2007 average). The numbers of rainy days are 12.9 in Bikaner and 10.4 in Jaisalmer. The coefficient variability of rainfall varies from 49 to 91%. The length of crop growing season is restricted from 4-10 weeks. The maximum temperature during summer months often goes above 47° C while the daily

minimum temperature during the winter months sometimes goes down to the freezing point. Occurrences of frost once in three years during winter and hot winds and dust storm during summer are common phenomenon. Light textured sandy soils cover major part of this region. At places these are underlain by compact indurated lime concretionary zone. Psammophytic scrub includes *Calligonum polygonoides* and *panicum turgidum* as most common community occurring on sand dunes and interdunal plains. Mixed Xeromorphic woodland includes *Prosopis cineraria, Ziziphus nummularia, Capparis desidua* community covering flat older alluvial plains and flat interdunal plains.

The population of the region is 30,39,753 (16,07,262 males and 14,32,491 females) as per 2011 census. The rural and urban percentage comes to 70.28 and 29.72. Out of the total population 77.9% is shared by Bikaner and 22.1% by Jaisalmer district. The density of population is 47.5 (78 in Bikaner and 17 in Jaisalmer). The literacy rate is 65.92% in Bikaner and 58.04% in Jaisalmer. The scheduled caste and scheduled tribe population comes to 18.99% and 1.41% respectively as per 2001 census. Out of the total population the main workers constitute 31.45%, marginal

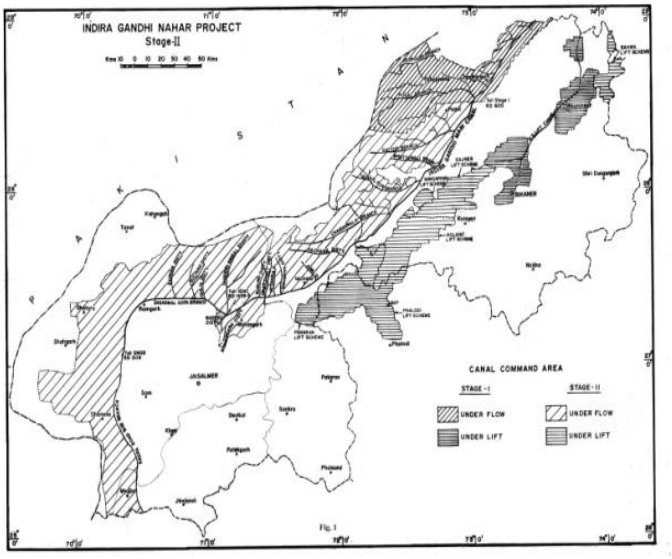


Fig. 1: Map of Study area

workers 9.85% and non-workers 58.70%. Amongst the working population, cultivators are 23.55%, agricultural labourer 2.51%, household industries 1.18% and other workers 14.06% respectively. The percentage of disabled population is 1.63 in Bikaner and 2.39 in Jaisalmer (Anon. 2007c, 2007d). The region has 54,11,164 livestock as per livestock census 2007. Out of this 47.55% is found in Bikaner and 52.45% in Jaisalmer district. Out of the total livestock cattle constitute 18.8%, sheep 38.9%, goat 37.7%, buffalo 2.5% and camel 1.6% respectively. The total milk production from this region is 522000 tons.

Method and materials

The land use map of Bikaner district prepared at CAZRI (1974), Land use/land cover map (CAZRI, 1990) and wasteland map (Balak Ram, 2004) as well as land use map of Jaisalmer district prepared at CAZRI (Sen and Lal, 1980, Chatterjee and Kar, 1992) and Land use/land cover map (CAZRI, 1990) are analyzed to assess pre-canal irrigation land use scenario and subsequent changes occurred due to introduction of canal irrigation. Using IRS LISS-III data of 2005-06 the present status of land use was ascertained, updated and mapped on 1:250,000 scale with limited field verification. The maps were further verified with IRS P6 LISS-III data of 2010-11 for modification. To correlate the findings and to assess the trend, the land records data (1970-71 to 2009-10) on land use, cropping pattern and crop productivity are analyzed. Other relational data and reports were also consulted. By integrating bio-physical resources and the present status of development, strategies and options are worked out for agricultural development and environmental improvement.

Results and discussion

Salient features of IGNP Stage-II

Canal irrigation in Bikaner was introduced from 1970-71 from IGNP Stage-I system through Anupgarh and Pugal Branches and Kanwar Sain Lift Canal covering a total culturable command area of 183,000 ha. KSLC, which is life line of Bikaner city was completed in 1976. IGNP Stage-II starts from tail of Stage-I, i.e. km 189 (RD 620) from Pugal headwork of Indira Gandhi Main Canal (Anon. 1999). The project work was started in 1971-72. The construction of Main Canal was started in 1975-76. The entire main canal of stage-II was completed by December 1986 and water was released in the canal on January 1, 1987. It comprises a culturable command area of 14.1 lac ha (8.73 lac ha under flow and 5.37 lac ha under lift system) utilizing 4930 Mm^3/yr of water. The salient features of Stage-II are given in Table 1.

Table 1.

Distribution system	District	CCA (ha)	Length (km)	Off take point (km)	Off take point RD
Gravity flowsystem		873727			
Direct distributaries & Minors from IGMC		36819	178.27		
Dhodha distributary	Bikaner	10423	-	200.77	658.7R
Dattor distributary	Bikaner	27462	158.10	216.41	710.0R
Bhuttowali system	Bikaner	12422	30.17	249.70	819.217R
Birsalpur Branch	Bikaner	79787	364.67	261.82	859.0R
Charanwala Branch	Bikaner/ Jaisalmer	110573	409.97	292.99	961.25R
Nachna Distributary	Jaisalmer	20211	105.34	341.37	1120.0R
Awai Distributary	Jaisalmer	4217	20.49	366.06	1201.0R
Sakaria Distributary	Jaisalmer	9521	52.90	382.36	1254.45R
Mitharia	Jaisalmer	3819	28.41	397.46	1304.80R
Ghantiali	Jaisalmer	36929	95.00	409.96	1345..0R
Rorund	Jaisalmer	9329	52.74	416.06	1364.94R
Mohangarh	Jaisalmer	8214	40.60	438.40	1438.32L
Mandau	Jaisalmer	12819	43.06	444.55	1458.5L*
Saheed Birbal Sakha	Jaisalmer	101763	396.55	444.55	1458.5R*

Sagarmal Gopa Sakha	Jaisalmer	184652	760.26	444.55	1458.5*
Gadra Road (Baba Ramdev) Sakha	Jaisalmer	202833	1048.17		309.0
Lift system		537018			
Sahaba Lift canal	Hanumangarh, Churu, Bikaner	240,000	667	33.23	108.160L
Gajner Lift Canal	Bikaner	75200	384	228.48	746.120L
Bangarsar Lift canal	Bikaner	10350	39	261.59	858.225L
Kolayat Lift Canal	Bikaner	116688	374.9	292.68	957.727L
Phalodi Lift Canal	Jodhpur	62660	417	340.83	1121.00L
Pokaran Lift Canal	Jaisalmer	32120	192.5	368.05	1201.500L

Of its total CCA, 46.24% is shared by Jaisalmer, 29.22% by Bikaner, 8.16% by Churu, 6.52% by Hanumangarh, 5.46% by Jodhpur and 4.25% by Barmer districts respectively. The length of distribution system under flow is 3783 km and that of lift canal system is 1823 km. with intensity of irrigation 80% in flow and 60% in lift area (IGNB, 2002). Altogether an area of 95,258 ha has been allotted to 53893 allottees and 1466.87 ha area has been afforested. There are 228 colonization villages in Bikaner and 114 villages in Jaisalmer districts covering 1,686,000 ha and 1,777,000 ha respectively. Up to 31 March, 2010 irrigation is opened in 1045000 ha area and total amount of Rs. 3181.76 crore has been spent.

Present land use

Interpretation of remote sensing data reveals 49.3% area of this region under agriculture. This includes 7.8% irrigated cropland and 41.5% rainfed cropland. Wastelands are 45.7% (sandy 32.3%, rocky/stony/ gravelly 12.9%), forest 0.4%, pasture 3.8% and settlement and water bodies 0.8% respectively (Fig 2). The net and gross irrigated area as per 2009-10 statistics comes to 297709 ha and 500391 ha respectively (Anon. 2011). The net and gross irrigated area comes to 11.59% and 19.48% of the total

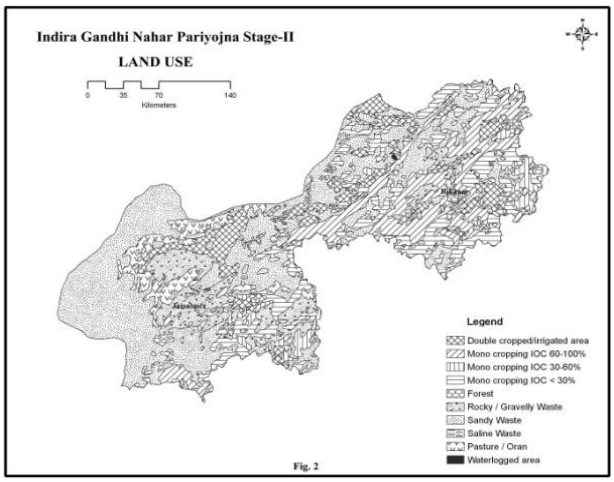


Fig. 2: Present Land Use map

agricultural lands. Out of the total gross irrigated area 51.4% is irrigated through canal and 48.6% through wells and tube wells. There are 23258 irrigation wells and tube wells. As per land use statistics 2009-10 the region has 2.02% area under forest land, land put to non-agricultural uses 8.03%, barren and uncultivable land 3.7%, permanent pasture 2.2% and culturable waste 46.67% respectively. The net sown area is 27.66%, current fallow 4.82% and other fallow lands 4.85% respectively. Double cropped area is only 3.27%. The intensity of cultivation decreases from east to west with the declining rainfall. The canal irrigated area is mainly concentrated towards the right bank along the Indira Gandhi main canal and Kanwar Sain Lift Canal. The irrigation intensity decreases as we move from north east to south west along Indira Gandhi Main Canal, its branches and distributaries and also away from main distribution system. Canal water hardly reaches near the tail end of distribution system. Permanent pastures and other grazing lands occur throughout the region. Culturable wastelands are characterized by moderately high to high stabilized to semi-stabilized sand dunes occurring north and western part of Jaisalmer district and western part of Bikaner district. Barren rocky/stony wastes are mainly concentrated around Jaisalmer town, Pokaran, Sankara and Bhaniyana in Jaisalmer district and around Kolayat in Bikaner district. Saline depressions are occurring near Pokaran, Ujlan, That and between Jaisalmer and Mohangarh. In Bikaner saline depression is found near Lunkaransar and Tauliyasar. Waterlogged areas are encountered near Gegra and Amarpura in Bikaner and Ghantiyali, Madasar and Nedai in Jaisalmer district.

Cropping pattern and crop production

Out of the total cropped area (2128049 ha) in this region rainfed crops like guar, bajra and moth constitute 45.3%, 19.2% and 13.4% respectively as per agricultural statistics 2009-10. Other rainfed crops are sesame, castor, moong and jowar. Irrigated crops like mustard, gram, wheat and groundnut constitute 3.1, 8.1, 3.13 and 3.9 percent respectively. Other irrigated crops are barley (0.2%), cumin (0.57%), isabgol (1.21%), cotton (0.25%) and methi (0.29%). Gram and taramira are taken on the conserved moisture. Moth and cotton are chiefly grown in Bikaner and isabgol in Jaisalmer district. During 2009-10 the region got a total production of about 367965 tons. This includes 225967 tons food grain, 117421 tons oilseeds and 10795 tons condiment and spices. The production of some important crops viz. gram is 77605 tons, bajra 19990 tons, wheat 66715 tons, groundnut 74323 tons, mustard 41721 tons, moth 12104 tons, isabgol 8601 tons, cumin 4064 tons and methi 6698 tons respectively (Anon. 2011).

Impact of Indira Gandhi Nahar Project

The objectives of Indira Gandhi Nahar Project were to halt the process of desertification; develop agriculture in the command area; create human settlements in the sparsely populated area; and provide drinking and industrial-use water to the inhabitants of the project

area and adjoining regions (Vyas, 1998). Creation of irrigation facilities and command area development were two parallel activities undertaken under this project. Besides, infrastructure facilities were also developed. The impact of IGNP in the region can be viewed in following manner.

Change in land use, cropping pattern and crop productivity

Development of irrigation system and command area development works were taken up simultaneously. Colonization was done and lands were allotted. Nurseries were established, sand dunes were stabilized, canal and road side plantation done and settlement sites and water points were provided. Grasslands were cleared for agriculture. These developments led to the intensification of agriculture. The area under culturable wastelands has declined by 9.2% and barren and uncultivable land 84.5% during the period from1970-71 to 2009-10. The area under 2 to 5 years fallow and current fallow are increased by 230.3% and 26.7% respectively. Details are given in Table 2.

Table 2.

Land use category	Bikaner	Jaisalmer	Total
	Change (%)	Change (%)	Change (%)
Forest	1073	136	413.9
Land put to non-agrl. uses	177	426	254.3
Barren and uncultivable land	-100	-84	- 84.5
Permanent pasture	133	35	56.3
Land under misc.tree crops	Abs.	Abs.	Abs.
Culturable waste land	-55	33	- 9.2
Other fallow land	209	293	230.3
Current fallow	44	0.1	26.7
Net sown area	111	260	139.3
Total cropped area	133	312	167.3
Area sown more than once	14485	Abs.	22432.7
Total reporting area	11	- 1	3.9

Resultantly the net sown area has increased by 139.3%, pasture 56.3%, forest 413.9% and land put to non-agricultural uses 254.3% respectively. Area sown more than once has increased from mere 1000 ha to 225327 ha. In Bikaner the net sown area has increased by 111% while in Jaisalmer it has increased by 139.3% (Anon. 1972, 2011).

Major changes are taken place in cropping system due to introduction of canal irrigation and also the exploitation of ground water. There were only selected rainfed crops viz. guar, bajra, moth, jowar and sesame prior to the introduction of irrigation (Sen and Gheesa Lal, 1980). During 1970-71 to 2009-10, the acreage of gram, mustard, wheat, groundnut, cumin, isabgol and cotton has increased to 171386, 64959, 66715, 83788, 12235, 25677 and 5238 hectares respectively. Thus the share of irrigated crops has reached to about 26% of the total cropped area. Besides, the acreage of bajra has increased by 23.5% and moth 2.8%. The productivity of almost all the crops has increased due to adoption of improved farming practices and use of high yielding varieties. The total production of the important crops in the region has increased by about 459% (5.6 times) i.e. from 65,865 tons in 1970-71 to 3,67,965 tons in 2009-10.

Afforestation and pasture development

It is planned to develop 70,300 ha area in Stage-II through afforestation and pasture development under ODA loan project. It includes 21400 km canal side plantation, 1250 km road side plantation, 4248 ha block plantation, 34070 ha sand dune stabilization, 5990 ha pasture development, 10 million trees for agricultural forest, 896 ha environmental plantation and farm forestry at 50 sites (Mandal, 2003). So far an area of 38,065 ha has been developed by 1994. Army has also afforested 7330 ha area towards left bank of main canal near Amarpura and pasture development in 3540 ha area between Bajju and Pugal. Anticipated achievements in ninth plan (1992-2007) includes 11080 km canal side plantation, 930 km road side plantation, 378 ha block plantation, 6751 ha sand dune stabilization, 500 ha pasture development, 70500 saplings towards environmental plantation and 8.79 lac saplings for developing farm forestry (Anon.2008).

Population growth and infrastructure development

Irrigation development has attracted more population in this region. It has increased by 310.8% during 1971 to 2011. The human development index comes to 0.779 in Bikaner and 0.673 in Jaisalmer (IDS, 2008). In 1971 there were 1191 villages (972 inhabited and 219 uninhabited) which are increased to 1633 in 2001 (1522 inhabited and 111 uninhabited). The livestock population has increased by 257.4% i.e. from 15,15,195 in 1972 to 54,11,164 in 2007. During the period from 1971 to 2001 the average size of land holding has declined from 22.81 ha to 10.61 ha in Bikaner district and from 25.14 ha to 10.7 ha in Jaisalmer district. The number of land holdings are increased from 47,898 to 1,84,485 in Bikaner and from 20,920 to 51,268 in Jaisalmer district during the period. The number of cultivators are increased from 1,23,454 to 5,67,845 and agricultural labourers from 15,733 to 60,072 (Anon. 1972, 2007). For settlement and land allotment, 342 colonized villages (228 in Bikaner and 114 in Jaisalmer) were created with a total area of 34,63,600 ha. Total villages in canal command area comes to 815 with an area of 5027000 ha. In Stage-II, 95,258 ha land was allotted to 53,893 allottees (Anon. 1999).

In infrastructure development from 1970-71 to 2009-10, the length of roads has increased from 2589 km to 9619 km; number of schools and colleges from 869 to 4593; and electrified villages from 68 to 1340. Safe drinking water facilities are created to 1400 villages. Veterinary facilities are available in 251 villages. 1220 villages are connected by road. There are 780 hospitals, dispensaries and other health centers and 1079 fair price shops. All types of auto vehicles are 270405. The total fertilizer consumption has reached to 28100 tons and 22188 quintals hybrid seed was distributed. The total mineral production has reached to 6909534 tons and minor mineral production to 5784810 tons in 2009-10 (Anon. 2011). Gypsum, limestone and ball clay are important minerals being produced in the region.

Agro-ecological impact

The IGNP system brought tangible impact on agro-ecological environment. The afforestation programme has indirect impact on agricultural yield due to the expansion of water supply through the erosion control effects of the irrigation water ways. It has brought moisture to the farm land and this has caused changes in the planting pattern. The tree canopy along the irrigation waterways has increased the productivity of water by not only providing more water but also bringing more area under irrigated cultivation than otherwise possible (Mandal, 2003). The adequate soil moisture helped in improvement of soil structure and raises the soil fertility (humus and carbon). Irrigation helped in aggregation and dusting of soil particles and colloids (Jaglan and Qureshi, 1996). Other impacts are the rapid expansion in vegetation cover, improvement in terrain stability, reduction in wind erosion, increase in animal feed and fire wood collection, provided shade to residents and animals and improvement in the quality of ground water. Other impact includes the improvement of the family income and asset building, standard of living, shift from mud houses to pucca houses, consumption of nutrients, entertainment, expenditure pattern, increase in employment and reduction in human and livestock migration (Anon.1999).

Negative impact and constraints

Waterlogging/salinization, rise of water table, silting of canals, invasion of weeds are some negative impact of canal irrigation. In spite of all efforts, the very objectives of agricultural development and creation of settlements in sparsely populated area are not fulfilled in Stage-II command area. Apart from the natural constraints discussed earlier, the major constraint in Stage-II was the faulty system of land allotment. Unlike in Stage-I, the land in Stage-II was auctioned by the govt. to highest bidders. As a result the land was purchased by rich and the powerful including traders, landlords, politicians and bureaucrats. A large amount of land in this area is known to be held as *benami* land (Vikas Rawal, 2005). These lands were given by actual owners to the un-experienced (about irrigated farming) poor people on contract basis. Therefore the objective of developing the agriculture and have affinity with land with permanent settlement is forfeited. Lower water allowance, inefficient water conveyance and non-availability of water) at desired time are another hurdle. Lack of coordination among different agencies functioning in the IGNP area and lack of meaningful participation of the settlers in management of the project are other drawbacks.

Strategies and options

In order to develop irrigation in such a fragile ecosystem the important strategies are, to ensure water security for agriculture, dependable water supply at source, creation of irrigation potentials at field level, effective conveyance of water, proper cropping pattern, crop rotation, promote arid horticulture, develop livestock based integrated farming system, development of post harvest technologies and value addition of crops, integrated nutrient management, plant protection measures including IPM, organic farming with emphasis on high value crops, complementary input of improved seeds, fertilizer etc. Increase in biomass production, livestock production and dairy development, establishment of fodder bank, rehabilitation of degraded lands, reseeding, development and protection of pastures and gap filling and management of forest lands are quite essential. Other measures are sensitizing farming communities with impact of resource conservation technologies (RCT), motivation/mobilizing of farmers for adoption of RCT, capacity building and technological support for adoption of RCT and generation and extension of hydrological and agronomic knowledge.

Besides, strengthen market forces and make bureaucratic interventions more effective and people's involvement and organizational coordination among different agencies working in the IGNP area are also essential.

Conclusions

The introduction of canal irrigation brought green and granary by putting 3.2 lakh ha area under irrigated farming and 1.5 lakh ha active dune complex into forestry. The human and livestock populations are increased by 273% and 123% respectively during the last four decades. The expansion of agriculture has led to increase net sown area by 310%, built up area and transport network by 260%, pastures by 34% and guar-moth-bajra to mustard-wheat-gram-groundnut cropping system. Terrain stability and vegetative cover increased and wind erosion declined. Infrastructure facilities are created. New areas have come up under ground water irrigation. Waterlogging /salinization,

silting of canal and invasion of weeds etc. emerged as negative impact. The agricultural development and settling of population has not been up to the mark. However the region has enough scope for development of integrated farming system, dairy development and livestock production, better use of large chunk of scrub land and proper use of desert's natural gifts.

References

1. Anon. (1972).*Statistical Abstract, Rajasthan, 1971*.Directorate of Economics and Statistics, Rajasthan, Jaipur, 248p.
2. Anon. (1999).*IGNP Studies for the State of Rajasthan*.Final Report Annex.A to J. Mac Donald Limited, Dalal Consultants & Engineers and Institute of Irrigation Studies.
3. Anon. (2007c).*Zila Sankhikiya Rooprekha 2005, Zila-Bikaner*.Arthik avam Sankhikiya Nidesalaya, Rajasthan, Jaipur, p.119.
4. Anon. (2007d).*Zila Sankhikiya Rooprekha, 2005, Zila-Jaisalmer*. Arthik avam Sankhikiya Nidesalaya, Rajasthan, Jaipur, p.104.
5. Anon. (2008).*Approach to tenth Five Year Plan (2002-2007).*Govt. of Rajasthan, Planning Department, Jaipur, p.49.
6. Anon. (2010).*Statistical Abstract, Rajasthan, 2010.*Directorate of Economics and Statistics, Rajasthan, Jaipur, 440p.
7. Anon. (2011a).*Agricultural Statistics of Rajasthan 2009-10*. Directorate of Economics and Statistics, Rajasthan, Jaipur, 105p.
8. Anon. (2011b). . *Zila Sankhikiya Rooprekha 2009, Zila-Bikaner*.Arthik avam Sankhikiya Nidesalaya, Rajasthan, Jaipur, p.110.
9. Balak Ram, (2004). *Wasteland updation report of Bikaner district, Rajasthan*. CAZRI, Jodhpur, p.28.
10. CAZRI, (1974).*Basic Resources of Bikaner district (Rajasthan).* CAZRI, Jodhpur, p. 86.
11. CAZRI, (1990a).*Report on Land use/land cover, Bikaner district*, *Rajasthan*. CAZRI, Jodhpur, p.24.
12. Chatterjee, P.C. and Amal Kar, (1992).*Integrated Natural and Human Resources Appraisal of Jaisalmer district.* CAZRI, Jodhpur, p.156.
13. IDS, (2008).*Human Development Report, Rajasthan* (An update 2008), IDS, Jaipur, p.133.
14. IGNB, (2002).*History of Indira Gandhi Nahar Project*.Indira Gandhi Nahar Board, Govt. of Rajasthan, Jaipur, p.405.
15. Jaglan, M.S. and Qureshi, M.H., (1996). *Irrigation development and its environment consequences in arid region of India*.Environment Management*,* 20(3)1996: 323-336.Springer, New York.
16. Mandal, Subrata, (2003).*Afforestation and Pasture Development Project along Indira Ghandhi Canal Area*: Third-Party Evaluator's Opinion. Ex-Post Evaluation Report on ODA Loan, JBIC, 2004, p. 63.
17. Sen, A.K. and Gheesa Lal, (1980).*Land utilization survey in Jaisalmer district, Rajasthan.* CAZRI, Jodhpur, p. 32.
18. Vikas Rawal, (2005). *Recent Peasant Struggles in Rajasthan.*The Marxist*,* 21(4) Oct-Dec 2005.
19. Vyas, V.S. (1998). *Sustainable irrigation in the arid regions of India*. In: The cornerstone of development. (Ed. Jamie Schmrr and Susan Haltz), IDRC, 1998, p. 320.

Mapping of Urban Growth Pockets, Hot spots of Poverty and Land Use Changes in Kolkata Metropolis: Its Impact on Urban Resource Management

Mala Mukherjee
Centre for the Study of Regional Development/ School of Social Sciences, JNU New Delhi
Email: malamukherjeejnu@gmail.com

Abstract

*Kolkata as the primate city of the east exhibits uneven urban growth and variation in population density along with rapid encroachment of vacant lands and water bodies in its eastern periphery where largest number of its slum population reside. GIS mapping of urban growth, density, percentage of households living in slums and land use change maps highlight the fact that in Kolkata, slum wards are located in the north eastern periphery and western peripheral parts where urban growth (1991-2001) is very high, but density is low. These areas are experiencing rapid changes in land use pattern. Encroachment of open spaces and water bodies in east Kolkata has a severe impact on resource management. It not only destroys natural resources but also snatches the livelihood opportunities for those who are earning through fishing and farming. Thus, this paper aims to correlate 'urban growth', 'land use changes' and distribution of deprived locales through GIS mapping. Indicators like lack of access to various assets, formal housing and certain basic services or amenities have been used to identify the wards which can be called as the '**Hotspots of Poverty'**. These wards are mainly located in eastern, northern and western peripheries of Kolkata. ARC-GIS soft ware and Census 2001 data are used for the mapping purpose and various methodologies like thematic mapping query building and superimposition of maps are employed.*

Introduction

Today's world is marked by unprecedented urban growth; the surplus urban population may represent a considerable volume of urban poor facing diverse deprivation and insecurity of housing as well as livelihood. In Asia, 2.2 billion people or one out two people live in urban centres and the continent has more than 11 mega cities each with more than 10 million population. These urban centres act as economic growth engines, cultural hubs and focal points of administrative as well as commercial activities, but the urban paradox exhibits poverty amidst of wealth in every Asian city. Many of the causes of the urban poverty are rooted in a complexity of resource management, lack of planning for urban growth, land use pattern and urban governance.

Objectives

Main objectives of the paper are as follows:

- To identify the wards with high growth, density and locales where major changes in land usepattern occurred in the last few decades
- To identify the wards with high concentration of slum population and regions with substandard living or '**Hot Spots of Poverty'**
- To correlate 'urban growth', 'land use changes' and distribution of deprived locales through GIS mapping.
- To understand the implication of urban resource management on various issues like urban poverty, land use pattern and urban planning.

Methodology and Data Sources

Census 2001 and 1991 ward level data of Kolkata are used for calculating composite index for measuring deprivation. Primary data have been collected from the field survey in Dhapa slum (the survey was conducted between 17th September to 17th December 2011) where 50 households have been interviewed through structured questionnaires.

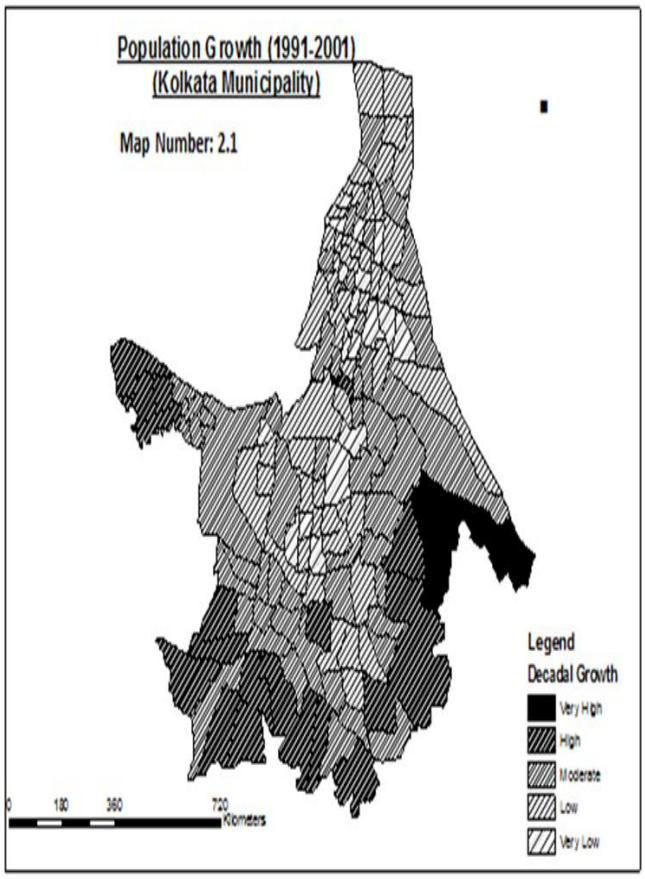
Discussion

Mapping of Urban growth, Density and Slum Locales within Kolkata

Urban growth and density are two important indicators which denote the stage of urbanisation. Though these two are neither negative nor positive indicators and these two indicators do not measure deprivation directly but, usually in urban geography, the areas with high density are often imagined as congested areas full of old dilapidated buildings and unauthorised squatter settlements. Similarly, it is often stated that, the areas with high density shows low growth rate or negative growth rate. Therefore, before analysing urban poverty, its growth and density should be measured for understanding the location of deprived locales.

Map number 2.1 exhibits ward wise variation in urban growth (1991-2001) across Kolkata. Population growth is very highest in ward number 108. According to decadal population growth, the entire city can be divided into five zones-

Map 2.1: Ward Wise Variation in Urban Growth (1991-2001)



A) Very High Growth- Very high growth rate is found in ward number 108 located in the south eastern fringe of Kolkata

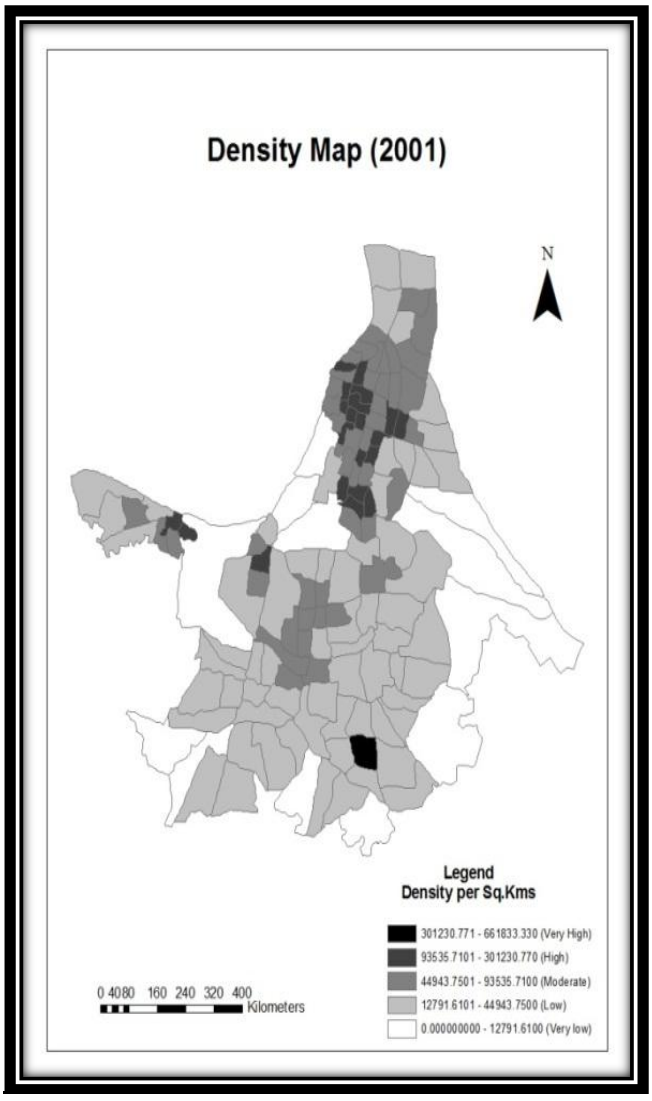
B) Wards with High Growth Rate- Ward number 106, 107, 109, 101, 113, 111, 114, 122, 123, 124, 125, 127, 128, 129,139, 138, 140 and 141 create areas with very high population growth. All these wards are located in the southern periphery of Kolkata. Among them, ward number 139, 138, 140 and 141 are situated near Kolkata port.

C) Wards with Moderate Growth Rate – This zone includes most of the wards of Kolkata and wards with moderate growth rate are found equally across the city, most of the wards of the north and Central Kolkata are included in it. Wards in the immediate vicinity of high growth wards are also recording moderate growth rate.

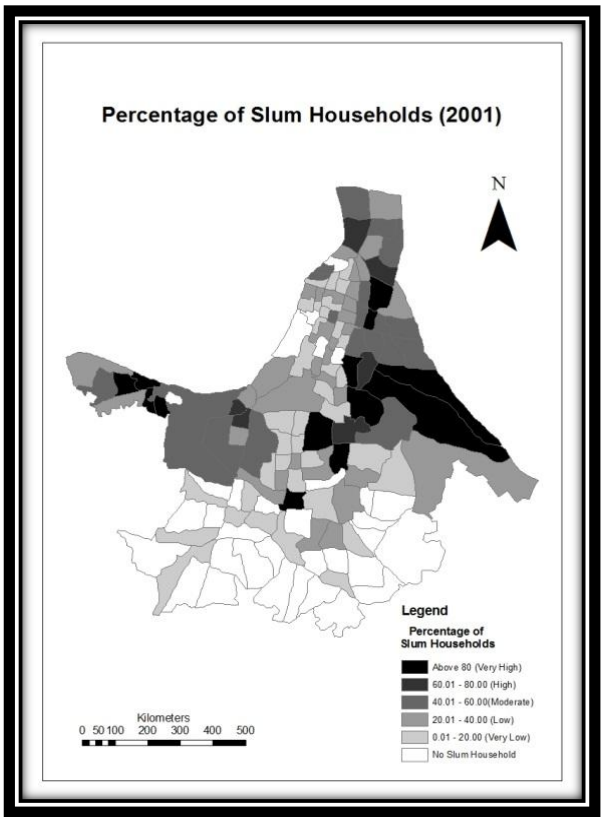
D) Wards with Low Growth Rate – Wards with low growth rate are found in the central Kolkata. In the north, ward number 1, 2, 3, 4, 5 and 14 are included in it, in the northeast ward number 57, in the south ward number 79, 78, 81 and few wards of Central Kolkata are found in this zone.

These five growth areas are clearly indicating the fact that population growth is maximum at the periphery and lowest at the core. It is not surprising in case of an old colonial city like Kolkata where the city core has already reached saturation point. But, the most interesting fact is that, wards with high growth rate are found mainly in the southern periphery of the city, not in its northern border.

i) Population Density (2001) - Population density refers to number of people per unit area in a well defined area. The word density conjures up a negative picture in our mind. An area with high density always depicts congestion and overcrowding. Therefore, in urban geography high density areas are often treated as deprived locales where people live in inadequate space and moreover, it is believed that core city always shows highest density.



Map 2.2: Ward Wise Variation in Population Density across Kolkata and Five 'Density Zones' Have Been Identified



Map 2.3: Percentage Distribution of Slum Households in Kolkata

Table 2.I.

Density Zones	Wards and Locality
Very High Density	Ward number 9, 8, 18, 25, 38 from north Kolkata, 133 from the west and 99 from south Kolkata.
High Density	Ward number: 4, 3, 7, 14, 15 (north Kolkata), 30,47, 46 (Central Kolkata), 139, 138 (West or Metiabruz-Garden Reach area), 118, 81, 82, 87, 73 (South Kolkata**)**
Moderate Density	Ward number: 1,2, 6,5 (north Kolkata), 75, 79 (south Kolkata) and 141, 140 (West or Metiabruz-Garden Reach area)
Low Density Area	Mainly located in south Kolkata
Very Low Density	Ward number: 57, 58, 108 and 109 (East Kolkata along Eastern Metropoliton Bypass), 80, 142 (Garden Reach and Taratola), 63. 45 (near Maidan)

ii) Percentage of Households residing in slums: Slum households are generally considered as the most deprived urban households and it is usually thought that they are found in the city core where density is very high. But, map number 2.3 is depicting that wards with more than 75 per cent or 3/4th of the total household residing in slums are found in the urban periphery, not in the city core. Three main slum locales can be identified from this map-

Table 2.II

Main Slum Locales	Location
Cossipore-Chitpur-Belgachia	North Kolkata (ward number 6, 3, 1, 12 and 5)
Tangra-Tiljala-Topsia	North eastern fringe of Kolkata, near the Eastern Metropolitan Bypass (ward number 58,57, 56 etc)
Metiabruz-Graden Reach	West Kolkata, near the port
Central and south	Scattered slum settlements in few wards

iii) Correlation between Density and Existence of Slum Settlements in Kolkata: Generally urban geographers often describe that slum and squatter settlements are found in high density areas and therefore, congestion is one of the salient features of the urban slums. But, map number 2.3 is depicting a completely different picture. This superimposed maps exhibits correlation between population density and percentage of households living in slums. Highest number of households living in slum is found in very low density areas, i.e. ward number 55, 56, 57, 58 and 59 (Tangra-Tiljala-Topsia region). Though it can not be said that wards with high density have very negligible percentage of slum households, because ward number 138, 137, 133 in Graden Reach Metiabruz area record very high percentage of slum households as well as very high density. Highest density is recorded in Jadavpur area (ward number 99) but this region record less than 20 per cent household residing in slums. Some wards with moderate density (ward number 6, 13, 14 in the north, 87 in the south and 46, 47 in the central part of Kolkata) record high percentage of household residing in slums.

Therefore, in Kolkata slum settlements are found in very low density area as well as in high and moderate density areas.

Table 2.II exhibits that Kolkata's top five wards with more than 90 per cent of the total population living in slums are located mainly in low density areas with high urban growth, except two wards in Metiabruz area. According to Census 2001, Tangra-Tiljala and Narkeldanga area record low density, high population growth and highest percentage of population living in slums. This area is located in the north eastern periphery of Kolkata. On the other hand, Metiabruz-Garden Reach area in the west near the Kolkata port is showing a completely different picture. Ward number 137 and 134 are recording more than 95 per cent of the total population is residing in slums but at the same time, these two wards record high density as well as high population growth in the last decade.

Therefore, wards located in the eastern and western peripheries of Kolkata record more than 90 per cent of the total population residing in slums, but the nature of urban growth is different in these two parts. Western periphery is recording high growth rate as well as fairly high density, but the eastern periphery is recording very high growth rate but very low density. According to the size of slum population wards located in Tangra, Tiljala and Topsia region (58, 65, 59, 66, and 67) and Narkeldanga area (ward 29) comprise the top six slum wards in Kolkata.

Table 2.3 Relationships between Urban Growth, Density and Existence of Slums in Kolkata

Ward number	Location	Rank in Percentage of Slum Population To Total Population	Urban growth (2001)	Population Density (2001)	Rank by size of Slum population
58	Tangra-Tiljala	1st (99.98% population live in slums)	High	Very low	1st
29	Narkeldanga	2nd (98.8% population live in slums)	Low	Low	5th
137	Metiabruz	3rd (98.35% people live in slum)	High	Moderate	19th
134	Garden Reach, West Port	4th (97.85% population living in slums)	High	High	11th
65	Tiljala	5th (91.97% population live in slum)	Moderate	Low	2nd

Spatial Transformation of Kolkata Metropolis

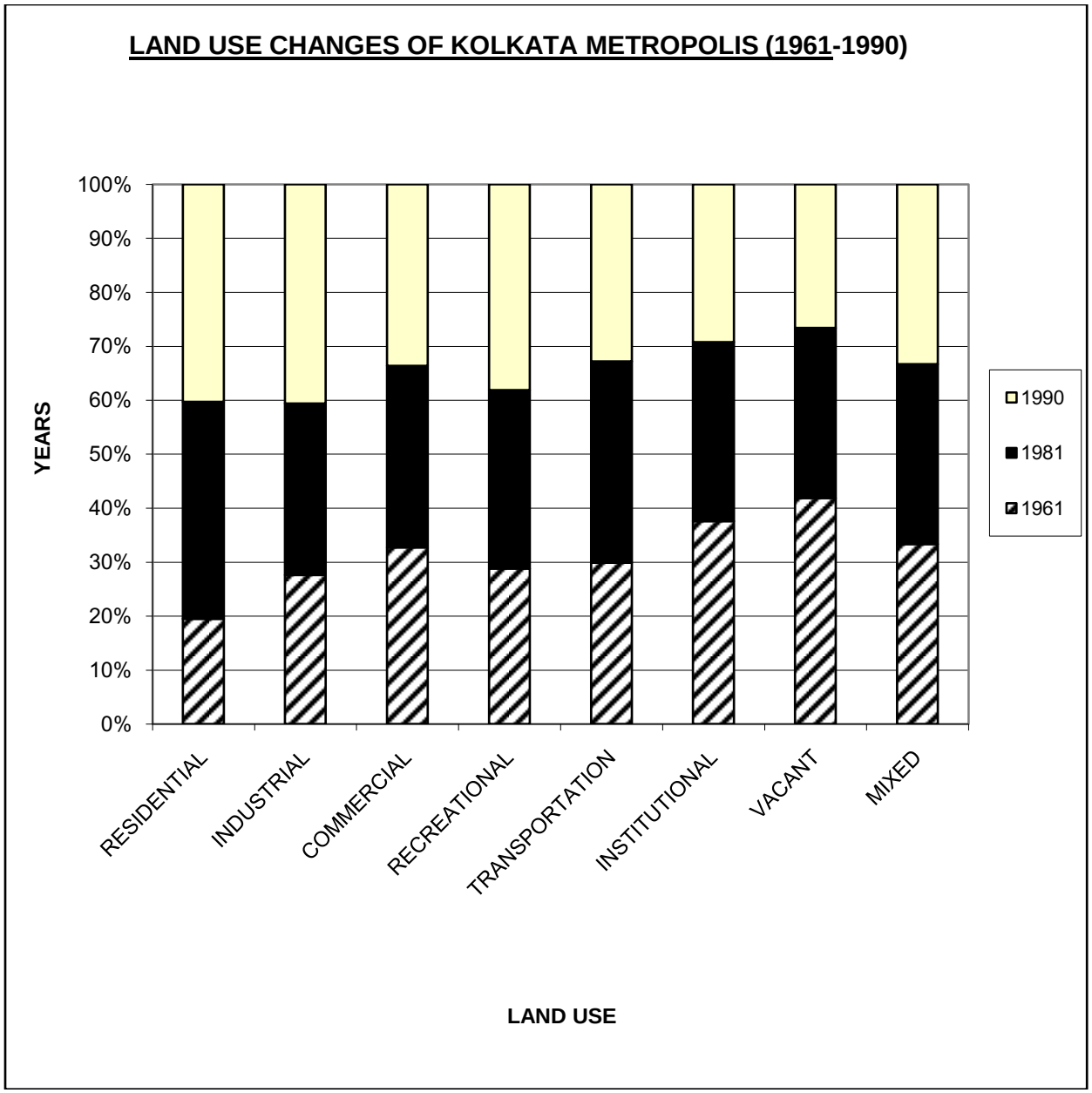
Detailed survey of Kolkata's land use had been conducted by KMDA since 1970's and recent application of remote sensing have revealed that in Kolkata metropolis there has been a steady increase in the residential land and sharp decline of vacant land. Land use map of KMC (1996) showed that the city proper had the highest area under residential land use (nearly 45 percent).

Considering the present rate of urban growth and land use, KMDA had proposed a multi-centered growth pole strategy in the Kolkata metropolitan region. A well-integrated system of settlements with specific functions would help to eradicate regional disparity in urban growth. Naihati-Bhatpara, Kamarhati and Sonarpore areas with very high population growth has been allocated for 1 to 1.5 million populations by 2025 and they would be known as major centres in 'Vision 2025-Perspective Plan of KMA'. Dum Dum, South Dum Dum, Baruipur, Bansberia, Bhadreswar, Chapdani, Kona, Garia-Jadavpur would be designed to house about 0.05 to 0.75 million population. It is interesting to note that Bhadreswar, Chapdani and Bansberia regions are not as populous as other regions. KMDA had proposed new metro cities in Kalyani, Barrackpore, Barasat, Salt Lake, Uluberia and

Baghnan. Among them Saltlake, Barasat and Barrackpore have already recorded high growth rates. Mapping of Socio-Economic Deprivation in Kolkata by 'Index of Sub Standard Living': The term 'socio-economic' deprivation indicates lack of access to social and economic opportunities. For analysing socioeconomic deprivation in urban households of Kolkata following indicators have been selected:

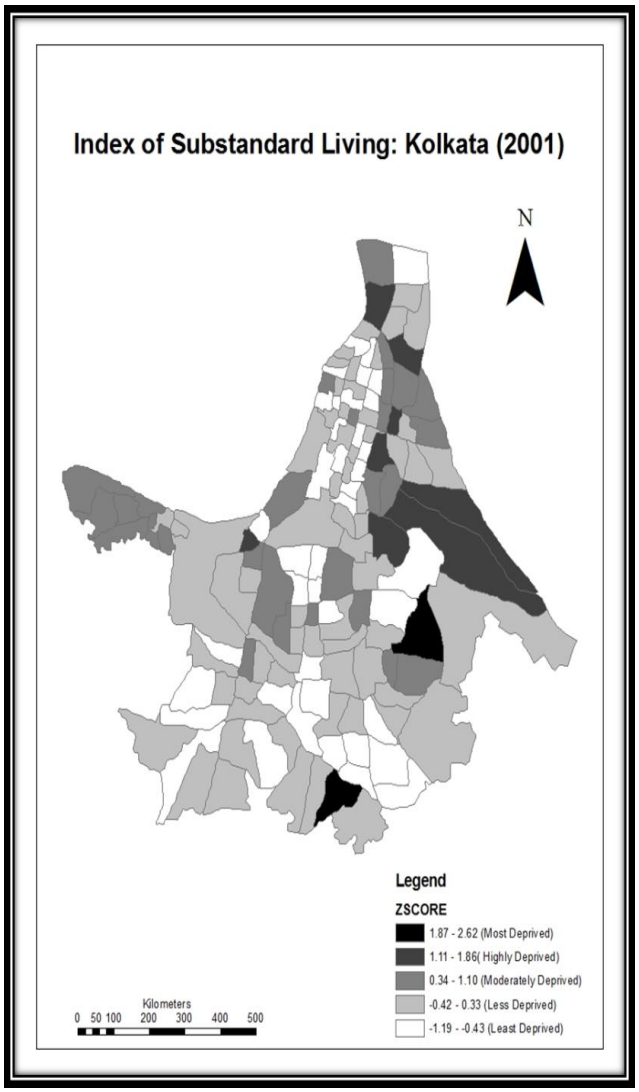
1. Percentage of Households Not Having Access to: Television, radio/ transistor, telephone, bicycle, two wheelers and four wheelers.
2. Percentage of households living in kutcha houses (houses built by non-permanent materials like bamboo, plastic, tin/asbestos, tiles etc. as roof, wall and floor materials)
3. Percentage of households not having access to banking service, electricity, LPG, potable drinking water in nearby sources, adequate room, separate kitchen and latrine.

Graph-IV



Source: Metropolitan Kolkata: An Anthology of Socio-Economic Studies and Survey Reports of KMDA, (1970-2004), Volume-I

Map 2.4: Index of Substandard Living



According to map number 2.4, highest score is recorded in ward number 108 (2.62) and 109 (2.40). Therefore, highly deprived wards are 57, 58, 29, 6, 13 and 36. These wards cover Tangra-Tiljala-Topsia region (57, 58, 108, and 109) and are situated in the eastern margin of Kolkata along the Eastern Metropolitan Bypass. Other wards constitute parts of Narkeldanga-Beliaghata region (ward 29), just adjacent to Tangra-Tiljala-Topsia region, Ultadanga-Maniktola area (ward13) and part of Cossipore region (ward-6) in the extreme north. Ward number 79 in the south-west also records high deprivation, it covers part of Khidirpore-Ekbalpore area. Though Garden Reach-Metiabruz region has recorded very high percentage of household living in slums and a significant number of households not having access to various assets or amenities but wards found in this area can be termed as moderately deprived locales. Moderately deprived wards are also found in north Kolkata as well as in central Kolkata, but in the south they are very few in number except those are located in the south-eastern fringe of Kolkata.

Deprivation Index	Score	Wards	location
Most deprived	1.87-2.62	110, 109	Eastern periphery, parts of Tiljala-Topsia-Kasba area
Highly deprived	1.11-1.86	58,57, 79,29, 13, 6, 36	North Tangra, Narkeldanga-Beliaghata, Ultadanga-Maniktola, Cossipore
Moderately deprived	0.34-1.10	1, 3,7,12, 14, 15, 21, 28, 31, 32, 39, 56, 59, 65, 80, 82,134, 135, 136, 137, 138, 139, 140, 141	Parts of Ultadanga, Cossipore, Tangra, Narkeldanga in north Kolkata Garden Reach Metiabruz, Ekbalpore area in south
Less deprived	-0.42 to 0.33	Wards are scattered in north, central and extreme southern part of Kolkata	
Least deprived	-1.93 to -.041	Central and south Kolkata	

Findings and Conclusion

Kolkata' the 'City of Joy' exhibit a unique type of urban deprivation completely different from western perception. Core city can not be considered as the epitome of urban deprivation or the highest expression of urban blight. Although it is absolutely true that, the city core depicts high density and very low urban growth, but households residing in the core city enjoy better access to amenities and infrastructures than those who living in the peripheral part. Eastern periphery depicts the height of urban deprivation and wards located in this region house the largest number of slum population of Kolkata and these people mainly belong to socially and economically deprived section of the society with very low level of education. Urban deprivation in Kolkata has multifaceted dimensions, only slum settlements cannot be termed as the

deprived settlements. Urban deprivation lies beyond slums especially in terms of housing and infrastructure. Kolkata has three main slum locales, i.e. Tangra-Tiljala-Topsisa in the east, Metiabruz-Garden Reach in the west near the vicinity of Kolkata port and Cossipore-Maniktala-Ultadanga in the extreme north, apart from these three locales slum areas are dispersedly found in various wards of central and south Kolkata. In central Kolkata, wards adjacent to Tangra-Tiljala-Topsia region have big slum clusters in Beniapukur, Entally, Narkeldanga and Beliaghata areas.

Though some wards of Metiabruz-Garden Reach area record almost all of their population living in slums but the size of slum population in these wards are far less than the wards constituting Tangra-Tiljala area. Moreover, in terms of housing quality and some basic infrastructure like nearness of water source and access to electricity Metiabruz-Garden Reach area performs better than Tangra-Tiljala region. In case of certain basic amenities and infrastructure all the wards of Kolkata perform poorly. Majority of the households living in Kolkata have no access to private vehicles, telephone service, LPG and adequate dwelling space. Most of the families live in either one-roomed or two roomed dwelling units and in the central Kolkata most of the households live in one roomed houses while majority of the households living in the south-eastern fringe of the city reside in two roomed dwelling units. therefore, those who live near the core city face acute crisis of adequate housing but those who live in the peripheral parts enjoy more dwelling space, but at the same time, it should not be forgotten that majority of the households living in the eastern periphery of Kolkata mainly reside in informal houses or huts built up of wide varieties of non-permanent materials like mud, bamboo, grass, thatch, bamboo and their conical roofs depict typical vernacular type of architecture, mainly covered by red tiles or asbestos. Thus one cannot say, that households living in the periphery have better standard of living than those who live in the city core within one or two roomed houses. Moreover, most of the households living in the eastern periphery are deprived of electricity, nearby water source and all types of essential assets like television, radio, private vehicles and telephone connection; it is no doubt quite ridiculous in twenty first century. It is noteworthy that highly deprived wards located in the extreme eastern, western and northern boundaries of Kolkata are mainly inhabited by scheduled castes (especially in the east), illiterate and slum population. Another remarkable fact is that wards adjacent to the Eastern Metropolitan Bypass, covering the Tangra-Tiljala-Topsia region records very high growth rate indicating the fact that these areas are growing rapidly and the city is expanding in this direction.

Spatial Pattern of Land Use in Theni District - A GIS Approach

V. Rengan
Department of Geography, School of Earth and Atmospheric Sciences
Madurai Kamaraj University, Madurai –625021
Email: veerengan@gmail.com

Abstract

Land is one of the most significant of all natural resources of the earth surface. Land is becoming a scarce commodity in the world over due to immense agricultural and demographic pressure. Land is an area of the earth's surface; human interference and interaction with this natural environment result in landuse. Land use is referred to as man's activities and the various uses which are carried on land. The term land use has several meanings, it includes both land cover and land use. Land use is the surface utilization of all developed and vacant land on a specific point, at a given place. The past land was not so important because there was less population. When man entered into the first stage of civilization he totally depended upon the practice of haunting and food gathering. From that day land became a resource and gradually the demand for land increased. In the 21st century the land demand is very high because of the increasing population and their facilities, modifying human being first and brings impact on land and their uses later. Proper land use is essential for future generation.

Theni District was bifurcated from Madurai District in the year 1996. The district had five Taluks, eight Blocks and 28 urban centres as per 2011 census. The GIS technologies nowadays occupy a prominent place among the modern computer tools and constitute an invaluable support in the solving of problems with a spatial dimension. Keeping this in mind the paper aims to identify and analyses the land use pattern in Theni District in 2007 with using Arc GIS environment.Key words: Land use, Theni District and GIS

Introduction

Land is a very important natural resource because it provides all sorts of food to man. Further it also forms the basis of life to terrestrial and aquatic flora and fauna in one way or the other. In the past pressure on utilization of land was minimum because there was less population. When man entered into the first stage of civilization he totally depended upon the practice of hunting and food gathering. He began to use the land i.e. he began to dig the earth, sow the seeds and took utmost care to get the best out of a piece of land. From that day land became a resource and gradually the demand for land increased. Land use means the use of land by human activities not necessarily always for financial profit or gain. Land use planning is to use land in such a way that the same land can support more population. Land use planning is a science that determines the type of land use through studying the ecological character of the land as well as its socio-economic structure. It is possible to plan for the appropriate use of the land and to enhance the present management of the land use by utilizing Geographical Information System (GIS). Remote sensing technique (RS) and geographic information system (GIS) are unique and important tools which can help to define priority areas for conservation and development and can also be used to accurately and efficiently verify the effectiveness of land use planning. The present attempt has taken Theni district which is one of the important districts in Tamilnadu. The status of land utilization in 2007 has been generated from combining various data sources such as topographic sheet, satellite imagery and field work.

Study area

The geographical environmental setup is the key factor for the distribution of land use and land cover of an area. The physical factors of an area influence the land use and other economic activities of the man. The degree of influence may vary from one region to another. In certain areas, natural features dominate the landscape and man is able to make only a minor impact. In some other areas, the land surface is dominant by cultural aspects. Land in any area has been assaulted from various fronts creating a crisis of mismanagement. In a developing country like India the crisis becomes acute. Hence proper land use planning is necessary to know the status of the existing land use planning.

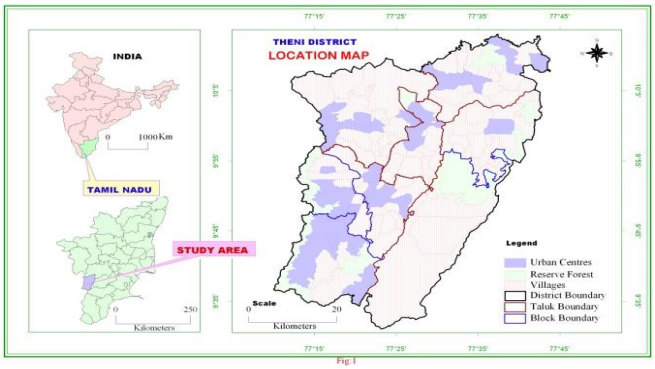


Fig. 1

Theni is one of the southern districts of TamilNaduState and it is bounded on the north by Dindigul district, on the east by Madurai district, on the south by portions of Virudhunagar district and Idukki district of Kerala State and on the west by Idukki (Kerala). The district administrative headquarters of Theni district is situated at Theni - Allinagaram town.

The district lies between 9° 30' North and 10° 15' North latitude and 77°10' East and 77°45' East longitude. The topography of the district is mostly hilly. Vaigai, Suruli, Varahanadi and Manjalar rivers are flowing in Theni district. The district comprises of two Revenue Divisions viz., Periyakulam and Uthamapalayam, and Five Revenue Taluks, viz., 1.Theni, 2.Periyakulam, 3.Andipatti, 4.Uthamapalayam and 5.Bodinaickanur. There are eight community development (CD) Blocks viz., Andipatti, K.Myiladumparai, Periyakulam, Theni, Bodiinaickanur, Chinnamanur, Uthamapalayam and Kambam for Rural development and Local administration.

Objectives

The main objectives of the study are:

- To assess the land use in Theni district
- To identify the distribution of land use and which is the most predominant in the district
- Use the GIS technique to suggest the sustainable land use in the district

Data base

For the present study, the following data base and techniques are used:

- Survey of India Topo sheets with 1: 50,000 scale.
- IKONOS 2007 image
- Topo sheet numbers: 58 F/4, 58F/8, 58 F/12, 58 G/1, 58G/2, 58G/5, 58G/6, 58G/9 and 58 G/10.
- Relevant literatures

Software used

1. Arc GIS 9.3
2. ERDAS Imagine 8.7 and
3. Arc View 3.2a

Results and Discussion

A. Land Use

Land use classification has been attempted by many agencies. In the USA a particular system of land use classification is followed which identifies hierarchical orders or Levels. In India traditional land use classification has 9 types. After the development of Remote Sensing technology NRSA has come out with its own system of land use classification which also has some similarities with the USGS system. However local conditions and the basic aim of research may be taken as the basis for land use classification. In the present study based on the existing condition the following ten lands use types are considered:

1. Agricultural Land
2. Dense Forest
3. Fallow land
4. Miscellaneous Land
5. Mixed Forest
6. Plantation
7. Rock Outcrop
8. Scrubland
9. Settlements
10. Water Bodies

1. Agricultural Land

Agriculture has played a key role in the development of human civilization. In 2007, about one third of the world's workers were employed in agriculture. Agriculture is backbone in developing countries, especially in India. Agriculture provides about a third of India's national income.

In Theni district agricultural land use in 2007 accounted for a share of 36% which covers nearly one third of the total area. Fig. 2 Shows the distribution of agricultural land use in the district. The central, northeastern, parts of eastern and parts of western areas have concentration of agricultural land in the study area. From the Digital Elevation Model it may be noted that these parts are mostly lowlands with fertile soils.

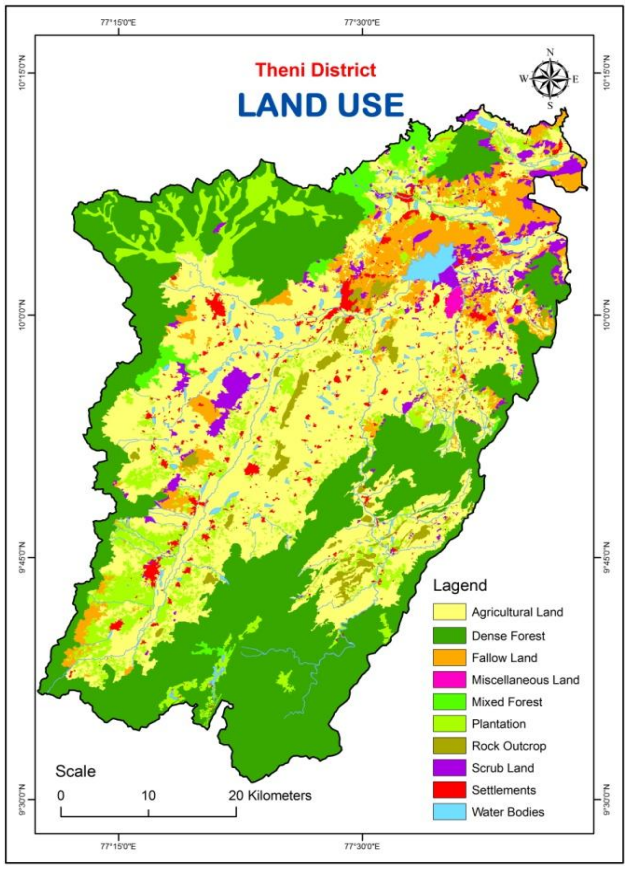


Fig. 2

2. Dense Forest

Forest is an important natural resource but recently area under forest is declining both due to human interference and also due to natural causes like climatic change. In Theni district the forest areas occupied in 35.8% of the total area. It is nearly equal to agricultural land. Upper Vaigai Reserve Forest, Suruli Reserve Forest, Bodinayakkanur Reserve Forest and Murugamalai Reserve Forest are the major forest area. Here again the DEM shows (Fig. 3) that the region is a mountainous area with the highest elevation in the district. Hence the best option of bringing the land under Forest has already been carried out.

3. Fallow land

This category includes both permanent fallow and current fallow. In the study area fallow lands have a share of 7.1%. Much of the fallow land is concentrated in the northeastern part of the study area (Table 1).

4. Miscellaneous Land

Miscellaneous land includes degraded land, barren land and other lands. Land degradation generally signifies the temporary or permanent decline in the productive capacity of the land (UN/FAO definition). Scientifically, the main attributor to land degradation is soil erosion (FAO). This is an important factor for unsustainable land use in any area. Barren land without cultivated land not a waste land that is called barren land. Barren land in which less than one third of the area has vegetation. In general barren land has this soil sand or rocks. Barren lands include deserts, dry salt flats, beaches, sand dunes, exposed rock, strip-mines, queries and gravel pits. The Theni district miscellaneous land is accounts for a share of 0.2%.

Table 1

Theni District - Land Use

Sl.No	Land Use	Area in sq km	In Percentage
1	Agricultural Land	1032.0	36.0
2	Dense Forest	1025.8	35.8
3	FallowLand	204.9	7.1
4	Miscellaneous Land	5.6	0.2
5	Mixed Forest	49.5	1.7
6	Plantation	286.2	10.0
7	Rock Outcrop	51.0	1.8
8	Scrubland	96.4	3.4
9	Settlements	62.6	2.2
10	Water Bodies	53.6	1.9
	Total	**2867.6**	**100.0**

5. Mixed Forest

Mixed Forest Land includes all forested areas where both evergreen and deciduous trees are growing and neither predominates. When more than one third intermixture of either evergreen or deciduous species occurs in a specific area, it is classified as MixedForestLand. Mixed forests are commonly found on the slightly elevated areas. Mixed forests occupied in southern and western part for a share of 1.7% of the total area. Here again DEM shows that the region has a comparatively steeper slope in the district.

6. Plantation

Plantation is an important agricultural as well as economy based agricultural activity. It covered nearly 10% of the total area. Cardamom, Tea, Mango and Coconut are the major plantations in the district. The northwestern and south regions are covered with plantations. Here again it may be noted that the DEM indicates that the region is moderately sloped upland area. Hence the best utilization of the land is made with the plantations.

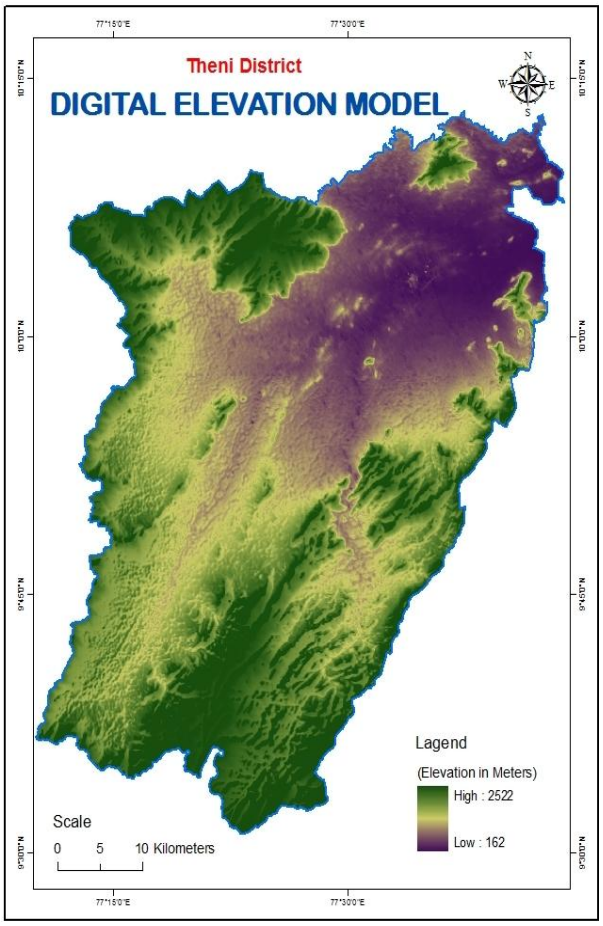


Fig. 3

7. Rock Outcrop

A rock formation that appears above the surface of the surrounding land is known as rock outcrops. Rock outcrops occupied only 1.8% in the central part of the study area.

8. Settlements

Settlements are becoming more important type of land use areas in various parts of the world. Rapid growth of population also makes settlements to increase in their areal extent. In the present study the settlement land

use occupies only 2.2% of the total area. It is limited in the area because most of the areas is hilly and utilized for agriculture and plantations. The settlements are highly concentrated nearer to the river and urban centers.

9. Scrubland

Scrubland covered a small area and it accounts for a share of 3.4%. It is spread in all parts in the district.

10. Water bodies

Water is a key component in determining the quality of our lives. Today, people are concerned about the quality of the water they drink. Although water covers more than 70% of the Earth, only 1% of the Earth's water is available as a source of drinking. Water bodies are important in agricultural and human consumption. The present study area has a number of tanks that are scattered all over the region. However most of the tanks are non perennial and have water only during rainy season. Other than the tanks Vaigai, Suruli, Theniar and VarahanadiRiver are the important source for drinking water and agricultural purposes. In total water bodies cover about 1.9% of the total area.

Conclusion

The following inferences are drawn from the analysis of the study area

1. Agricultural land is the most important type of land use and it lies in central and northern parts of the district
2. Dense forest is the another most dominant type of land use it covers southern and western parts of theni district
3. More than 60% of the land under in agricultural and dense forest.
4. Plantation and Fallow land gets third and fourth rank in the district, while other land use very minimum in the district
5. The lowlands are used for agriculture, moderately elevated areas for plantations and the highlands are used for forest.
6. Only the fallow and scrub lands are the areas where some modification of land utilization may bring a better utilization of land.
7. Already steps have been initiated to bring fallow lands under cultivation by introducing suitable crops.
8. Similarly the scrubland is planted with drought resistant trees so that the environment will become greener.

Geological, Geomorphological and Structural Studies of Mainpat Plateau, Through RS/GIS Techniques

Trivedi R. K., Adil S. H., *Soni L. K. and Patel V. N.
Department of Applied Geology
Dr. H. S. Gour Central University, Sagar
**Geological Survey of India, Western Region, Jaipur*

Abstract

The Mainpat Plateau, a mesa landform, is at an elevation of around 1080 m from msl in comparison to the general elevation of 560, belongs to Surguja district, Central India. Consisting of Archaeans (granite-gneisses, phyllite, etc.) at the base, followed by Gondwanas and Deccan basalt and at the top having a cover of laterite and bauxite. The contour map of the study area shows that the periphery abruptly ends with steeply sloping escarpments though the general surface is undulating. The study reveals that the area is affected with shallow and deep weathering. Gneisses are more pediplain in comparison to granite.

Faults are generally seen in the Breakers terrain and the southern part appears to be more disturbed. Though clear evidences are not seen, their presence is often suspected at several places by vertical scarps, highly fractured and jointed nature of the sandstones observed during field checks.

A prominent shear zone (Central Surguja Shear) identified over 100 km, from river Mahan in the west to Binda Nagnaha in the east. The satellite imagery study reveals that the Surguja crystalline are tectonically disturbed and constitute a block characterized by the dominance of ENE-WSW trending lineament. The region to the south and north of this block appears to be tectonically less disturbed and shows different lineament pattern. Within the crystalline two sub-parallel shears, separated by about 1 to 10 km have been identified.

Introduction

The area of study Mainpat Plateau falls in Surguja district in Chhattisgarh state, India. It is located in Survey of India toposheet numbers 64 N/1, N/5 and N/6 lying between longitudes E83°08' to 83°25' and latitudes N22°41' to 22°55'. The plateau is located about 45 km SSE of Ambikapur, the District Headquarter of the Surguja. Area is conveniently approachable in all seasons by well connected by road, from District Headquarter (45 km) and that reaches upto the top of the plateau. The nearest rail head is Bishrampur (SE Railway) situated at a distance of 65 km from the study area and nearest air ports is Raipur (Chhattisgarh) and Ranchi (Jharkhand). Sitapur is the main townships and tehshil headquarter 28 km from the study area.

The study area is occupied by Mainpat plateau which is covered by Deccan Traps. The average height of the plateau is 1080m and maximum height is 1165 m above MSL at Parpatia village on Mainpat in the western side of the plateau. The top of the whole plateau is covered by laterite and bauxite. Laterite and bauxite is the residual product of extreme chemical weathering of pre existing aluminous rocks under favorable geomorphic, climatic and hydro-geologic conditions. In Mainpat plateau, basalts of Deccan volcanism are the rock which had undergone chemical weathering. Mobility of an element is a function of solubility, sorptive phenomenon and translocation (Dennen *et al*., 1977). The highly mobile and soluble constituents like Si, Mg, Ca, Na and K are leached out from basalt and least mobile chemical constituents like Al, Fe and Ti remain at place. Thus geochemical processes of lateritisaton and bauxitisation can be summarized as a selective mobilization, leaching and partial re-precipitation going hand in hand with hydration of the elements that remain in the weathering profile. It is, therefore, quite essential to study the geochemistry of parent rock and residue in respect of major and trace elements which will ultimately lead to understand the process of laterisation/bauxitisation in that particular area. The plateau has dendritic drainage pattern of its streams because of the undulating flat nature of plateau top. Otherwise it is showing radial drainage pattern from its slopes.

Geology

The Mainpat plateau has a wide range of rock types varying in age from Archaeans (granite-gneisses, phyllite etc.), Gondwanas and Deccan basalt. Archaeans found at foot hill overlain by Gondwanas at western escarpment, and covered by basalt at the top. The stratigraphic successions of the area are as follows (Patel *et al.,* 2005).

Table Stratigraphic Succession of the Study Area

Period	Supergroup/ Group	Litho-Units
Recent to Sub-Recent		Alluvial soil, Laterite and Bauxite
Upper Cretaceous to Lower Paleocene	Deccan Trap	Basaltic flows
Cretaceous	Lameta	Earthy Greenish to White Sandstone
upper Carboniferous to Lower Cretaceous	Barakar Talchir	Coarse grained sandstone with Coal Seams, Fine grained sandstone, siltstone, green Shale
Middle to upper Carboniferous	Gondwana	Conglomerate, sandstone
Precambrian	Chhattisgarh	Granite-gneiss, phyllite, quartzite etc.
Archaean	Basement	Granite/Gneiss, Phyllite, Quartzite, Acid and Basic intrusions.

Geomorphology of the area

Various geomorphological studies, instituted in and around the study area, highlight the following. Before discussing the geomorphological impact around Mainpat plateau, it is essential to specify that geomorphology should be considered under two heads, namely-

1. Natural geomorphological impacts
2. Man made geomorphological impacts.

Natural geomorphological impact, mean geomorphological changes resulting due to natural factor (wind, water, temperature etc.). Man-made geomorphological factors mean changes brought about artificially by the actions of man (mining, industry, engineering etc.) which have brought in changes in the existing topography of the land, drainage pattern, slope etc. Severe weathering processes acting on bedrock cause enrichment of Al, Fe and Ti and depletion of Si, forming ferruginous and bauxitic duricrusts. Although this process is more common in the inter-tropical belt, bauxitic duricrusts also occur in other climatic regions. To relate the environment influences weathering in distinct climatic region, we studied profiles developed on igneous rock by Horbe and Anand (2011).

The geomorphology of the area was interpreted based on study of satellite imagery or arial photographs (map 1). Lithology of the area and denudation process have played major role for the formation of most of the landform. Main geomorphologic features are discussed below. The Mainpat plateau is in the important feature of the area. Residual/denudational hills and pediplains are major landforms located in the area. Present a frequency distribution of major plateau type bauxite deposits of world according to their height from MSL (Bardossy & Aleva, 1990).

Plateau

The study area is occupied by Mainpat plateau which is covered by Deccan Traps. The average height of the plateau is 1080m and maximum height is 1165 m above MSL at Parpatia village on Mainpat in the western side of the plateau. The ground elevation around the plateau is about 600m (MSL). The contour map shows steep slope on escarpment of the plateau.

Table Plateau type bauxite deposits based on height above MSL

Height above MSL (in Met)	Number of places	Example
Above 2000	3	Nilgiri & Palni bauxite deposit, India. Passa quartro massif, Brazil.
1200-1600	6	Eastrn ghat, India, Adamaoua, Cameroon
800-1200	9	Tougue, Dabola, Pita-labe, Guinea, Southern Vietnam Highland. Mainpat deposit, India
400-800	20	Los pijiguaos, Venezuela
0-400	38	Boke, Fria, Guinea, Trombetas, paragominas, Brazil, W. Kalimantan, Indonesia, Weipa, Darling range, Australia, Guyana costal belt, Gujarat & Katch deposit, India

Drainage

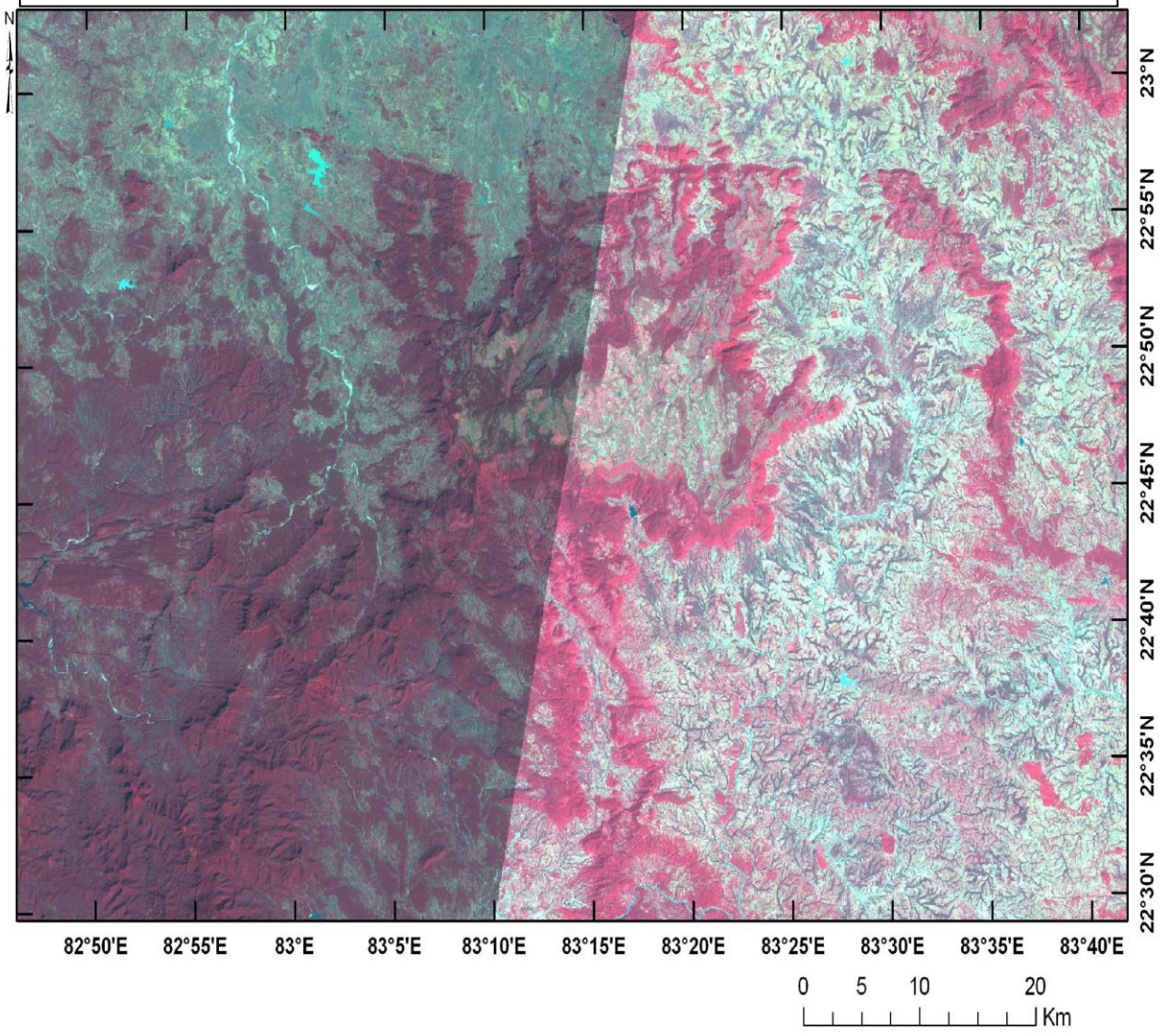
The area is drained by a series of stream lets which are part of Mand and Barnai drainage systems which ultimately forms the Hasdo and Rihand rivers system. The plateau has dendritic drainage pattern of its streams because of the undulating flat nature of plateau top. Other wise it is showing radial drainage pattern from its slopes. It is controlled by the fractures, lineaments, faults, topography and Lithology. The drainage density varies from place to place. Streams cut deep valley at the slope of the plateau (Map 2).

The drainage density (length of stream/ unit area) map show in the central part of the plateau towards North-South is high drainage density because in this part of the plateau is mostly drainage flow parallel and frequency also high (Map 3). The drainage frequency (no. of stream/ unit area) map shows the top of the plateau is very high frequency and decreases to the slope to ground surface (Map 4).

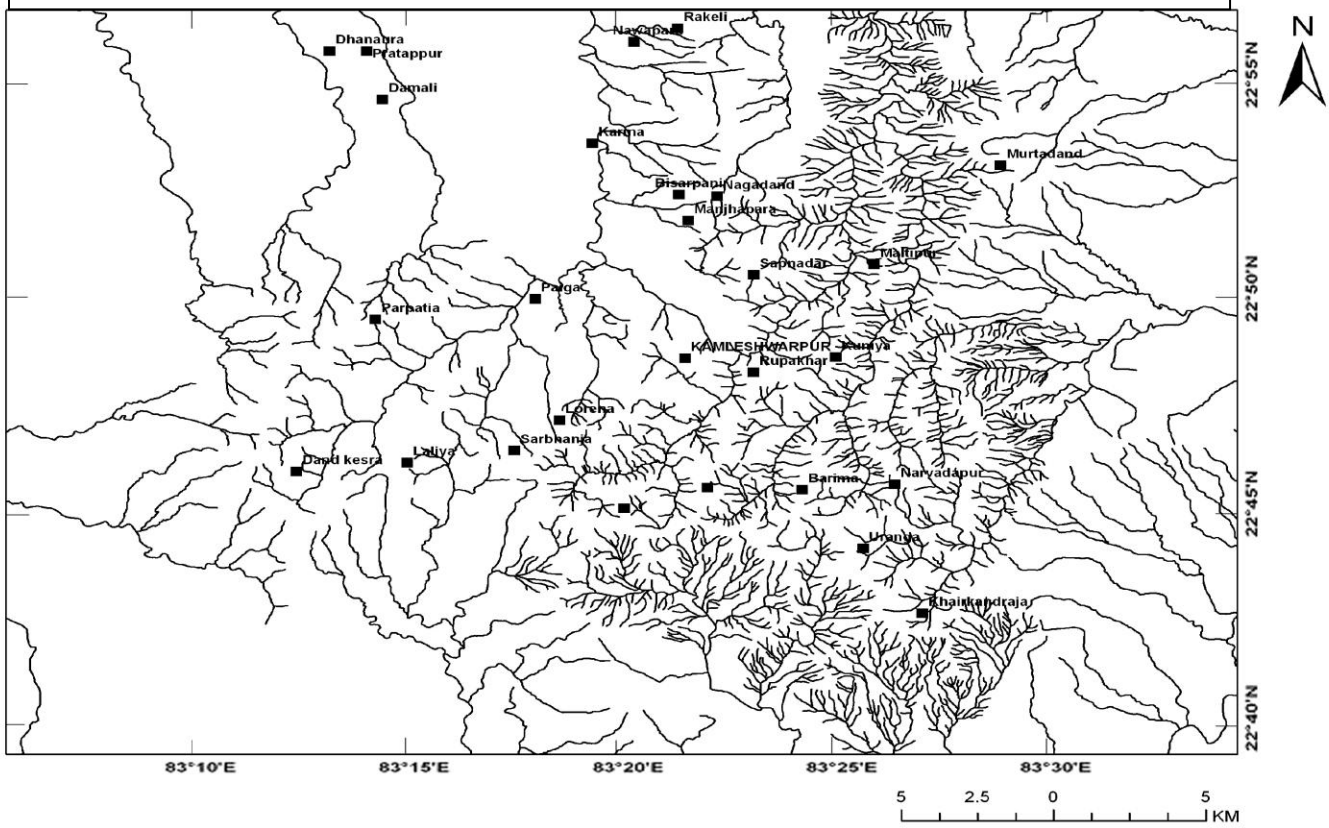
Topography

The surface of the Mainpat plateau is undulating which is marked by variation in slopes, gently sloping mounds and shallow valleys. Mostly periphery abruptly ends with steeply sloping escarpments. This occurs mainly where they are formed by horizontal lava flows (map 5). The bauxite generally occurs on moderate slopes 3°-15°. Nowhere as it was found on slopes steeper than 25°. The top of the conical hills emerging from plateau surfaces are barren. On horizontal parts of several plateaus, only thin and siliceous bauxite occurs, Rao and Raman (1979) and Raman (1986).

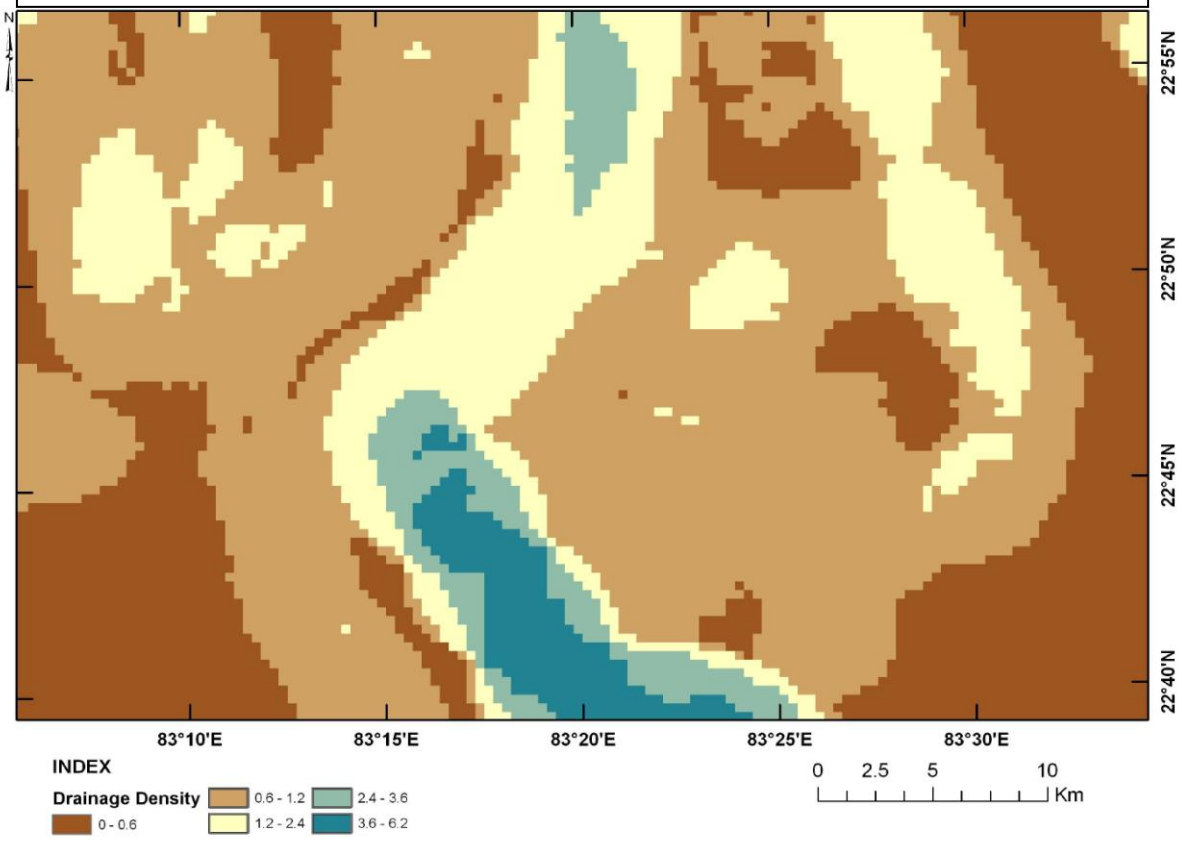
MAP-1. SATTELITE IMAGERY MAP OF THE MAINPAT AREA



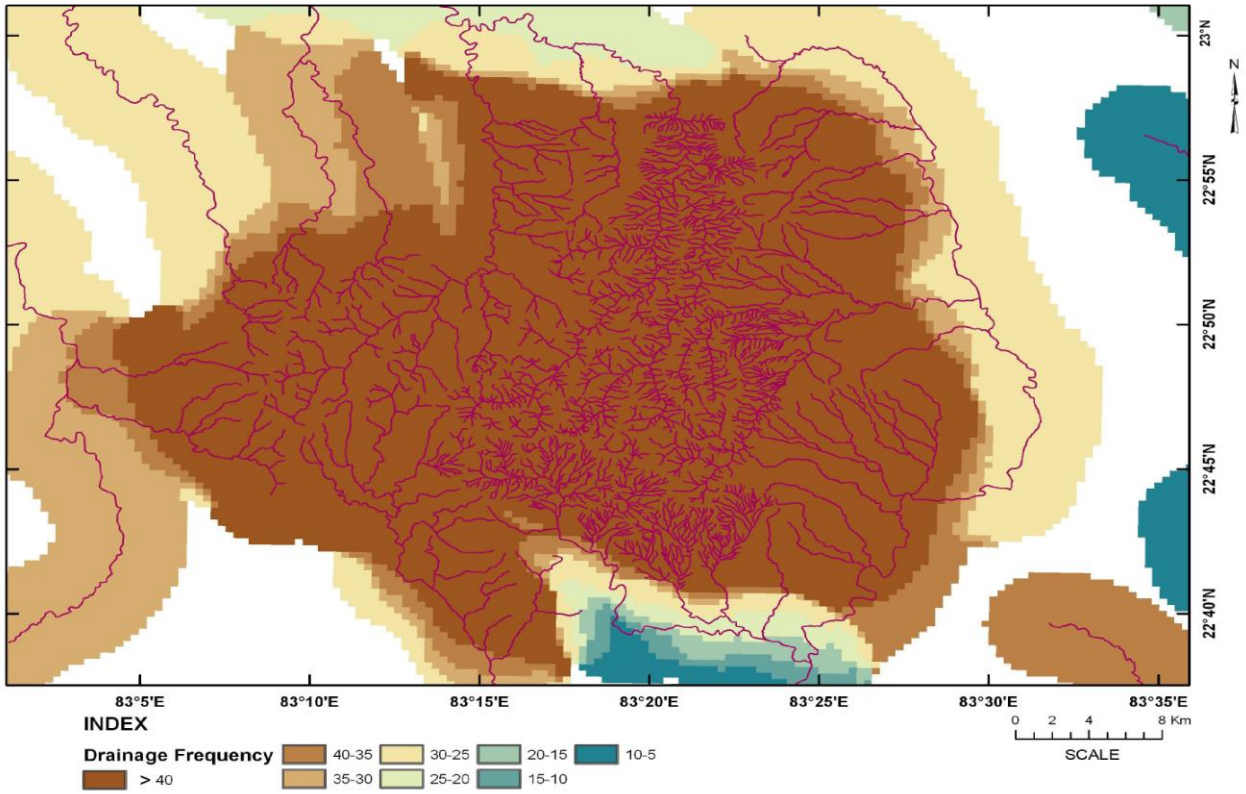
MAP-2. DRAINAGE MAP OF THE MAINPAT PLATEAU, SURGUJA CHHATTISGARH



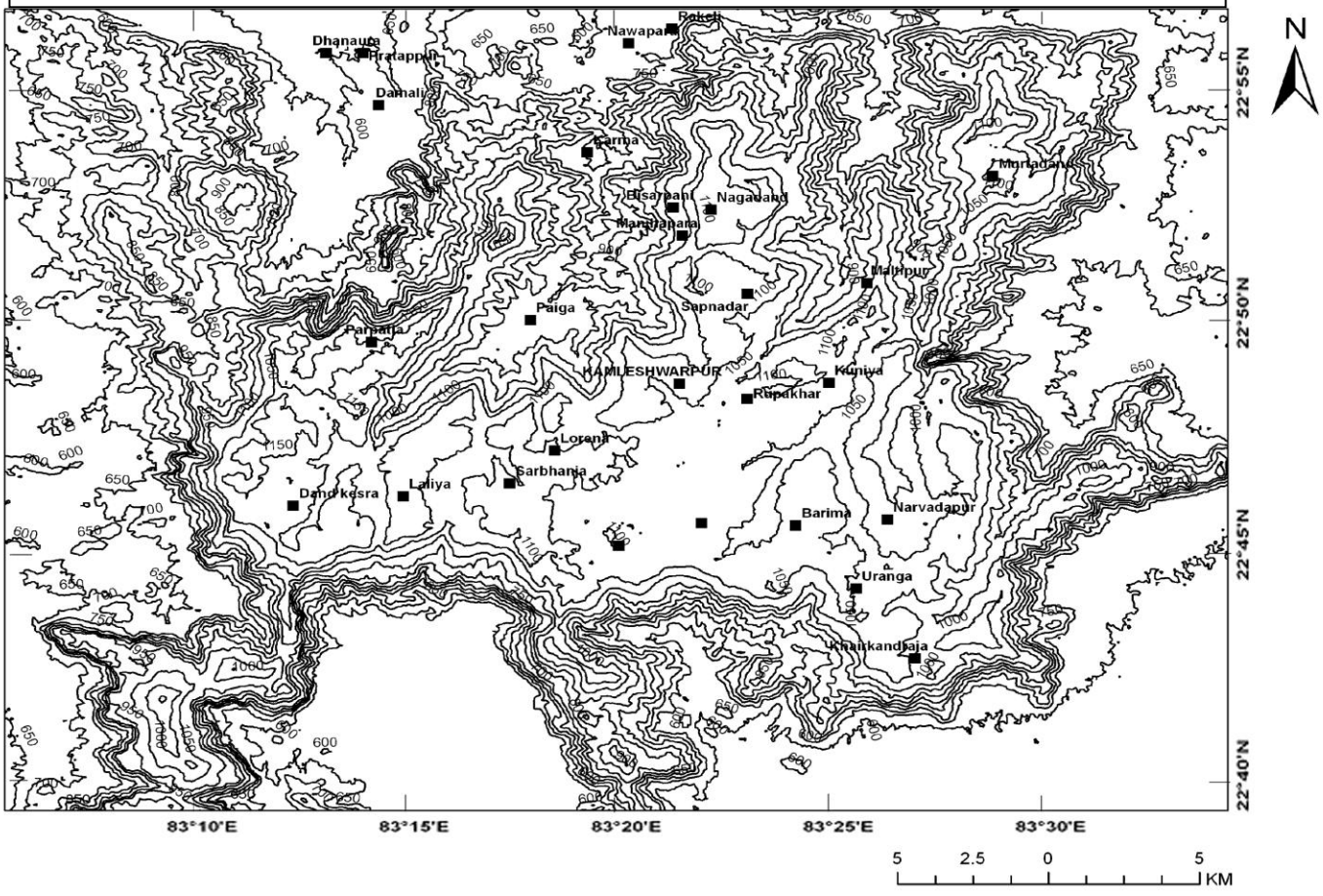
MAP-3. DRAINAGE DENSITY MAP OF THE MAINPAT PLATEAU



MAP-4. DRAINAGE FREQUENCY MAP OF THE MAINPAT PLATEAU



MAP-5. CONTOUR MAP OF THE MAINPAT PLATEAU. DISTRICT SURGUJA



Denudational/Residual hill

These are granite hills and are scattered throughout the area. Residual hills are mainly isolated and are comparatively lower in altitude. Residual and denudational hills are mainly controlled by lithological variations, distribution of fracture zones, faults, joints, lineament, litho contacts and type of weathering. Around the study area of the maximum height of denudational/residual hill is 1000m above MSL in the granite terrain. The highest point of the plateau is near parpatia village (1168 MSL) and some other locations are Dand kesra (1099 MSL), Uranga (1074 MSL), Nagadand (1109 MSL), Kamleshwarpur (1116 MSL), Kuniya (1114 MSL) and Barima (1088 MSL).

Pediplain

The studied area is affected with shallow and deep weathering. Gneisses are more pediplained in comparison to granites. Shallow weathering pediplains are found near to the denudational hills and the soil thickness gradually increases from hill towards deep weathering pediments (Mishra *et al*.; 2008).

Geomorphological agents which are responsible for development of Bauxite/Laterite profile after alteration of basalt can be revealed from a collaborated study with geochemical anomalies. The study reveals that the south central part of the study area have higher drainage density in which the laterite profile developed. The bauxite profile, on the other hand, was found in the areas with low drainage density. It may be because; the occurrence of laterite profile may develop over a systematic water regime. And the concentration of alumina becomes higher in the areas where the iron oxide leached out from the parent rock with the infiltrating water.

Structure and tectonics

The satellite imagery study reveals that the Surguja crystalline are tectonically disturbed and constitute a block characterized by the dominance of ENE-WSW trending lineament. The region to the south and north of this block appears to be tectonically less disturbed and shows different lineament pattern (Nair *et al*.; 1988). Within the crystallines two sub parallel shears, separated by about 1 to 10 km have been identified (Kak *et al*., 1983).

The Proterozoic sequence of Surguja crystallines, surmised to be the western extension of the Chhotanagpur Gneissic Complex, was thrown in to isoclinal tight folds, as a result of coming together of Peninsular and Bundelkhand blocks during Satpura orogeny (Radhakrishna, 1989).

The Surguja crystalline show a structural pattern, evolved through deformation in three phases (Hansoti, 1973; Saxena, 1975, 1981; Negi, 1981). During the first phase of deformation, this is a result of N-S compressive stresses and tight isoclinal folds trending ENE-WSW, also giving rise to axial plane foliation. Increase compression and shear stresses led to the rupture along axial regions, with the development of the shears which are well manifested in the form of closed spaced fracture system, essentially aligned parallel to the axial trace of the folds. The culmination of this deformation phase has been marked by granite activity.

The open to tight upright folds with their axis aligned in the same direction as were superimposed during the second phase of deformation. Plunge folds depict variable low angle, trending towards E and W. Axial plane shearing also accompanied to some extent during this deformation. The phase was marked by the emplacement of pink granite and pegmatite.

The last phase of folding is conspicuously shown by the closure of the outcrops along the strike, with their axis running perpendicular to the axis of first fold. As a result of E-W compressive stresses, cross folds formed during the phase with simultaneous generation of several cross-faults and associated fractures. Intrusive of pegmatites, aplite and dolerite dykes, marked the culmination of this phase.

Development of the rift valley preceding the deposition of Gondwanas also left some imprints on the original deformation structure.

Towards the final phase of deformation the folded super structure witnessed intense shearing along ENE-WSW to WNW-ESE trending. This shear zone extends for over 100 km from Mahan in the west to Binda Nagnaha in the east and its manifestation is seen in the form of quartzo-feldspathic cataclasite. Associated with the main shear, are several sub parallel shears, though of smaller extent. Reactivation of the shears during subsequent deformation is also surmised. The shearing led to extensive mylonitisation, development of shear foliations, recovery and recrystallisation, influx of aqueous fluids and development of retrograde assemblages in metabasites.

Reference

1. Bardossy, G. and Aleva, G. J. J. (1990): Lateritic bauxites. Elsvier, pp 624.
2. Dennen, W. H. and Norton, H. A. (1977): Geology and Geochemistry of bauxite deposits in the lower Amazon basin, Econ. Geol. 72, pp 82-89.
3. Hansoti, S. K. (1973): Annual report for the F.S. 1972-73. Unpub. Rep., Atomic Minerals Division, Hyderabad.

4. Horbe, A. M. C. and Anand, R. R. (2011): Bauxite on igneous rocks from Amazonia and Southwestern of Australia: Implication for weathering process, Journal of Geochemical Exploration, Australia. Vol. 111, pp 1-12.

5. Kak, S. N., Perumal, N. V. A. S., Satyanarayana Rao, S. R., Krishnamurthy, B. and Phadke, A. V. (1983): Three case studies illustrating the use of remote sensing techniques in uranium exploration. Proc. NNRMS Seminar, Hyderabad. Vol. III, pp 50-52.

6. Mishra, B. K., Hemraj, Saha, B. and Shreeramamurthy, A. (2008): Regional search for lamproite/ kimberlite in Tapti lineament zone in Raigarh, Jashpur and Surguja districts of C.G., Unpub. Rep. Geol. Surv. Ind., F.S. 1997 to 2000.

7. Nair, K. K. K., Jain, S. C. and Yedekar, D. B. (1988): Geology, structure and tectonics of the Son-Narmada-Tapti lineament zone. Rec. Geol. Surv. Ind. Vol. 117, pt 3-8, pp 136-147.

8. Negi, B. S. (1981): Annual report for the F.S. 1979-80. Unpub. Rep., Atomic Minerals Division, Hyderabad.

9. Patel, D. R., Dhekaware, H. D. and Kankane, S. (2005): Bauxite deposits of Mainpat plateau, Surguja district, Chhattisgarh, India. ICSOBA-2005, pp 242-249.

10. Radhakrishna, B. P. (1989): Suspect tectono-stratigraphic terrain elements in the India subcontinent. Jur. Geol. Soc. Ind., Vol. 34, pp 1-24.

11. Raman, P. K. (1986): Decisive controls in the formation of the east coast bauxite deposits of India. Jour. Geol. Soc. Ind. Vol. 28 (1), pp 1-8.

12. Rao, M. G. and Raman, P. K. (1979): The east coast bauxite deposits of India. Bull. Series A, Econ. Geol. No. 46, G.S.I. pp 24.

13. Saxena, V. P. (1975): Annual report for the field season 1974-75. Unpub. Rep. Atomic Mineral Division Hyderabad.

14. Saxena, V. P. (1981): Annual report for the field season 1980-81. Unpub. Rep. Atomic Mineral Division Hyderabad.

Understanding Land Gradation Scenario in Chambal, India: A Journey through Maps

Padmini Pani
Assistant Professor
Centre for the Study of Regional Development
Jawaharlal Nehru University, New Delhi-110067
E-mail: padminipani.jnu@gmail.com

Abstract

Sustainable development, a very broadly used expression and idea. The notion of sustainable development is a challenge to combine increasing alarm about a variety of environmental problems with socio-economic issues, which can be mapped using various data sources. Maps would help to prepare sustainable remedy and policy for better response and adoption. The paper is about the scenario of semi arid environment where land degradation is a challenging issue and its implications on lively hoods. Ravine erosion is one of the severe forms of land degradation in semi arid India, where the loss of top soil has major physical and economic implications. The most affected area in India is Chambal valley, in particular, has been severely affected by ravine erosion for last few decades. Around 5000 sq km is affected by ravine erosion in India. Chambal Valley is highly inaccessible due to the difficult terrain conditions and history of higher crime rate. To look in to the scenario of the area the different year Remote Sensing data proved to be very useful tool for the ravine mapping and helped to understand and assess the changing scenario of the affected area through maps. Villages which are situated inside the ravine are badly affected by the encroachment of ravine. The village conditions are assessed through the light of population census data.

Introduction

Degradation is a process of change over time. Hence land degradation refers to a temporary or permanent decline in the productive capacity of the land, or its potential for environmental management. Land degradation is commonly recognized as a global problem related with desertification in arid, semiarid zones.,Out of the worlds dry lands 37 per cent of the world's total population live on land that is either potentially or actually degraded.

The extent of land degradation in India is increasing over time, with growing increasing rate (Ratna Reddy, 2003). As per NRSC (Formerly NRSA,) estimates, in terms of cultivable land the extent of degradation accounts for 11.63 per cent of area in 1980-82, 18 per cent in 1988-89 and 16.31 per cent in 1986-89. Among the various types of land degradation in India, ravine is one of the severe forms of land degradation, where the loss of top soil has major economic implications. Land degradation by ravines and gullies is wide spread in Indiabut the most critical zone is the Chambal Valley of Madhya Pradesh and Uttar Pradesh, and in parts of Rajasthan. The Lower Chambal Valley of Madhya Pradesh is severely affected by gully erosion. The area is mostly dissected and is made up of steep ridges; low slopping hills, deep trenches and broad meanders. In the past few decades, the Chambal ravine has come to be seen as a national problem. Mapping through remote sensing one of the key tool in monitoring local, regional and global environmental issues. Since geospatial investigations offer an excellent opportunity to study the land degradation status of a fragile environment, whereas socioeconomic study depicts the real world scenario of a region in terms of the livelihood condition.The present study is an attemptto use the different year remote sensing data and survey of India topographic sheets to prepare land degraded area over different year where the socio economic indicators were taken from village census abstract and mapped it with given the suitable weightage.The prepared map is showingthe interrelation ship with land degradation andits impact.

The Study Area

The area under study is Morena district of Madhya Pradesh in central India, which forms part of the lower Chambal valley (Fig. 1). The total geographical area of the district is 4989 sq.km. located between 26°17'15"N and 26°52'22"N latitudes, and 76°28'30"E and 78°32'55''E longitudes. The drainage of the area is governed by river Chambal flowing in SW-NE direction. Physiographically a major part of the area is covered by thick alluvium deposited by Chambal and its tributaries. Climatically the area falls within the limits of semi-arid region. Ravines are the major characteristic feature in the area, most of which are developed in both sides of the river Chambal.

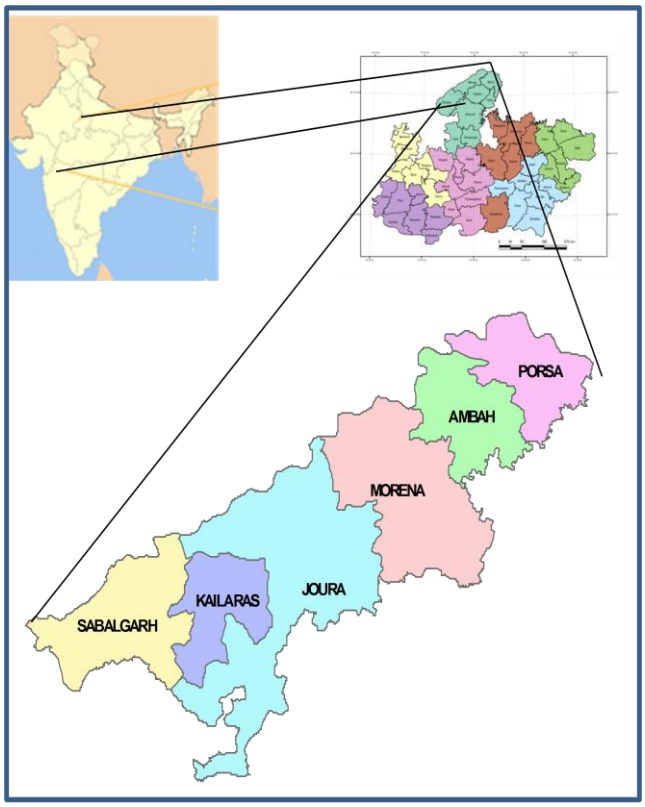


Fig. 1: The Study Area

Literature Review

The first well recognized geological study of the area was carried out about 81 years ago. The comprehensive work intended to classify the rocks in chronological order was done by Heron (1917). This pioneer effort was succeeded by Pascoe (1959) and Krishnan and Swaminathan (1959). The Vindhyans were given the status of a system when it was first recognized by Oldham (1856). Significant contributions to the geology of the Vindhyan system have been made by Vredenberg (1906), Heron (1922), Coulson (1927), Auden (1933), and by a number of workers from the Geological Survey of India. A pioneering study in the ravines of Lower Chambal Valley have been made by Sharma (1980). Kalra *et al*. (1989) observed that Landsat TM data aided with aerial photographs are very useful in delineation, classification and monitoring the extent of ravines. Based on their studies, they proposed some suitable reclamation measures. In a ravines area, it seems that the first aerial and satellite based study for mapping of cropland erosion was carried out by Stephens and Chilar (1981, 1982). The utility of Landsat MSS data for ravine mapping in India has been reported by Singh (1977). and Singh 1984. Using both satellite images and aerial photographs, Bali and Karale (1977) and using satellite images alone Karale et al. (1981), attempted to delineate and classify ravines. Hironi et al. (1991) studied in detail on ravine morphology and its land use planning using satellite data. Pandey et. al. (1993) studied how Landsat multi-temporal data can be utilized to determine environmental changes. Singh et al. (1998) tried to evaluate the utility of IRS – 1C PAN data for monitoring gullied and ravenous lands in western Uttar Pradesh. Pani et al. (2001), Pani et al. (2013) observed an increase of ravine affected area and the villages have constantly been shifting from their original locations in response to soil degradation and erosion. The evaluation of different landform units and the implication of neo-tectonic activity in the area using Remote sensing techniques have been carried out by Pani et al. (2005,). Pani et al. (2009) carried out a study of erosion intensity assessment in a part of the Lower Chambal Valley.

The study of farmers' perception reveals that farmers are deeply aware of the problems of land degradation in the region and have adopted various coping strategies that include changes in farming practices, reliance on multiple livelihoods and spatial reallocation of household labour (Pani et al. 2011).

Data and Methodology

Three types of data sets have been used in the present study:

i) Remotely-sensed data, viz. IRS 1C -LISS III data of 2005, has been used for the present study at various stages.

ii) Survey of India (SOI) Topographicsheets at 1:50,000 scale. Field data, viz. GPS measurements, ravine measurement, meteorological data census data, etc. Relevant information pertaining to geology, lithology, irrigation details, forest details about the area collected from the available reports and maps published by the concerned departments.

In order to understand the interrelationships between land degradation and socio-economic development across space, this study has tried to develop a methodology which can be broadly grouped into four stages such as:

a) In the first step, all the data have been converted to digital format, by digitization of existing maps and village locations. Remote sensing data are already in digital format.

b) The second step involves generation of thematic layers of information from different sources. It involves digital image processing of remote

sensing data and further processing of existing maps and field data for extraction of pertinent information.

c) The third step involves the generation of the GIS database. A base map has been generated from SOI topographic sheets at 1:50,000 scale compromising surface drainage features, transportation network, canals and location of settlement areas. All data have been geo-referenced to the base map. LISS-III data have been geo-referenced and resampled using the nearest neighbour interpolation method.

d) The fourth step consists of integration of multi-disciplinary datasets into composite information set which can answer a broader range of question in the spatial context.

Thematic Map generation

Satellite images (Fig. 2) have been used for preparation of various thematic maps. Thematic maps are the true representations or are the resultant snapshots of the different process, which are continuously operating on the earth's surface. The various thematic maps like land use/land cover, ravine map, drainage density, slope, aspect are prepared to depict the spatial distribution of the area. These thematic maps are digitized and standardized for referencing and used in a GIS environment for integrations and further analysis.

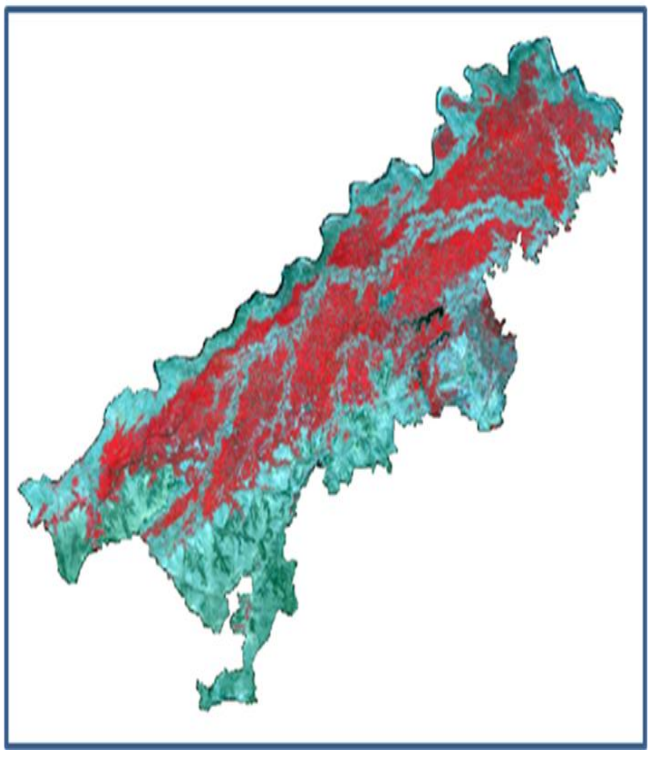


Fig. 2: The FCC generated for Morena District

Digital Interpretation

Image preprocessing is necessary before information is extracted from the image because it ensures that the image is as close to the true radiant energy and spatial characteristics at the time of data collection Using ERDAS Imagine Digital Image Processing (DIP) software the digital data is processed on high end computer. A minimum of 20 ground control points were collected and the average root mean square (RMS) error of 0.85 pixels was achieved. Ideally one would want an RMS error less than 1 and as close to 0 as possible. These steps were necessary to ensure that any additional spatial data would overlap exactly.

Methodology for land degradation status

In order to assess the status of gully erosion and intensity of erosion in the study area the first step used is to identify the ravenous zone of the area. For this study supervised classification method has been used and ravinesare delineated in the study area.

Methodology for Socio-economic Status

All villages lying within the study area were geo-referenced and digitised, using District Census Village Boundary Map, in Arc-GIS environment and were superimposed on the ravine map of the district. Based on this mapping exercise, the villages of the district were classified into two groups: those located within the degraded area and those situated outside. Village-level data available through Census of India, 2001 were then used to generate composite indices of development. The village development index analysis and mappedhave been done in a GIS environment to generate an index of the level of development for each village through the village development index map. Specific individual indexes are developed after analysis of particular sectors. The individual indexes indicate the development in that sector of amenity. Primary census data of 2001 was used for assessing the social and economic development of a village. Village development index (VDI) was worked out using about 16 different parameters which may have an impact on the land degradation status of the area. Initially a representative development index for each parameter has been calculated by assigning value in the scale from 1 to 4.

All the villages have been reclassified and ranks has been assigned from 1 to 4 as per the each parameter where 1 represents the less availability of the facility and 4 represent the more availability of the facility. Hence each representative development index (RDI) reflects the development level of a village with respect to that individual amenity which has been considered

for. The representative development indexes are then summed to arrive a village development index based on social and physical parameters respectively. These village development indexes reflects the overall development of the village based on the parameters concerned and further reclassified in to four categories based on the level of development. Finally, both social and physical parameters are combined together to have an overall composite village development indexes.

Results and Discussion

On the basis of shape, depth, side slope and head slope three different types of ravines: young, mature and old are observed. The ravine system in the region is dynamic and is changing in terms of its size, pattern and areal extent. In the images the ravines appear in different shades of bluish green or greenish blue with a mottled texture due to the unconsolidated nature of the soil. The total degraded area in Morena district, as estimated from IIRS LISS-III 2005, is 1237.14 sq km, out of which the total ravine area is 588.45. Thus, out of the total area of the district, 24.87 per cent was found to be under wasteland and ravine land account for 11.83 per cent of the total area. Of the total area under wasteland 47.57 per cent was ravines (Fig. 3). The comparative assessment of levels of socio-economic development between villages situated within and outside the degraded area is expected to reveal whether there are systematic differences in the levels of development among these two categories of villages. This analysis has been carried out for the different sets of composites indices and the results presented in Table 2 and 3 brings out the significant differences that exists between villages within degraded area vis-a-vis those located outside the area.

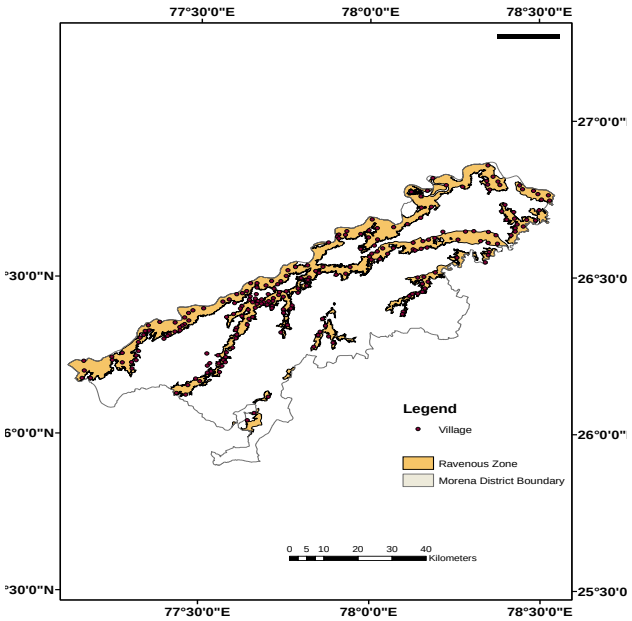


Fig. 3: Ravine Map

Table 1. Village Development Index (Based on Social parameters)

Class	Class Interval	Details	No. of Villages	Percentages
0	0-9	Area not Surveyed	54	-
1	10-15	Poorly Developed	134	18.01
2	16-20	Marginally Developed	444	59.68
3	21-25	Developed	152	20.43
4	25-30	Well Developed	14	1.88

Table 2. Village Development Index (Based on Physical parameters)

Class	Class Value	Details	No. of Villages	Percentages
0	0-9	Area not Surveyed	52	-
1	10-15	Poorly Developed	41	5.50
2	16-20	Marginally Developed	261	34.99
3	21-25	Developed	436	58.45
4	25-27	Well Developed	8	1.07

Table 3. Composite Village Development Index

Class	Class Value	Details	No. of Villages	Percentages
0	0-16	Area not Surveyed	52	-
1	17-35	Poorly Developed	198	26.54
2	36-40	Marginally Developed	448	60.05
3	41-49	Developed	127	17.02
4	50-52	Well Developed	8	1.07

Table 4. Comparison of Details of Various Village Development Indexes

Details	Social Parameters	Physical Parameters	Composite	Social Parameters	Physical Parameters	Composite
Classes	No. of Villages	No. of Villages	No. of Villages	Percentages	Percentages	Percentages
Poorly Developed	134	41	198	18.01	5.50	26.54
Marginally Developed	444	261	448	59.68	34.99	60.05
Developed	152	436	127	20.43	58.45	17.02
Well Developed	14	8	8	1.88	1.07	1.07

Index of Socio-Economic Development

The village development index (VDI) analysis has been prepared in a GIS environment to generate an index of the level of development for each village. Specific individual indices are developed after analysis of particular sectors. The individual indices indicate the development of specific sectors of socio-economy. Primary census data of 2001 was used for assessing the social and economic development of a village.

VDI was worked out using 16 different parameters which may be linked with the land degradation status of the area, which have been further grouped into two classes: social and physical. Initially a development index for each parameter has been calculated by assigning value in the scale from 0 to 4. The indicators such as education facility, medical facility, drinking water, post and telegraph, electricity, bank, communication, approach, entertainment are considered as social indicators, whereas forest area, irrigational area, area under cultivable waste, per capita agricultural area, total agricultural area are considered as physical indicators. The development indices are then combined to estimate a village development index based on social and physical parameters separately (Table 1 and Table 2). Finally an overall composite village development index has also been computed (Table 3, Fig. 4). On the basis of composite development score, villages have been classified into various groups and comparative analysis of level of development in villages within and outside the ravine area has been undertaken to derive the implications of land degradation and level of socio-economic development (Table 4). The total villages are 798 out of which 50 villages are not surveyed.

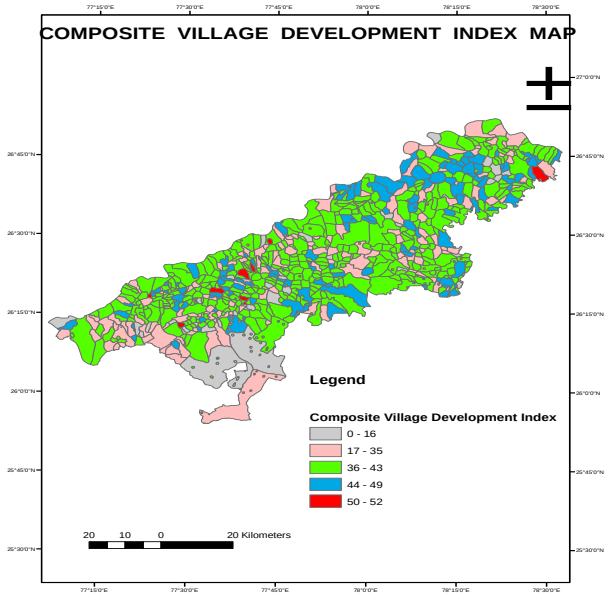


Fig. 4: Composite Village Development Index Map

As per the composite development index 198 Villages fall under poor and 448 villages fall in marginally developed village category, which forms 26.54 and 60.05 percentages respectively of total villages surveyed . Hence it can be said that about 86 percent of the villages are poorly developed or marginally developed. However, a significant limitation of the study is that it relied on village level data from population census to study the socio-economic implications. A more robust estimate of the impact of land degradation on socio-economic variables in a relatively inaccessible area would require extensive field research in the study region as well as analysis of high resolution remote sensing data. The present study provides important insights to carry forward the analysis on the basis of primary survey.

Conclusion

Land degradation, as a process, is not only affected by the way nature-human interactions take place in a specific spatial context, but also has several socio-economic implications. This study, following a multi-disciplinary approach, attempts to integrate multiple data sources and methodologies to study the implications of land degradation in semi-arid India. Using remote sensing data with field validation, an estimate of the extent and broad pattern of land degradation in a remote and fragile ecological region in central India has been provided. The evidence presented here shows that villages located within the degraded area have consistently lower levels of socio-economic development than those located outside the area. The result is true not only for over-all levels of development, but also for policy-controlled indices such as infrastructure development index. In other words, being located within an area affected by land degradation adversely affects the level of socio-economic development. These results complement the findings of earlier studies on the linkages between land degradation and socio-economic development. It points to the significance of ecological settings in explaining regional diversities in growth performance (Palmer-Jones and Sen, 2003). However, the precise nature of the linkages between these two processes needs to be further probed by examining the direct and indirect implications of land degradation on rural livelihoods and well-being of people at a more disaggregated level. This evidence also suggests that negative externalities arising out of adverse geographic conditions and environmental degradation may operate at different scales. Even within a relatively less developed region, being located within ravines implies lower levels of development and less access to public infrastructure.

The findings of the work help in understanding the interrelationship between environmental degradation and socio-economic development in one of the poorest regions of India. The questions of ecological sustainability, poverty and development policy are interlinked. The present work, by predicting the extent of gully formation and linking it with the socio-economic profile of the region provides important insights into the ways village economies respond to environmental degradation. Issues relating to ecological sustainability and poverty have been identified as one of the key concerns. This study follows an inter-disciplinary approach and tries to present the case for use of GIS techniques to understand the environment-society relationship.

References

1. Auden, J.B., (1933).'*VindhyanSedimentation inthe Son Valley, Mirzapur district*.' Memoir, Geological Survey of India, 62 (2), 141-256.
2. Bali, Y.P.Karale, R.L.(1977). '*Sediment Yield Index as a Criterion for Choosing Priority Basins'*, IAHS-AISH Publication No.122, Paris, P. 180-188.
3. Heron, A.M. (1922).'*The Gwalior and Vindhyan systems of south eastern Rajputana*,' Memoir Geological Survey of India, 45, (2), 129-179.
4. Heron, A.M. (1917).' *Geology of north-eastern Rajputana and adjacent districts'*, Memoir Geological Survey of India, 19(4).
5. Hironi, Kalyan(1991). '*Land use Planning and Geomorphology AStudy of SawaiMadhopur'*New Delhi: Concept Publishing Company.

6. Karale, R.L., Y.P. Bali & K.V. Rao(1981).'*Soil Mapping Using Remote Sensing Techniques'*. Proceedings Indian Academy of Science andEngineering Sciences 3:197-208.

7. Kalra, N.K. and Kachawaha, Rakesh(1989). '*Application of Multistage Remote Sensing in Delineation and Reclamation of Ravines in Eastern Rajasthan'*, Processing,Symposium, Engineering Application of Remote Sensing and Recent Advances, I.S.R.S., Dehradun.

8. Karale, R.L., Saini, K.K., and Narula, K.K. (1981).'*Mapping and Monitoring Ravines Using Remotely Sensed Data*'. Journal of Soil Water Conservation, India 32.

9. Krishnan,M.S. and Swaminathan, J. (1959).'*The Great Vindhyan Basin of Northern India'*, *Jour Geol. Soc. India*, 1, 10-30.

10. Oldham, T. (1856).'*Remarks on the Classification of the Rocks of Central India, Resulting from of the Geological Survey'*. *Journ., Asiatic. Soc. Bengal,* 25, 224-256.

11. Palmer-Jones, R, and K, Sen. (2003).'*What has luck got to do with it? A regional analysis of poverty and agricultural growth in rural India'*,*Journal of Development Studies*, 40(1), 1-33.

12. Pandey Dherendra, Saxena Rajesh and Gaur S.C. (1993).' *Study of Environmental Changes dueto Ravine Development along ChambalRiver near Bhind and its environs in NNRMS'*Bangalore,1994 Conference.

13. Pani, P; Mohapatra S.N; and Singh U.C.(2005). '*Evaluation of Different Landform Units and neotectonic implications in a part of Lower Chambal Valley, using satellite images – a Computer Aided Geomorphic Approach*'. In: Himalayan Orogen: Foreland Interaction, ed. A. R. Bhattacharya and K KAgarwal, Lucknow: Palaeontological Society of India, 210-224.

14. Pani, P., Mohapatra S.N. (2001). '*Delineation and Monitoring of Gullied and Ravinous Lands in a Part of Lower Chambal Valley, India, using Remote Sensing and GIS'*. ACRS 2001, Singapore. 1, 671- 675.

15. Pani, P., Mohapatra, S.N. (2009). '*Ravine Erosion in India: A Geospatial Study of Lower Chambal Valley*'. Geography and You 9 (52), 20-25.

16. Pani, P., Mishra D K and Mohapatra S. N. (2011).'*Land degradation and livelihoods in semiarid India: A Study of Farmers' Perceptions in Chambal Valley'*, Asian Profile, 39 (5), 505-519.

17. Pani, P., Carling P. (2013) *'Land Degradation and Spatial Vulnerabilities: A Study of Inter-Village Differences in Chambal Valley, India'*, DOI:10. 1080/10225706.2012.754775, Asian geographer.

18. Pascoe, S.E.H. (1959). '*A Manual of the Geology of India and Burma'*, I & II Pearson Prentice Hall.

19. Ratna Reddy, V., (2003).'*Land Degradation in India: Extent, Costs and Determinant'*. Economic and Political Weekly 38 (44), 4700-13.

20. Sharma, H S (1980).'*Ravine Erosion in India'*, New Delhi: Concept.

21. Singh, A.N., M.F. Baumgardner, and S.T. Kristof, (1977). '*Delineating Salt-Affected Soils in Part of the Indo-Gangetic Plain by Digital Analysis of Landsat Data*', Technical Report 111477, LARS, Purdue University, West Lafayette, Indiana, 21 p.

22. Singh, A.N., Y.K. Sharma & S. Singh.(1998). '*Evaluation of IRS-1C PAN data for monitoring gullied and ravinous lands of western U.P. Remote Sensing and Geographic Information System for Natural Resources Management'*. A joint publication of Indian Society of remote sensing and NNRMS, Department of Space, Bangalore.

23. Stephens, P.R. and Chilar, J. (1981).'*The potential of remote sensing to monitor soil erosion on cropland*'. Proc. Fifteenth Int. Symp. Rem. Sem. Enriron, ERIM, Ann Arbor, MI.

24. Stephens, P.R. and Chilar, J. (1982).'*Remote sensing based methodology to map and monitor cropland erosion*', Proc. Seventh Canadian Symp., Rem. Sens.

25. Vredenberg, E. 1906. Suggestions for the classification of the Vindhyan System; *Rec. Geol. Surv. Ind.,* 33, 255-260

Spatial Distribution of PHC and Identification of Major Diseases in Nilgiris District - A Geo Medical Study

J. Ganesan[1] and Dr. V. Saravanabavan[2]
[1]Research Scholar & [2]Assistant Professor
Department of Geography, School of Earth and Atmospheric Sciences
Madurai Kamaraj University, Madurai –21
E mail: jganeshbuasc@gmail.com

Abstract

Health is influenced by a number of factors such as adequate food, housing, basic sanitation, lifestyles, protection against environmental hazards, nutritional disorder and communicable diseases. The study area Nilgiris is situated in the south Western part of Tamilnadu. There are 29 Primary Health Centers 197 health sub centers and 2 Government General Hospital in Nilgiri district. The 29 primary health centers are situated in Udagamandalam, Coonoor, Kothagiri, Kundha, Gudalur, and Pandalur. Each Primary healthcare center covers about 6 Taluks in Nilgiris district. The data collected were both Primary and Secondary data and suitable cartography analysis and statistical analysis were executed. Buffer analysis is used to identify the spatial pattern of distribution of the PHC (Primary Health Center) Suitable Cartographic techniques are employed to prepare thematic maps using Arc GIS 9.3 software. The present study will form the basis for future planning of health care services in the study area.

Introduction

India has a vast network of public and private health services manned by a large number of medical and paramedical personnel, but poor location decisions constrain geographical access to health services in rural and less developed areas. In this paper, an attempt is made to examine location, geographical accessibility and disease pattern of Primary Health Centers (PHCs) in Nilgiris district, located in western part of Tamilnadu. In recent years in all countries trying to give 'health for all' still remains a distant reality because of poor geographical access to health services and explosive cost of utilization (Ravichandran. et.al 2008). Non-availability and distorted geographical-distribution are some of the important reasons for poor geographical accessibility not only in India, but also throughout the Developing Countries. Health is a common theme in most culture. Among definitions still used, probably the oldest is that health is the absence of disease. In some cultures, health and harmony are considered equivalent, harmony being defined as being at peace with self, the community, god and cosmos. The ancient Indians and Greeks shared this concept and attributed disease to disturbances in bodily equilibrium of what they called humors. (United Nations Conference at San Francisco in 1945).

Primary health care

Primary Health Care is the first level of contact with the health system to promote health, prevent illness, care for common illnesses, and manage ongoing health problems *(Lakshmi, 2004)*. Primary Health Care extends beyond the traditional health sector and includes all human services which play a part in addressing the inter-related determinants of health. (Ganesan, et. al, (2007). It is the essential health care made universally accessible to individuals and acceptable to them, through their full participation and at a cost the community and country can afford.

Study area

Nilgiris district is basically a hilly region, situated at an elevation of 2000 to 2,600 meters above MSL. Almost the entire district lies in the Western Ghats. Its latitudinal and longitudinal dimensions being Latitude: 11° 00' to 11° 45' N Longitude: 76° 15' E to 77° 00' E. Nilgiris district is bounded by Mysore district of Karnataka and Wayanad district of Kerala in the North, Malappuram, and Palakkad districts of Kerala in the west, Coimbatore district of Tamilnadu in the South and Erode district of Tamilnadu and Chamrajnagar district of Karnataka in the East. Nilgiris district has an area of 2,452.50 km^2 .In Nilgiris district the topography is rolling and steep.

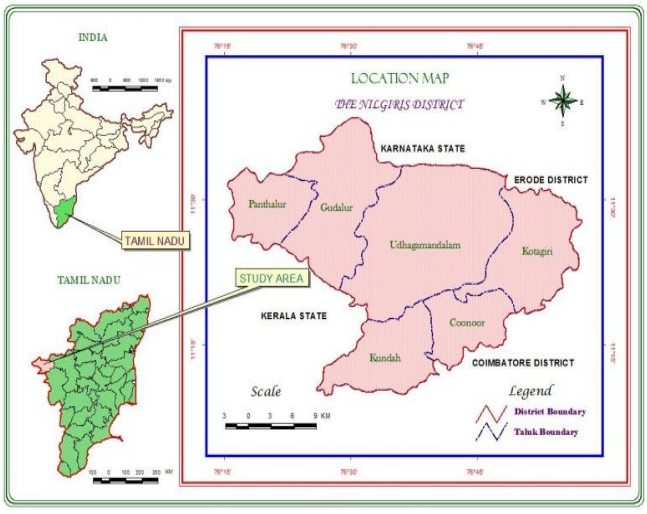


Fig: 1

Nilgiris District comprises of six taluks viz Udhagamandalam, Kundah, Coonoor, Kotagiri, Gudalur and Pandalur. This district has Two Municipalities namely, Wellington Cantonment and Aruvankadu Township. The District consists of 56 Revenue Villages according to the 2011 census. Nilgiris district has a population of 735,071, roughly equal to the nation of Guyana or the US state of Alaska. This gives it a ranking of 495th in India (out of a total of 640). The district has a population density of 288 inhabitants per square kilometer. Its population growth rate over the decade 2001-2011 was -3.55 %. Nilgiris district has a sex ratio of 1041 females for every 1000 males, and a literacy rate of 85.65 %. As per the 2001 Census, Hindus formed the majority of the population (78.60%), followed by Christians (11.45%), Muslims (9.55%) and others (0.4%).

Aims and objectives

- To analyse and identity the spatial pattern of primary health center and disease pattern in Nilgiris district.
- To identify the prevalence of major diseases and the occurrence of diseases in PHCs through Taluk wise in Nilgiris district.
- To identify suitable location for future planning

Results and discussion

A. Spatial Distribution of PHC Location in Nilgiris District

The primary health center is a multipurpose unit established at the peripheral level to render preventive and curative medical service to the rural community. A primary health center has been established in all taluks in Nilgiris district namely, Ooty, Coonoor, Kothagiri, Kundha, Gudalur and Pandalur. There are 29 PHCs in Nilgiris district (Fig. 2). These 29 PHCs include Udagamandalam taluk which has 7 PHC centers, Pandalur taluk- 5 PHCs, Coonoor taluk - 4 PHCs, Kothgiri taluk - 5 PHCs, Gudalur taluk - 4 PHCs and Kundha taluk - 4 PHCs. In this taluk according to this analysis all the villages are served by in this PHC.

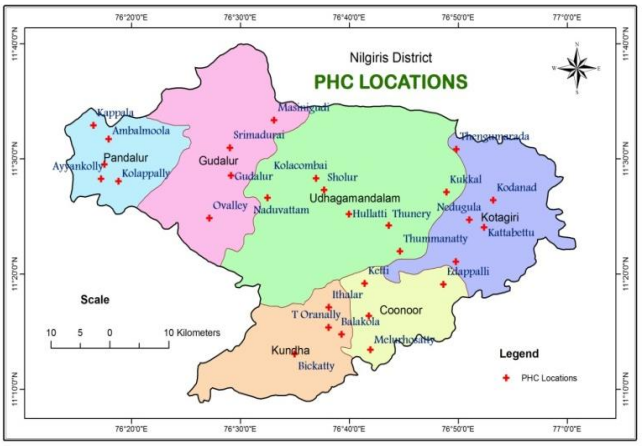


Fig: 2

The PHCs are rendering health care service to various diseases but due to geographically and socio-economic variation the disease registered in each PHC also varies.

PHC service area in Nilgiris district

Nilgiris district completely covered by high altitude areas with dense forests and different climatic conditions occur. The district health care system is difficult when compared to other areas. Keeping this in mind a buffer method is applied and created 6.5 km radius ring with help of Arc GIS 9.3 platform to identify service areas of every PHCs in Nilgiris district.

In Udagamandalam taluk there are 7 PHCs. These 7 PHCs serve only the interior part of Udagamandalam (Ooty) town, but the exterior area is not served by the PHCs. Government authorities can establish one or two PHCs in the outer area of this taluk to fulfill the service.

Coonoor, Kothgiri and Kundha taluks have 13 PHCs and all the villages are served by in these PHCs.

There are 5 PHCs in Pandalur taluk and almost all the rural villages are serviced by these PHCs expect Nelliyalam village which is not served by any of the above mentioned 5 PHCs.

In Gudalur taluk there are 4 PHCs which cover the revenue villages except Nelliyalam.

Nelliyalam is located between Pandalur and Gudalur taluk. In this buffer analysis it is concluded that the 29 PHCs serve almost all the revenue villages in this district except peripheral villages.

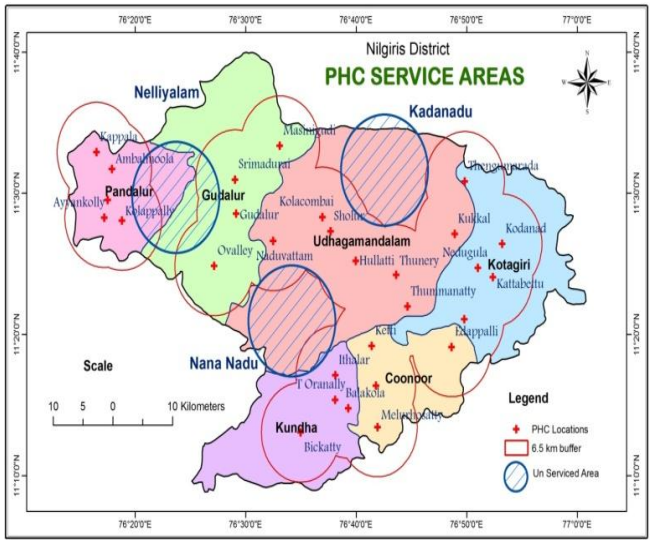


Fig: 3

PHC disease pattern

"Webster" defines disease as a condition in which body health is impaired a departure from a state of health,

an alteration of the human body interrupting the performance of vital functions.

Disease may be defined as a condition of the body or some part or organ of the body in which its functions are disrupted or deranged. (Oxford English Dictionary) The simplest definition is that disease is just the opposite of health and any deviation from normal functioning or state of complete physical or mental well being (Saravanabavan, 2004, 2006). WHO has defined health but not disease. This is because disease has many shades (spectrum of disease) ranging from in apparent (sub clinical) cases to severe manifest illness. Some disease commence acutely (food poisoning) and some insidiously.

The present investigation is to bring to light the rural health status in Nilgiris district. The following diseases are identified and analysed. They are Respiratory system, Cardiovascular System, Pyrexia Related Diseases, Connective Tissue Disorder, Pregnancy Related Disorder, Skin, Insect/Animal Bite, Gastro Intestinal System, Genitourinary System, Neurological Disorder, ENT, Dental, Ophthalmic, Nutritional Disorder and Endocrine System. These diseases are grouped in each taluk for detailed analysis.

A. Udagamandalam Taluk Primary Health Center

The distribution of diseases in Udagamandalam taluk primary health centers for the year 2009 indicate nearly 16 type of diseases (Fig: 4). The number of cases registered for Respiratory diseases is the maximum (50828). Cardiovascular system (7775), Gastro intestinal system (7763), ENT (3801), Skin (3280), dental (2960). Other diseases are also registered in these primary health centers.

Ooty is one of the main tourist attraction place for people. People regularly come here throughout the year for tourism. This creates more solid waste in this town. The smoke pollutes the atmosphere and causes diseases. This pollution may be the major reason for the prevalence of respiratory diseases in this zone.

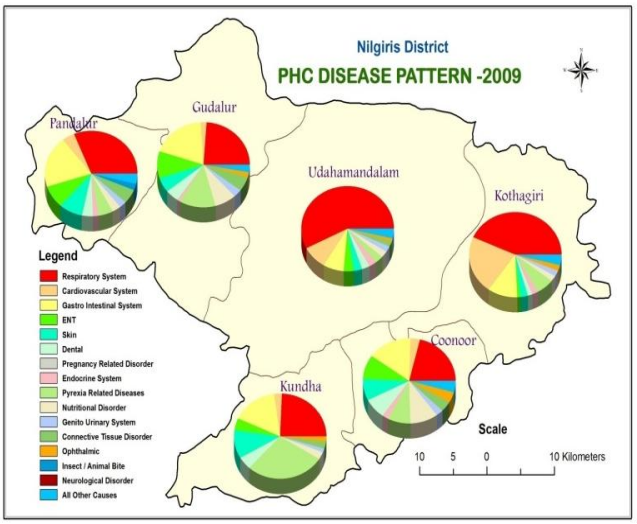


Fig: 4

B. Coonoor Taluk Primary Health Center

The distribution of diseases in Coonoor taluk primary health center for the year 2009 is represented in Table 1, The maximum number of cases registered is for respiratory disease (14969) and gastro intestinal system (12636). This is followed by nutritional disorder (8350) and pyrexia related disease (7096). Minimum number of cases is registered for dental (5374), skin (4929) and cardiovascular system (2970).

However the patients treated for respiratory system disease is sizeable throughout the year. In this area the labourers are mostly engaged in agricultural activities. There is more number of tea factories in this region. The smoke emitted from these units has polluted the atmosphere and might have caused this disease.

Nutritional disorder includes anaemia, vitamin A deficiency, vitamin B deficiency and malnutrition. Most of the people do not get proper nutritious food. Also most of the tea labourers take food at improper time to cause the prevalence of nutritional disorder.

Skin related diseases are also noticed in Coonoor taluk primary health center. There are a number of tea gardening in this area and people work in these plantations as labourers. This may be the reason for the occurrence of skin related diseases.

Patients registered for pyrexia related diseases are also sizeable in Coonoor taluk primary health center. Climatic change and unprotected drinking water and also one of the reasons for pyrexia related diseases. Pyrexia related diseases include viral fever, typhoid fever, measles, chicken pox and malaria.

C. Kothagiri Taluk Primary Health Center

Kothagiri taluk primary health center is located along the north eastern part of the study area. The distribution of diseases in Kothagiri taluk primary health center for the year 2009 is clearly indicated Fig. 4.

In this primary health center also the maximum number of cases treated is for respiratory diseases (13443). This is followed by cardiovascular system disorder (5773) and gastro intestinal system disorders (3746).

However the patients treated for respiratory system disease is sizeable throughout the year. In this area the labourers are mostly engaged in agricultural activities. The smoke emitted from the tea factories of this region has polluted the atmosphere and have caused this disease.

D. Kundha Taluk Primary Health Center

The distribution of disease in Kundha primary health center for the year 2009 is represented in Table 1. The maximum number of cases is registered for pyrexia related diseases (6642), followed by respiratory (5176),

gastrointestinal system (3587) and skin diseases (1902). Kundha primary health center has more number of cases treated for pyrexia related diseases due to the pollution of water in this taluk.

E. Gudalur Taluk Primary Health Center

In Gudalur taluk the highest type of disease identified is gastro intestinal system (7757) followed by pyrexia related diseases (6082), ENT (3251), skin related diseases (1945) and nutritional diseases(3256). Gudalur primary health center has more number of cases treated for respiratory diseases. This is due to dumping of solid waste; more number of people working in tea factories and water pollution in this taluk.

F. Pandalur Taluk Primary Health Center

The distribution of diseases in Pandalur taluk primary health center for the year 2009 is represented in Fig. 4.

The distribution of disease pattern in Nilgiris district primary health centers revealed that six diseases are predominant. They are respiratory system disease, gastro intestinal, pyrexia related, cardiovascular system, nutritional disorder, skin diseases.

Udagamandalam taulk primary health centers revealed predominant of four diseases. They are respiratory system disorder, cardiovascular system, Neurological Disorder, Endocrine System and other diseases category.

Coonoor taluk primary health centers revealed major diseases like Pyrexia Related Diseases, Connective Tissue Disorder, Skin, Gastro Intestinal System, Genitourinary System, Neurological Disorder, ENT, Dental, Ophthalmic, Nutritional Disorder and Endocrine System.

Table. 1

Nilgiris district – Disease pattern - 2009

S.No	Taluk Name	Respiratory	Cardiovascular System	Gastro Intestinal System	ENT	Skin	Dental	Pregnancy Related Disorder	Endocrine System	Pyrexia Related Diseases	Nutritional Disorder	Genito Urinary System	Connective Tissue Disorder	Ophthalmic	Insect/Animal Bite	Neurological Disorder	All Other Causes
1	Ooty	50828	7775	7763	3801	3280	2960	122	2585	2565	2022	1747	1478	935	239	150	2675
2	Coonoor	14969	2970	12636	5671	4929	5374	150	1756	7096	8350	1874	2718	2479	735	109	2536
3	Kothagiri	13443	5773	3746	394	983	554	51	763	1903	591	578	275	539	130	99	981
4	Kundha	5176	708	3587	793	1902	970	14	123	6642	509	256	463	352	170	36	160
5	Gudalur	9321	991	7757	3251	1945	1821	32	480	6082	3256	1140	1865	623	232	26	886
6	pandalur	16667	2499	8616	3929	4772	2462	241	1307	3057	1689	1302	2479	496	1111	63	1552

It could be observed that the maximum number of cases registered is for respiratory disease (16667). This is followed by gastro intestinal system (8616), skin related disease (4472) and ENT (3929). In this Taluk also respiratory diseases are highly concentrated because of predominant tea factories and field labour.

Conclusion

A variety of factors influence human development, both favourably and unfavourably. Some of these factors are environmental, natural or manmade. The factors include physical, chemical, biological and social, economic, cultural factors, education, genetic factors, prenatal health development factors and nutritional factors.

The service area of the primary health centers form the areal unit for mapping Buffer analysis using GIS which is performed to investigate the unserved areas and to suggest suitable locations for future planning.

Pandalur taulk primary health centers revealed predominant of two diseases. They are Insect/ Animal bite and Pregnancy Related Disorders.

The other taluks have less important in all diseases for the year 2009. In the study area respiratory system diseases is dominant in all the primary health center zones.

People living in Nilgiris district suffer due to polluted air, water and land which have affected the health of the people. In these areas labourers are mostly engaged in agricultural activities.

To conclude it may be stated that even though the study area is located adjacent to Nilgiris district settlement the health status of the rural people is very poor. This is mainly because of the low socio-economic status of the people. Further the environmental conditions of the study area is also polluted and degraded. Hence the awareness of the people towards

protecting the quality of the environment is very much essential. This could be achieved only through environmental education. People should be offered better opportunities to improve their economic conditions. This could be achieved by the co-operative effort of the people and government.

References

1. Ganesan, J et.al, (2007): A Study on Morbidity Status In Thirumangalam Block And Madurai City, A Micro Level Study Using GIS. Paper submitted to Department of Geography, Madurai Kamaraj University, Madurai.
2. Lakshmi .K (2004): Distance and Health Care Services to Rural mass. A micro level study - Madurai District. UGC-minor research project.
3. Ravichandran. S. et.al (2008): "Medico-Geographic study on disease pattern in primary health care system in Karurtaluk"- A micro level study using GIS. Paper submitted to Department of Geography, Madurai Kamaraj University, Madurai.
4. Saravanabavan, V (2004): Identification of Health Care Delivery System For Paucibacillary Leprosy in Tamil Nadu. Paper Published in Geographical Review of India. Vol 59 no 3 Calcutta Pp 216-224.
5. Saravanabavan, V, et.al (2006): Travel and Health Care Utilization Pattern of Patients in Vadipatti block- a Micro Level Study Using GIS. The Paper Published in the journal of the Deccan Geography. Vol.44, No.2 dec, 2006 Pune pp 97-108.

Geospatial Analysis of Infrastructural Facilities in Tiruchirappalli District, Tamilnadu, Using GIS

M. Ashok Kumar
Department of Geography, School of Earth and Atmospheric Sciences
Madurai Kamaraj University, Madurai –21
Email: mlashokkumar@gmail.com

Abstract

Population explosion and resulting demand of appropriate service and infrastructural facilities are posing serious challenges for the administrators and planners. In a developing country like India a structured planning procedure is required such that the development activities and infrastructure facilities are available at both urban and rural area. However, a condition where majority of people live in rural area and are provided with the least infrastructure facilities, creates a regional imbalance in development, causing migration of population from rural to urban areas. Proper infrastructural planning helps in eradication of mass poverty, certain of more employment opportunities, checking of mass city ward push migration, improvement in living standard of the masses, narrowing the gap between the urban and rural living and generation of a self-substaining development process. The major infrastructural facilities taken for present investigation are health and education.

Geospatial technologies play a key role in generating timely and reliable information for planning and decision making at all the levels from macro to micro. Even though it is widely recognized that GIS is a modern technological tool to analyse both spatial and non-spatial data including temporal aspects in a cost-effective and efficacious manner. The study area is Tiruchirappalli district which comprises of 8 Taluks, 14 Blocks and 439 Villages. This district consists of 4 Municipalities and one Municipal Corporation which is also the headquarters of the district. It lies between 10^o to 11^o 30'of the North latitude and 77^o 45' to 78^o 50' of the Eastern longitude. The total geographical area of the district is about 4,511 sq.km. The total population of the district is 27, 13,858 persons in 2011. For the preparation of maps GIS software's Arc View 3.2a, ERDAS imagine 8.7 and Arc GIS 9.3 will be used. The results will be represented in the form of simple maps and diagrams and inferences are drawn.

Introduction

Infrastructure is an important aspect for all countries of the world, particularly developing countries. In India more than 60% of the peoples are living in rural areas but the availability of infrastructural facilities there is very limited. Education and healthcare are important components of basic infrastructure. Rapid increase in population, rising standard of living and higher levels of literacy exert tremendous pressure on the available health care and educational facilities. As a result it caused the growth of unorganized system of education and health care facilities. Most of the health and educational facilities are concentrated in cities and towns while in rural areas there is found a large gap in its distribution. However, such a condition, where majority of people live in rural area and are provided with the least infrastructure facilities, creates a regional imbalance in development, causing shift in population from rural to urban areas. Hence administrators or decision-makers require an efficient GIS based tool which will assist them to get the updated scenario of the region. GIS is becoming a vital tool in health and educational applications covering database management, planning and service area mapping, location identification, etc. Distribution of services as well as health and education requirements need to be addressed in spatial domain in order to identify what is needed at individual location rather than looking into the problem as a whole. Infrastructural facilities identification is most favorable to support the facilities and identification in relation to a settlement's location is an important component of balanced development.

Study area

The present study area namely Tiruchirappalli district is an inland district located in the central segment of the state of Tamilnadu. The district lies between 10^o 15' and 11^o 12' North latitudes and 78^o 10' and 79^o 5' East longitudes.

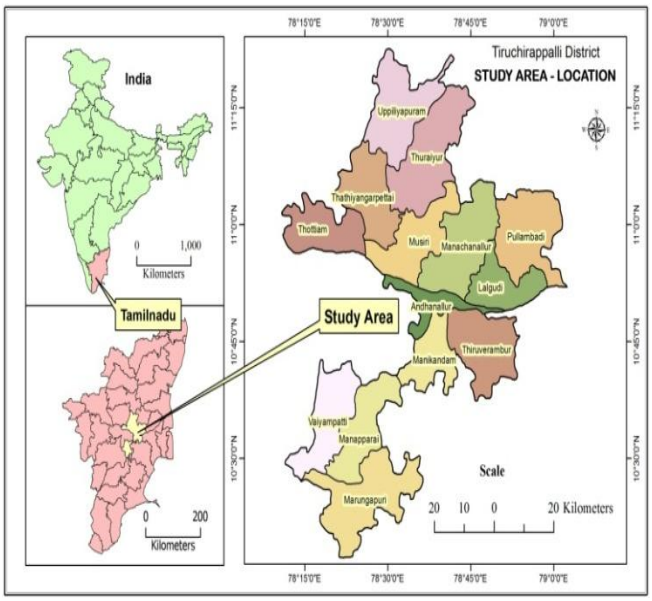


Fig. 1

The district is divided into eight taluks namely, Lalgudi, Manachanallur, Musiri, Manapparai, Srirangam, Tiruchirappalli, Thottiam and Thuraiyur. These taluks are further divided into fourteen blocks namely Lalgudi, Pullambadi, Manachanallur, Manapparai, Marungapuri, Vaiyampatti, Musiri, Thathiyangarpettai, Manikandam, Andhanallur, Thiruverambur, Thottiam, Thuraiyur and Uppiliapuram. Tiruchirappalli district has a population of 2713858 persons as per the year 2011. There are 1347863 males and 1365995 females. The density of the study area is 582 persons per sq.km. The literates account to about 83.5 percent in 2011.

Aims and objectives

The main aim of this paper is to highlight the infrastructural facilities for health and educational planning and development of rural area. To fulfill the aim, the following objectives are set as the main goal

- To study the spatial dimension of selected infrastructural facilities in Tiruchirappalli district
- To identify the suitable areas to locate these service facilities for community development areas.

IV. MATERIALS AND METHODS

A. Data Used

The following data sources are used for the present study

- ❖ Primary Census Abstract-2001
- ❖ SOI Topographic sheets 1:50,000 scale
- ❖ Relevant literatures

B. Software Used

- o Erdas Imagine 8.7
- o Arc GIS v 9.3 and
- o Arc View 3.2a software used to mapping analysis.

Results and discussion

A. Infrastructural Facilities

The spatial pattern of infrastructural facilities in a place reflects the status and significance of varied socio-cultural and demographic aspects in the study area. The study area has 14 blocks and eight taluks. The present study has considered the infrastructural facilities of rural settlements of the study area. Taking this as the basis as well as the availability of data, the following infrastructural facilities are taken for spatial analysis. A total of six major groups are considered. They are:

1. Medical Facilities
2. Educational Facilities
3. Post & Telegraph Facilities
4. Banks
5. Drinking water Facilities and
6. Recreational Facilities

To assess the status of these infrastructural facilities a ratio is taken between the total population/households and the number of infrastructural facilities. Table 1 provides the availability of these infrastructural facilities in the study area.

1. Medical Facilities

India has a vast network of public and private health services manned by a large number of medical and paramedical personnel, but poor location decisions constrain geographical access to health services in rural and less developed areas. Health care facilities include government hospitals, private hospitals, medical shops, clinical services, blood bank, laboratory, scanning lab, siddha and ayurveda clinics. Upkeep of good health was always given priority by civilized man. He has been making tremendous efforts to overcome illness and was successful in combating dreaded diseases.

Table 1. Tiruchirappalli District -Infrastructural Facilities

Sl.No	Village Name	Educational	Medical	Post & Telegraph	Banks	Recreational	Drinking Water
1	Andhanallur	73	30	19	17	1	79
2	Lalgudi	115	49	41	25	2	172
3	Manachanallur	147	38	35	22	4	142
4	Manapparai	104	44	20	30	1	92
5	Manikandam	91	28	14	10	2	100
6	Marungapuri	163	77	35	27	0	157
7	Musiri	128	45	36	13	0	126
8	Pullambadi	83	30	28	14	0	137
9	Thathiyangarpettai	84	31	28	18	1	103

10	Thiruverambur	59	22	16	8	0	80
11	Thottiam	125	62	30	18	1	92
12	Thuraiyur	135	34	46	17	0	118
13	Uppiliyapuram	89	24	22	15	1	88
14	Vaiyampatti	118	55	28	45	2	93
	Total	**1514**	**569**	**398**	**279**	**15**	**1579**

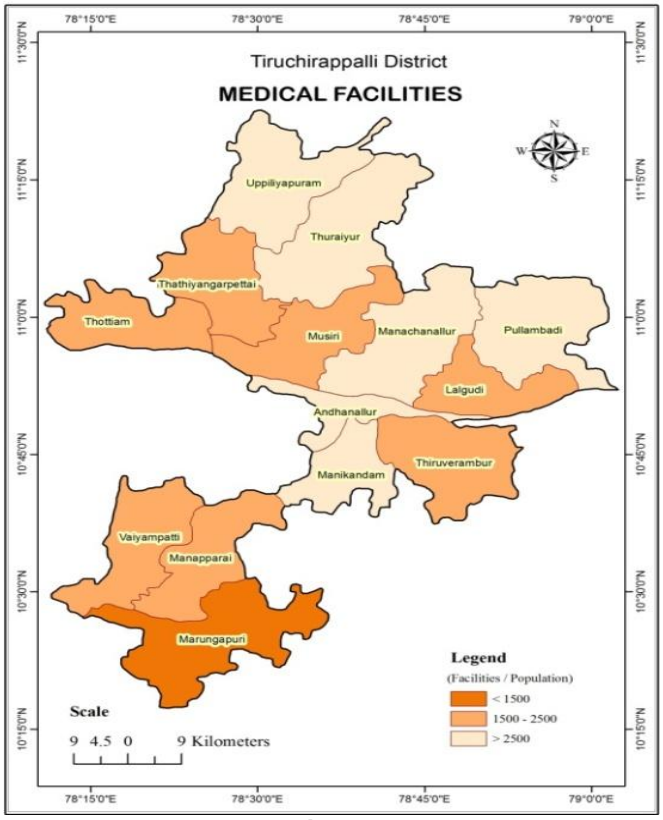


Fig. 2

The present study area Tiruchirappalli district one block namely Marungapuri block has a comparatively better service facility and has at least one hospital/clinic for every 1500 people or less. Manapparai Vaiyampatti, Thiruverumbur, Lalgudi, Musiri, Thathiyangarpettai and Thottiam blocks have one health unit 1500 to 2500 people. Other blocks have a low concentration of this infrastructural facility.

2. Educational Facilities

The level of education is a versatile indicator of the regional development. The importance of education and its distribution is a crucial factor for development planning for any developing country and India is not an exception. It is one of the prime concerns of the government.Development of the human society is measured by many ways. One of the most common indices used to indicate the level of development is the significance of service (tertiary) activities. Education is one of the most important components of this service sector.

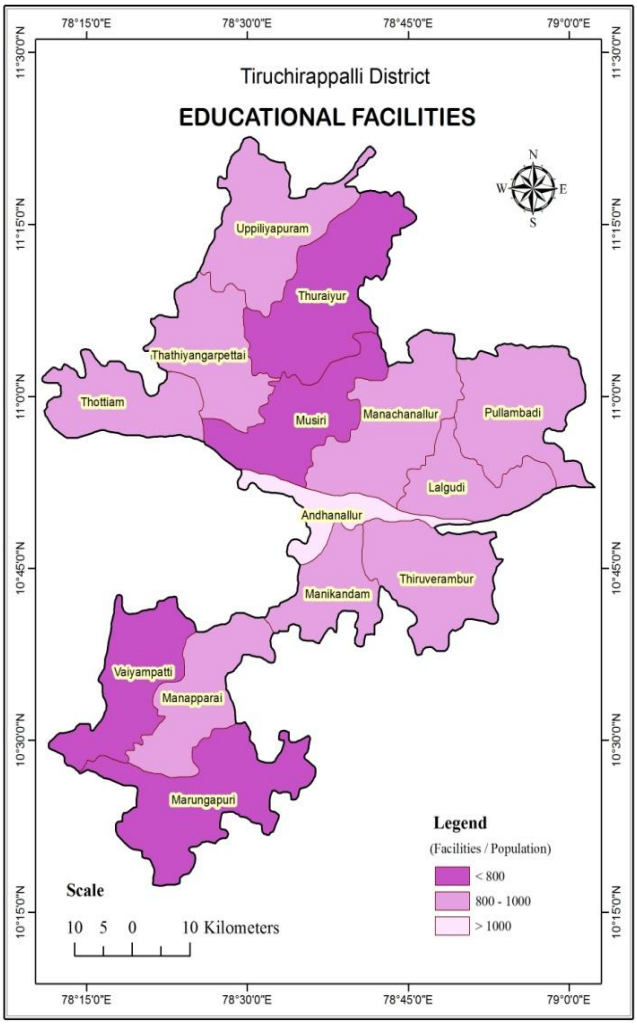


Fig. 3

Education means gaining the knowledge and learning new skills. Education is provided at various levels such as schools, colleges and professional institutions. Marungapuri, Vaiyampatti, Musiri and Thuraiyur blocks have a comparatively higher level of this service facility. Here one institution is available for every 800 people. Two blocks are located in the central part and another two blocks located in southern end of the district. Andanallur village have least served in this category. Other blocks have a moderate service.

3. Post & Telegraph Facilities

One of the important development in human history is postal services. In early time the information is exchanged only through post. Modern technology has made a number of other services like courier, internet and mobile phones to provide this service in recent years. Marungapuri, Musiri, Thathiyangarpettai, Thuraiyur, Pullambadi and Lalgudi blocks have the highest level of service in this facility and has at least one Post & Telegraph facilities for every 3000 people or less. Manikandam and Manapparai blocks are least served than the other blocks in the district.

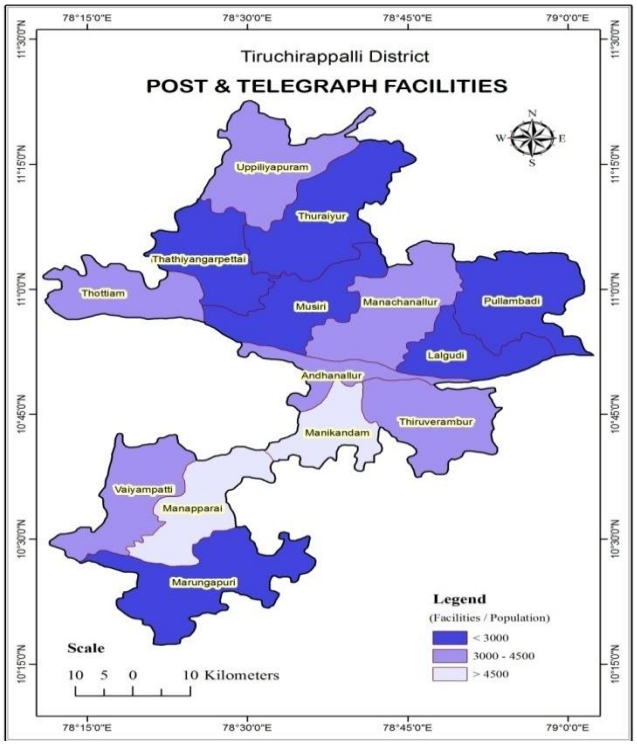


Fig. 4

4. Bank Facilities

Banks are important money related facility in the world. Both Village and Urban areas are there. But rural areas these facilities are very limited. For the present study area Marungapuri, Manapparai and Vaiyampatti blocks have the highest level of service in this facilities and have at least one bank facilities for every 4000 people or less. Manikandam, Thiruverambur, Musiri and Thuraiyur blocks have low share. Other blocks have a moderate share in these facilities.

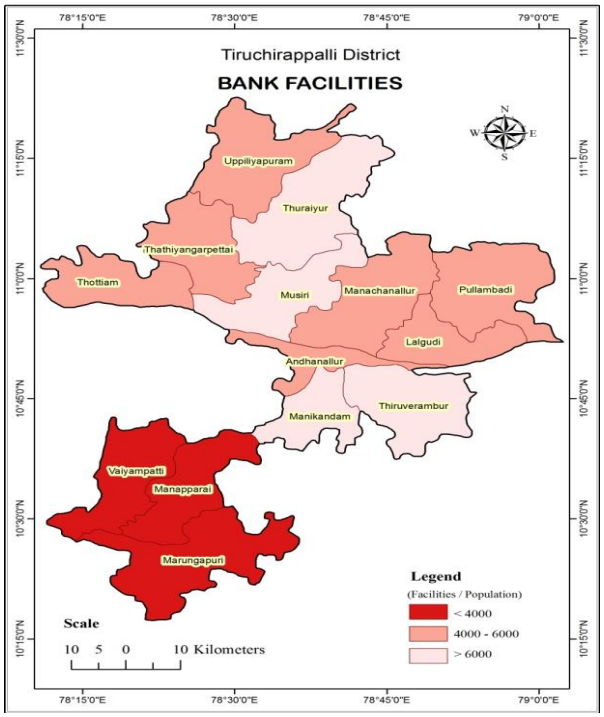


Fig. 5

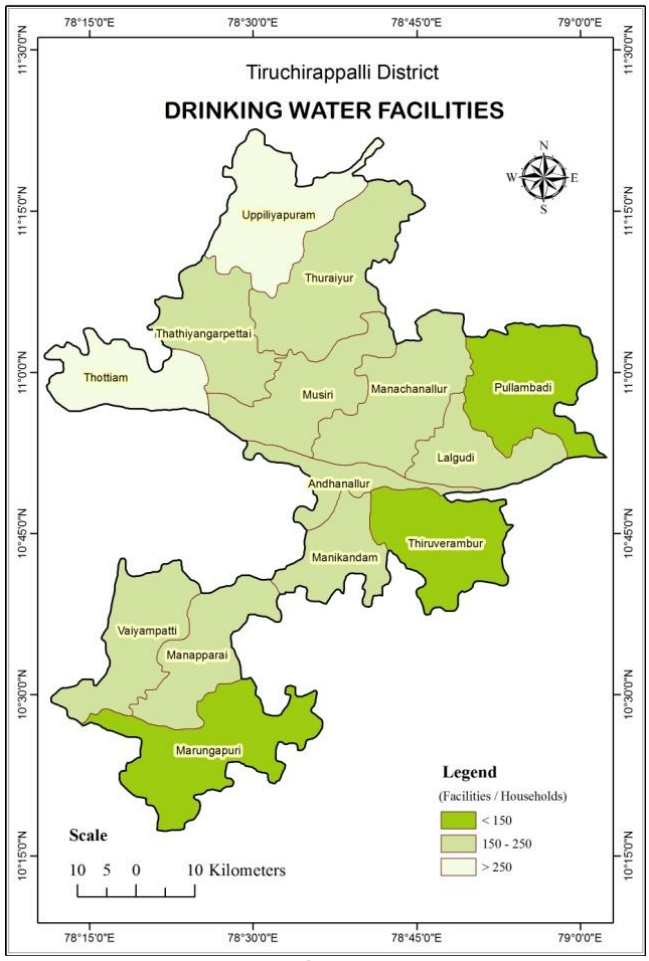


Fig. 6

5. Drinking Water Facilities

Water is precious for human life in the world. In a developing country like India the availability of water is very low in recent, years because of monsoon failure and other reasons. In Tiruchirappalli district one block faces shortage of water facility, but this district has a comparatively better situation. The different types of sources of drinking water facilities are considered for the present analysis and they include wells, hand pumps, taps and tanks.

Marungapuri, Pullambadi and Thiruverambur blocks have the highest level of service in this facility. Thottiam block has low facility and other blocks have moderate in nature.

6. Recreational Facilities

Recreational facilities are very limited in rural areas than urban areas. In urban areas a varity of these facilities concentrated. On the otherhand village areas have limited or some villages don't have such recreational facilities. Thuraiyur, Musiri, Pullambadi, Thiruverambur and Marungapuri Blocks have recreational this facility. Manachanallur, Lalgudi, Manikandam and Vaiyampatti blocks have high concentration in this facility. Andanallur and Thathaiyangarpettai blocks moderate concentration, while other blocks moderate concentration.

.

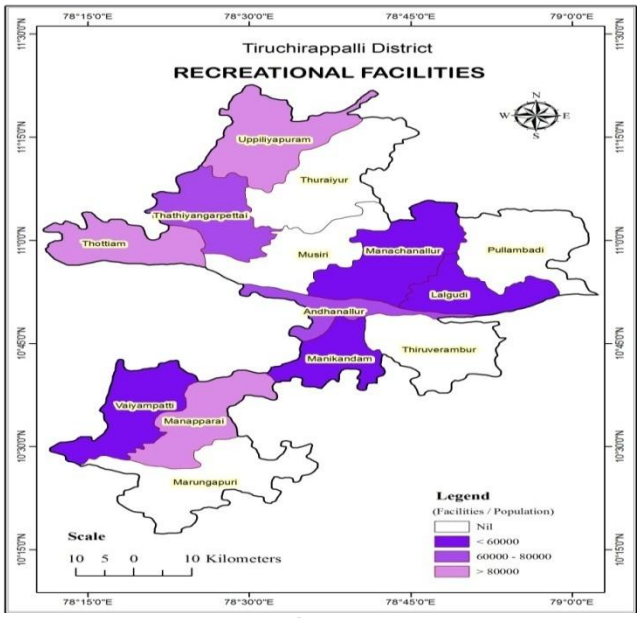


Fig. 7

Conclusion

The following inferences are drawn from the analysis of the study area

1. Marungapuri block has better infrastructure facility compared to households and population except recreational facility
2. Northwestern part blocks have moderate to low infrastructural facilities
3. Blocks in the Southern parts are well served in health and educational facilities compared to the northern part of the blocks.
4. Vaiyampatti, and Musiri blocks have better to moderate service facilities compared to the other blocks based on population and households.
5. Andanallur block is poorly served in most of the service facilities.
6. Drinking water facilities are good in all blocks.
7. Government should have an action for upgrading these infrastructural facilities in rural areas depending upon population and accessibility.

A temporal study can also be undertaken to find out the improvement of status of various infrastructural facility services for future development planning.

Studies on Spatio-Temporal Variation of Literacy in Kerala in GIS Environment

Veena Surendran, Dani V, Lekshmi G S and E Saravanan
Centre for Earth Science Studies, Training and Extension Division, Akkulam, Thiruvananthapuram-695031
Email: veenapunalur@gmail.com

Abstract

Literacy is the important indicator of development in a society and its region. Attainment of Universal primary education is one of the Millennium Development Goals of the United Nations to be achieved by the year 2015. To keep this point in view an attempt is made to study the change in literacy for KeralaState. KeralaState is the consistent forerunner in the achievement of literacy during the years 2001 & 2011. Kerala ranks first in the country with a literacy rate of 93.91 %. It also holds the first rank in the country in female literacy with 91.98 % and second rank in the country in male literacy with 96.02 %. Another important aspect about literacy of Kerala is that the rural literates are higher than urban literates.This paper aims to study the temporal variation of literacy in Kerala during the census period 2001 and 2011 using GIS software (ArcGIS 9.3 version). An attempt is also made to identify the spatial variation in literacy for 2001 and 2011 for rural and urban, male and female using the census data. During 2001 census, the districts having high rate of literacy is found in Kottayam, Pathanamthitta, Alappuzha and Ernakulam. The medium rate of literacy is found in Thrissur, Kozhikode, Kollam, Kannur and Malappuram districts. Palakkad, Kasargod, Wayanad, Trivandrum and Idukki districts having lowest rate of literacy.Pathanamthitta, Kottayam, Alappuzha, Ernakulam are the districts having highest rate of literacy during 2011 and Kollam, Trivandrum, Malappuram, Idukki districts having medium literacy rate. The lowest rate of literacy during 2011 is found in Palakkad, Wayanad and Kasargod districts.

Kottayam district achieved first rank in literacy rate during 2001 census whereas in 2011 census Pathanamthitta district superceded Kottayam district and achieved first rank. Palakkad district found to be lowest rate of literacy during 2001 and 2011.The district having high female literacy rate is found in Kottayam district in both 2001 & 2011. Palakkad district has low female literacy during 2001 and in 2011. During 2001 census the male literacy rate is high in Kottayam district whereas in 2011 census Alappuzha district became higher rate of literacy. It is observed that the rural literacy rate is higher in Kottayam district during 2001 census, and during 2011 census, Pathanamthitta district the rural literacy happened to be high. Based on the above study, series of thematic maps have been prepared in GIS format and analysed the spatio-temporal variation of literacy in terms of rural, urban, male, female population in the district level for two different periods (2001 & 2011) for Kerala state.

Introduction

Literacy refers to the ability to read for knowledge and write coherently and think critically about the written word. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society. It has an impact on an individual's ability to participate in society and to understand important public issues. It further provides the foundation upon which skills needed in the labour market are built. Skills of literate population also have a bearing on how well a country performs economically. Finally, having a population that has strong literacy skills also places a country in a better position to meet the complex social challenges that it faces. For example, strong literacy skills are linked to better health outcomes for individuals. A highly literate population will be able to better able to deal with issues of governance in a highly diverse society.

Study area

Kerala is an IndianState located on the western coast of southern India (Fig. 1). The state has an area of 38,863 km^2 (15,005 sq mi) with a population of 3.33 crore and is bordered by Karnataka to the north and north-east, Tamil Nadu and south, and the Arabian Sea to the west. Lying between north latitudes 8°18' and 12°48' and east longitudes 74°52' and 77°22',Kerala experiences the humid equatorial tropical climate. The state has a coast of length 590 km (370 mi) the width of the state varies between 11 and 121 km (22–75 miles). Kerala is socially a very progressive society. It has the highest Human Development Index (HDI) among all Indian states; at 0.921 it is higher than all nations of the world except Norway and Austria. It has the highest literacy rate

(93.91%), highest life expectancy (74 years) and lowest sex ratio (as measured by the ratio of number of men to number of women: 923 men per 1000 women) in India.

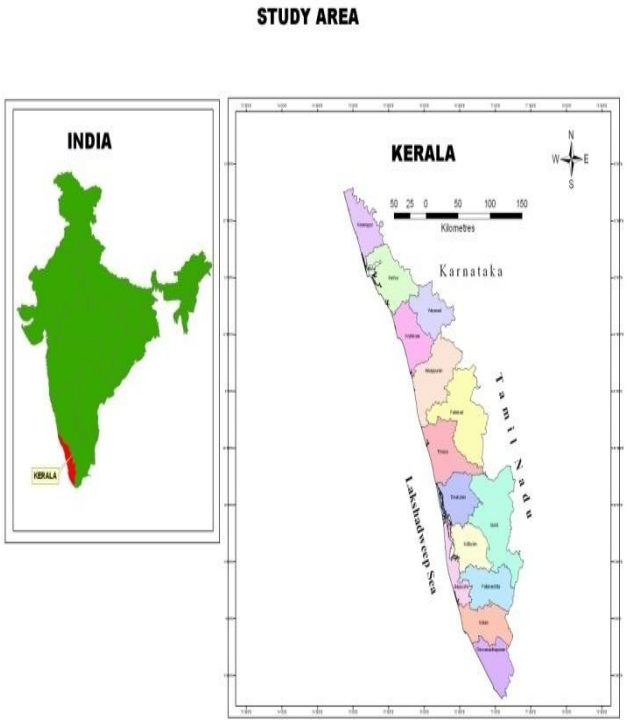


Fig.1

Aims and objectives

- To study the temporal variation of literacy in Kerala during the census period 2001 and 2011.
- To identify the present scenario of dynamics of literacy in Kerala.
- To assess the trend of rural, urban, male and female literacy in Kerala
- To delineate the districts having maximum and minimum literacy rate over rural, urban, male and female population in Kerala.

Data sources

Data sources are 1) Survey of India Toposheets of Scale 1: 50000 2) Secondary sources of data collected from Directorate of Census Operations, Kerala.

Methodology

The study is purely based on secondary sources of data which were collected from the Directorate of Census Operations, Kerala. The process of completion of the work included data collection & analysis base map preparation, layer presentation and finally designing thematic maps. To find out the dynamics of literacy over rural, urban, male and female in Kerala, thematic maps were prepared using GIS.

Results and discussion

As literacy development is concerned; Kerala has the distinction of being a historic state in India so far. Kerala's literacy rate is comparable to the most advanced regions of the world. The spatial pattern of literacy in Kerala state has been discussed on the basis of the temporal variations from 2001 to 2011 for male, female, rural, urban and general literacy rate and the male-female differences in literacy rates in the districts of Kerala (Fig. 2 & Fig. 3). Four regions identified as having (1) High, (2) moderate and (3) low literacy levels for both years reveals the spatial pattern in Kerala state.

A.1. Districts having High Literacy Rate (2001)

During 2001 census, the districts having high rate of literacy is found in Kottayam, Pathanamthitta, Alappuzha and Ernakulam. Kottayam district achieved first rank in literacy rate as 95.90 % and Pathanamthitta with 94.83 %, Alappuzha with 93.43 % and Ernakulam with 93.19 percent. These districts also have the highest male and female, urban and rural literacy rates. While male literacy rate varies from a minimum of 95.80 % in Ernakulam district to a maximum of 97.33 % in Kottayam district. The female literacy rate ranges from the minimum of 90.66 % in Ernakulam district to the maximum of 94.34 % in Pathanamthitta. Ernakulam district with 92.19 % stands minimum in rural literacy rate and Kottayam with 95.80% was at the maximum. In urban literacy rate Alappuzha with 93.73 % is at the minimum and Kottayam with 95.91% is at the maximum.

A2. Districts having Moderate Literacy Rate (2001)

The medium rate of literacy is found in Thrissur (92.26%), Kozhikode (92.23%), Kannur (92.58%) and Kollam (91.18%) districts. Regarding the male-female literacy rate, the minimum being Malappuram , for both male (93.25%) and female (86.26%). The maximum literacy rate for male is at Kannur with 96.12% and female is at Thrissur with 89.70 %. Kannur district with 91.02 % stands minimum in rural literacy rate and Thrissur with 91.5% was at the maximum. In urban literacy rate Kollam with 91.51 % is at the minimum and Thrissur with 94.23 % is at the maximum.

A3.Districts having Low Literacy Rate (2001)

Palakkad (84.34%), Kasargod (84.57%), Wayanad (85.25%), Trivandrum (89.27%), Idukki (88.69%) and Malappuram (89.61%) districts having lowest rate of literacy. Regarding the male-female literacy rate, the minimum being Palakkad, for male (89.51%) and Kasargod for female (79.12%).The maximum literacy rate being Thiruvananthapuram, for both male (92.63%) and female (86.13%). Palakkad district with 83.55 % stands minimum in rural literacy rate and Idukki with 88.45% was at the maximum. In urban literacy rate Wayanad with 87.15 % is at the minimum and Idukki with 92.91 % is at the maximum.

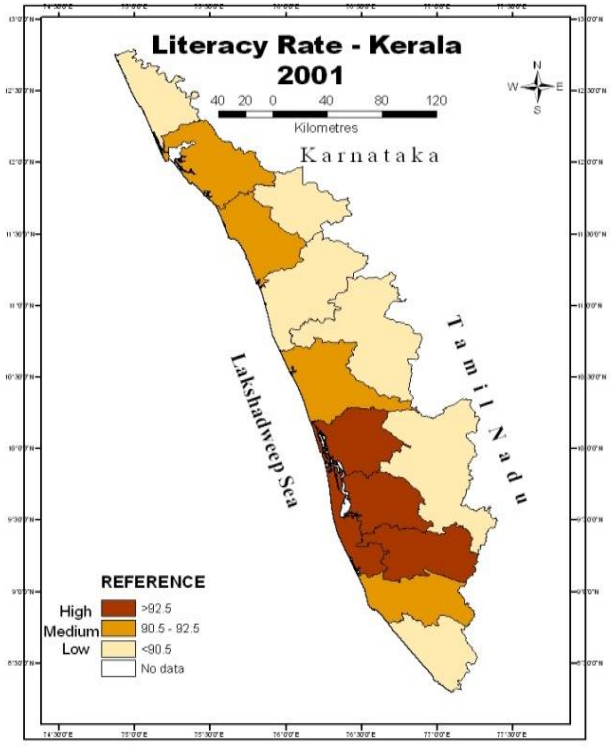


Fig.2

B.1. Districts having High Literacy Rate (2011)

During 2011 census, the districts having high rate of literacy is found in Pathanamthitta (96.93%), Kottayam (96.40%), Alappuzha (96.26%), Ernakulam (95.68%), Kannur (95.41%), Thrissur (95.32%), Kozhikode (95.23%) are the districts having highest rate of literacy. This area also has the highest male and female, urban and rural literacy rates. While male literacy rate varies from a minimum of 96.98% in Thrissur district to a maximum of 97.90 % in Alappuzha district. The female literacy rate ranges from the minimum of 93.16 % in Kozhikode district to the maximum of 96.26 % in Pathanamthitta. Kannur district with 93.87 % stands minimum in rural literacy rate and Pathanamthitta with 96.87% was at the maximum. In urban literacy rate Kozhikode with 95.47 % is at the minimum and Kottayam with 97.16% is at the maximum.

B2. Districts having Moderate Literacy Rate (2011)

The medium rate of literacy is found in Kollam (93.76%), Trivandrum (92.66%), and Malappuram (93.55%), Idukki (92.19%) districts. Regarding the male-female literacy rate, the minimum being Thiruvananthapuram, for male (94.59%) and Idukki, for female (89.58%).The maximum literacy rate being Kollam, for both male (95.83 %) and female (91.94%). Thiruvananthapuram district with 91.98 % stands minimum in rural literacy rate and Kollam with 94.09% was at the maximum. In urban literacy rate Thiruvananthapuram with 93.23 % is at the minimum and Idukki with 95.73 % is at the maximum.

B3. Districts having Low Literacy Rate (2011)

Palakkad (88.48%), Wayanad (89.32%) and Kasargod (89.84%) districts having lowest rate of literacy. Regarding the male-female literacy rate, the minimum being Palakkad, for both male (92.26%) and female (84.98%). The maximum literacy rate is at Kasargod being with 93.93% for male 86.12 % for female. Palakkad district with 87.23 % stands minimum in rural literacy rate and Wayanad with 89.22% was at the maximum. In urban literacy rate Wayanad with 91.62 % is at the minimum and Palakkad with 92.44 % is at the maximum.

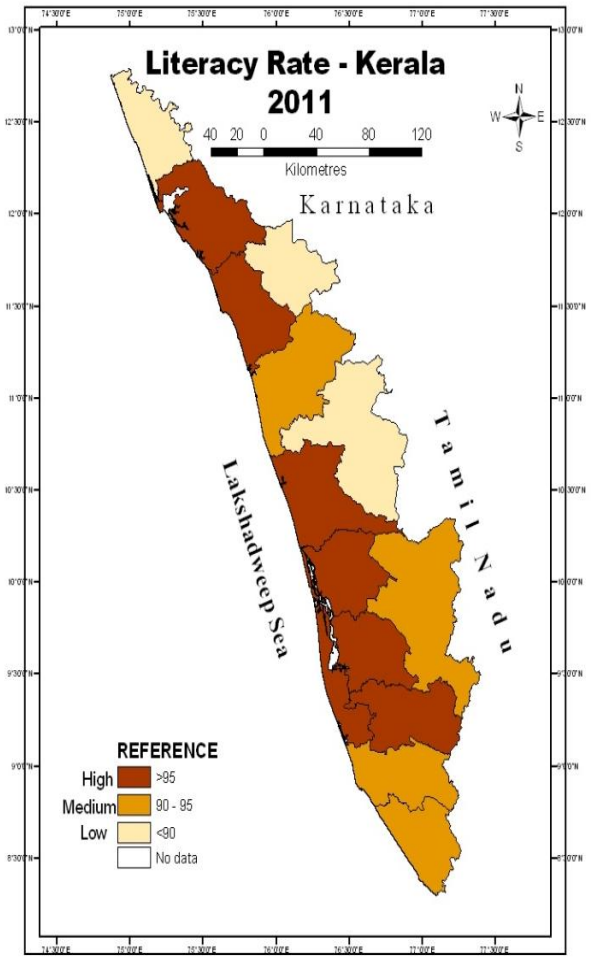


Fig.3

Reason for the High rate of literacy on the above said districts are mainly due to the good number of educational institutions, high standard of living etc. The districts which have low rate of literacy are generally rural in manner and most of the people are involved in primary activity.

The gender gap in literacy needs some explanations. Here are some common:

- Families may attach much more importance to male offspring than to female offspring. Therefore, parents make much more of an effort to see that their male offspring go to school.

- Female children are needed at home more urgently to help the mother take care of the family. Their help with household chores is viewed as a higher priority than going to school.
- A female child may be less marriageable if she is too educated. It is a common perception that a young man would not want to marry a young woman who knows more than he does.
- There may be few jobs or positions in the society open to educated females. The family, then, has little economic incentive to educate a female child.

Due to the same reason, there are also exist a wide disparity in the literacy rates of urban and rural areas. These disparities are attributed to four main factors.

- The necessity for education in urban areas is much greater than in the rural areas.
- Urban places are far better equipped with large number of education institutions of all grades.
- The urban population is socially more aware and economically more capable of imparting education to their children and finally due to,
- Rural-urban migration in search of employment.

Even though the above factors are applicable for all districts of Kerala, rural literacy rate of Kollam and Alappuzha districts are high. This is mainly due to the mission of 'Preraks'. Kerala State Literacy Mission is implementing the literacy and equivalent programme by appointing 'Preraks'. Preraks and assistant Preraks are those who have the responsibility to running the literacy centre, conducting survey to identify eligible neo-literates / non – literates in the area, grouping identified learners according to their literacy skills, conducting the literacy class as per time schedule, monitoring attendance of learners, assessing progress of learners' achievements etc.

Conclusion

The empirical evidence of the present paper indicates that there exist inter-district inequalities in the literacy rates in case of male and female population as well as between urban and rural areas. Reduction of inequalities is not an isolated objective. It calls for coordinated action in various fields, to counteract the dynamics of socio-economic underdevelopment on the one hand and political institutional framework on the other. In order to remove the illiteracy state had started 'Akshara' project under State Literacy Mission. But it has not achieved any miracle through the campaign approach, rather there is a long path to be traversed. The campaign mode of total literacy has only given us hope, faith and conviction that is one model which can assure us of the right results in right time in the right manner in the most participative, democratic and cost-effective way. It has, however, to be remembered that the campaign is a mode and not the goal. Total literacy is our goal, our polestar. The paths may be more than one but all of them must lead to be primary or centrality of that goal.

Pedagogical Foundations for Effective Competency Building in the Hydrographic and Cartographic Sectors

Shekhar Murthy
President IIC Academy
Visakhapatnam, India
shekhar.murthy@iictechnologies.com

Ronald Furness
Advisor IIC Technologies Inc
Sydney Australia
ronald.furness@iictechnologies.com

Duncan Wardle
Course Director(MGI) IIC Academy
Taunton, United Kingdom
duncan.wardle@iictechnologies.com

Abstract

Human endeavor in maritime sectors is ever increasing towards the exploration of oceans for both economic growth and environmental sustenance. The demands on marine geospatial information, its management and promulgation for the purposes of maritime security, resource development and exploitation as well as habitat protection, to list but a few, reiterate the need for competency building in the hydrographic and nautical cartographic sectors.

Standards of competence have been exhaustively defined for hydrographic surveying and nautical cartography by the International Board comprised of eminent professionals representing the International Hydrographic Organization (IHO), the International Federation of Surveyors (FIG) and the International Cartographic Association (ICA) and these standards are disseminated as IHO Publications S-5 and S-8 Category 'A' / Category 'B' standards respectively.

While the learning content and outcomes have been succinctly defined in the IHO/FIG/ICA standards, the authors suggest that additionally, the training methodology and delivery mechanisms should address the learning styles of the so-called millennial professional which, with increasing dominance, include leading edge technological advancements and internet connectivity, and that these should be built on strong academagogical foundations.

Attempting to build on the significant contribution of the work by the International Board, this paper identifies and classifies the competencies elucidated in the S-5 and S-8 Standards of Competence in terms of knowledge, skills and attitude attributes; suggests suitable learning methodologies to assure achievement of stated learning outcomes and provides an academagogical framework we believe is suitable to leverage technology and build a learning ecology that suits millennial learning styles.

The competency pipeline in hydrographic and cartographic sectors

The sciences of hydrography and nautical cartography demand competencies that enable effective conduct of the following broad activities as elucidated by Schiller et al [1]:

- Surveying of waters, and recording of aquatic data;
- Processing of the data, administering the data in information systems, and analyzing the total set of data;
- Visualizing the waters on charts and in information systems, and informing about the waters.

The execution of the aforesaid activities requires building competencies that encompass generic and distinct knowledge, skills and behaviors that translate into consistent performance at work that is worthy of a qualified global professional. Generic knowledge and skills would broadly cover numeracy, geography, science, analysis and problem solving, and computing skills, which form the prerequisites over which the specialisms of hydrographic knowledge and skills is built.

Building a curriculum to address the requirements of the hydrographic and nautical cartographic professionals necessitates articulation of what, why, where, when and how they perform their duties,through which a structured syllabi is evolved. In the present context these have been elaborated in detail by the FIG/IHO/ICA, as Standards of Competence for the hydrographic surveyors (S5) [2] and the nautical cartographers (S8) [3].

Adapting a curriculum to a context requires application of appropriate pedagogical precepts. The context referred here broadly includes, technology, past experience, future expectations, societal and governmental norms, standards of industry, security and environment. Bloom's taxonomy [4], along with suitable pedagogical constructs, provide a sound framework for implementing a curriculum effectively. The effective delivery of curriculum, however, is still no guarantee for building and nurturing a competent, responsible global professional, for it also depends upon "critical competencies" defined by Gardiner [5] which include:

- Accept ownership and responsibility;

- Ability to act in principled, ethical fashion;
- Skill in oral and written communication;
- Interpersonal and team skills;
- Skills in critical thinking and problem-solving;
- Respect for people different from oneself;
- Ability to change;
- Ability and desire for lifelong learning.

The learning approach must align to the needs of the millennial (defined here as those born after 1980). If millennial are going to form our future workforce, then it should follow that our policies, methods, and processes need to be millennial-centric, rather than historic. Prensky [6] states, "Today's students are no longer the people our educational system was designed to teach." Prensky adds, "the single biggest problem facing education today is that our current teachers, speak an outdated language (that of the pre-digital age), and are struggling to teach a population that speaks an entirely new language.

Surely, as a consequence, our focus needs urgent change. The direction of effort is as important as speed and flexibility in a global context. Employment in future would know no borders, nor have corporate edifices as addresses. Anytime, anywhere, "any-many" would be the workplace of the future! Obviously, the governing rules would change. And the academia of today should become the catalyst of this change.

An effective learning content must conscientiously foster and promote the right Attitude - Skills - Knowledge (ASK) by designing relevant learning tasks that integrate the ASK elements [7]. The learning tasks in turn should realistically simulate the professional and societal environments in which the tasks are to be performed. The challenge therefore is to explicitly identify the learning outcomes and create tasks which will guarantee achievement of the stated outcomes. The triad of the ASK model is depicted in Fig. 1.

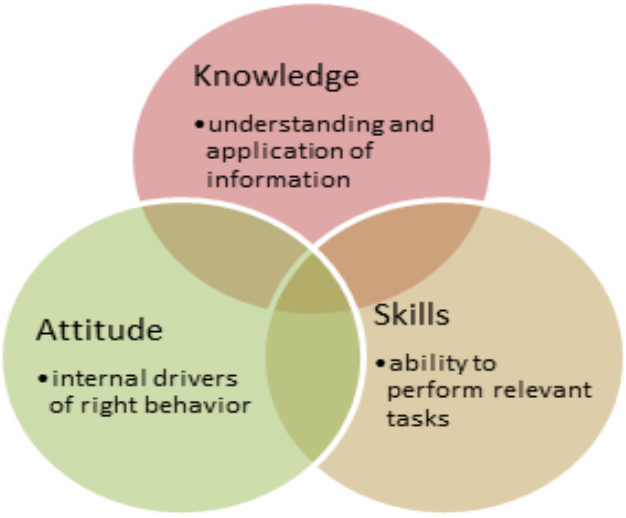


Fig. 1: The Attitude-Skills-Knowledge triad

The learning delivery system should thrive in an ecology that promotes adult to adult learning, also referred in the literature as "andragogy". The underpinning consideration here is to link the subject matter 'what is to be taught;' with the teaching methodology, 'how is it to be taught' [8]. In fact, should the subject be formally taught in a conventional sense, or should it be facilitated, where faculty and students are active partners. The change from a teacher-centered learning (pedagogy) to a student-centered learning (andragogy) and thence to self-determined learning (heutagogy) requires a paradigm shift. Academagogy seeks to utilize the appropriate parts from learning theories [9] and blend them in the context where they could be effectively implemented to deliver holistic outcomes.

The Academagogical framework

THE ACADEMAGOGICAL FRAMEWORK HINGES ON THE CONCEPT OF SOCIAL CONSTRUCTIVISM: FOR ONE, IT ADDRESSES THE MAJOR SKILL GAP OF TEAM WORK IN THE FIRST TIME PROFESSIONALS IN INDUSTRY; TWO, IT PROVIDES MORE INTERACTION AMONGST PARTICIPANTS AND FACILITATORS, THEREBY, GIVES MORE OPPORTUNITIES FOR ACTIVE COMMUNICATION; AND THREE, IT USES ONE OF THE MAJOR STRENGTHS OF MILLENNIAL VIZ., SOCIAL CONNECTIVITY ROUND THE CLOCK. THE SALIENT CHARACTERISTICS OF SOCIAL CONSTRUCTIVISM [10] THAT PROVIDES THE BASIC FOUNDATION TO THE PROPOSED ACADEMAGOGICAL FRAMEWORK ARE DEPICTED IN FIG. 2.

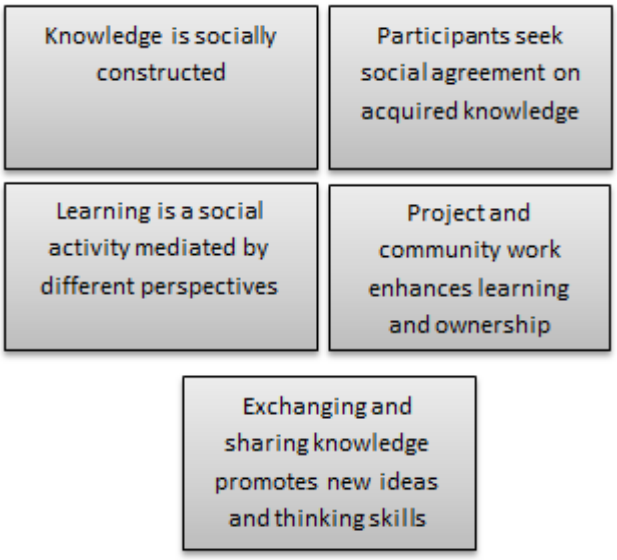


FIG. 2: CHARACTERISTICS OF SOCIAL CONSTRUCTIVISM

A conceptual map of the academagogical framework is presented in Fig. 3. The map has six stages numbered 1-6, which delineates six stages in which the framework can be developed and implemented.

- Stage 1 is where the Subject Matter Expert (SME) along with the Learning Consultant (LC) studies the prescribed curriculum and

crystallizes clear course objectives with measurable outcomes that signal the success of a course;

- Stage 2 is the stage where the course objectives are transformed into specific learning outcomes, clearly identifying the knowledge, skill, and attitude components;
- Stage 3 deals with the mapping of learning outcomes (what needs to be taught) to learning methodology (how it is to be taught). The prescription of academagogy becomes relevant here, for it forces us to select the best learning approaches that suit achievement of the stated outcomes. Our learning approach could select methods using the principles of andragogy and heutagogy;
- Stage 4 introduces participatory learning, where both the faculty and students take ownership for successful conduct of the course and have a stake in achievement of the outcomes. The course schedule, timelines, and accountability are fixed and unequivocally stated;
- Stage 5 is the stage where actual course delivery begins and progress tracked. The progress is jointly discussed between the faculty, students and the consultant, and course corrections effected as may be necessary;
- Stage 6 is the stage of overall review, reflection and feedback so as to make continual improvements to the course content and delivery, keeping in mind advances in technology, process and established best practices.

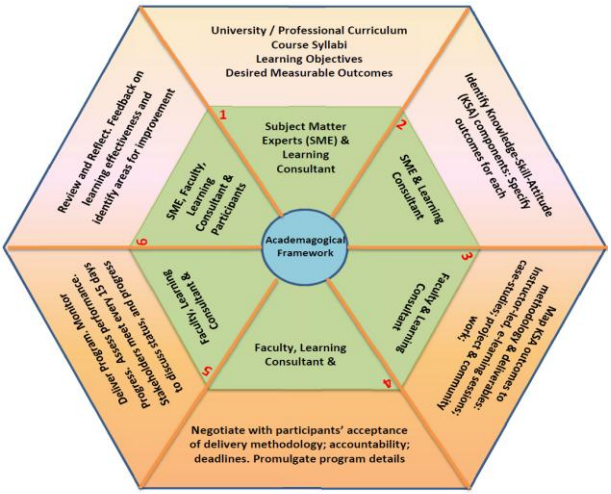


FIG. 3: CONCEPTUAL MAP OF ACADEMAGOGICAL FRAMEWORK

The academagogical framework offers three major benefits [11]:

- Promotes joint ownership of outcome based academic curriculum between the learners and facilitators;
- Encourages communication and teamwork;
- Leverages on the millennial need for social connectivity on a 24x7 basis.

More significantly, the framework supports:

- Holistic transformation from using of information to application of wisdom;
- Converting knowledge into action through experiential learning and simulated role plays;
- Nurturing positive attitudes impacting behavioral transformation.

Applying academagogical framework to a sample hydrographic survey course

The stages of development of an academagogical framework elucidated above are now being applied to a sample hydrographic survey course. The examples given below are intended to be illustrative and attempt to describe possible alternatives that may be relevant to the context in which the framework is applied.

Stage 1: Distilling course objectives and measurable outcomes

- Given the opportunity to undertake hydrographic surveying for purposes of nautical charting (C), the participant, in the capacity of a team member (A), will be able to apply theoretical concepts and principles of hydrographic surveying and demonstrate skills in capturing and processing survey data (B), which will be verified by a supervisor (D);
- Demonstrate a mastery of the fundamental knowledge and skills (D) required for functioning effectively as a team member (A) in a hydrographic survey team or office, and an ability to integrate and apply them effectively to practice (B) in the workplace that processes and reports survey data (C).

The objective stated above has four distinct parts: (A) Audience (B) Behavior (C) Condition (D) Degree of Mastery.

Some example of the measurable outcomes from the aforementioned objectives can be:

- Number and severity of errors during capture and cleaning of data;
- Number and severity of errors in setting up of equipment, configuration and calibration;
- Degree of confidence and time-taken to complete a specific task;
- Degree of confidence to manage unscheduled changes caused by uncontrollable extraneous factors.

Stage 2: Identify learning outcomes using the ASK model, for example:

- Describe the theory of geodesy and tides (assessing knowledge);

- Recognize factors of risks and safety in boat work (demonstrating evidence comprehension);
- Show how changes in sound velocity affect sonar depth measurement (demonstrating evidence of application);
- Calculate gradient from maps in m, km, % and ratio (demonstrating evidence of analysis);
- Propose solutions to mitigate risks during a small hydrographic survey work (demonstrating evidence of synthesis);
- Assess the importance of quality control in 3D visualization and editing (demonstrating evidence of evaluation);
- Configure hydrographic processing software (demonstration of psychomotor skills);
- Set-up the equipment needed for a multibeam hydrographic survey (demonstration of psychomotor skills);
- Conduct a patch test and compute results (demonstration of psychomotor skills);
- Recognize and accept the need for international standards in hydrographic surveying and nautical charting (demonstration of attitude);
- Display a willingness to communicate with peers and supervisors on the conclusions arising from survey data analysis (demonstration of attitude).

Stage 3: Mapping learning outcomes to appropriate learning methodologies

Selecting appropriate learning methodologies is the key to achieving learning outcomes.

- For example, under the cognitive domain of Bloom's taxonomy, knowledge can be acquired by recognizing, describing, and locating (all verbs) hydrographic survey reports (noun). The discussions on the interpretation of such reports can be instructor-led in a class room session (facilitator) where participants can clarify and debate (verbs again) to improve their understanding of the subject;
- In the affective domain, the behaviors that need attention and development relate to: (a) receive –willingness to listen and experience; (b) respond – willing to participate in a group; (c) value – express personal opinions, judgments (d) internalize – ability to reconcile to internal conflicts, adopt belief system;
- In the psychomotor domain, the emphasis is on skills development: manual, intellectual, or computational, which are relevant in modern times. A large part of effective hydrographic survey training is tilted towards skill development.

An effective learning methodology must embrace to deliver outcomes in each of the three domains – cognitive, psychomotor, and affective. Table 1 to 3 summarizes methods that can be applied to align content delivery in line with the Bloom's taxonomy:

- Table 1: Methodologies for Bloom's Taxonomy – psychomotor domain;
- Table 2: Methodologies for Bloom's Taxonomy – cognitive domain;
- Table 3: Methodologies for Bloom's Taxonomy – affective domain.

TABLE 1: BLOOM'S TAXONOMY – PSYCHOMOTOR DOMAIN [12]

Class	Actions (verbs)	Evidence of learning
Imitation	copy, follow, replicate, repeat, adhere	watch instructor and repeat action, process or activity
Manipulation	re-create, build, perform, execute,implement	carry out task from written or verbal instruction
Precision	demonstrate, complete, show, perfect, calibrate, control,	perform a task or activity with expertise and to high quality without assistance or supervision; able to demonstrate an activity to others
Articulation	construct, solve, combine, coordinate, integrate, adapt, develop, formulate,modify, master	relate and combine associated activities to develop methods to meet varying, novel requirements
Naturalization	design, specify, manage, invent,project-manage	define aim, approach and strategy for use of activities to meet strategic need

TABLE 2: BLOOM'S TAXONOMY - COGNITIVE DOMAIN [13]

Class	Actions (verbs)	Source of learning (nouns)
Knowledge	Select, list, name, define, memorize, label, identify, locate, recite, state, recognize	events, people, recordings, videos, filmstrips, text, articles, papers, television, podcasts, webinars, paradigms, terms
Comprehension	match, restate, paraphrase, explain, give examples, defend, distinguish, summarize, interrelate, extend	recordings, plays, story, speech, maps, photographs, models, study- reports, analogy, summaries, articles, reports, terms
Application	organize, simulate, generalize, dramatize, prepare, produce, choose, sketch, apply, solve, draw, show, paint	illustration, solution, question, map, project, forecast, diagram, analytical findings
Analysis	compare, analyze, classify, distinguish, point out, categorize, differentiate, infer, survey, select, prioritize	questionnaire, survey, graph, report, breakdown, defect, case studies, argument, propaganda, statement, conclusion, glossary
Synthesis	compose, hypothesize, develop, design, combine, construct, produce, plan, create, invent, organize	play, experiment, alternative action, case studies, hypothesis, formulation, book
Evaluation	judge, relate, weight, criticize, support, evaluate, consider, critique, recommend, summarize, appraise, compare	conclusion, reflection, self-evaluation, recommendation, survey, court trial, standards, guidelines, laws, regulations

TABLE 3: BLOOM'S TAXONOMY – AFFECTIVE DOMAIN [14]

Class	Actions (verbs)	Evidence of learning
Receive	ask, listen, focus, attend, take part,discuss, acknowledge, hear, be open to, retain, follow, concentrate, read,do, feel	listen to instructor, take interest in session, take notes, turn up, participate passively
Respond	react, respond, seek clarification,interpret, clarify, provide other references and examples, contribute, question, present, cite, becomeanimated or excited, help team, write, perform	participate actively in group discussion, active participation in activity, interest in outcomes, enthusiasm for action, question and probe ideas, suggest interpretation
Value	argue, challenge, debate, refute,confront, justify, persuade, criticize	decide worth and relevance of ideas,experiences; accept or commit toparticular stance or action
Conceptualize Values	build, develop, formulate, defend,modify, relate, prioritize, reconcile, contrast, arrange, compare	qualify and quantify personal views, state personal position and reasons, state beliefs
Internalize Values	act, display, influence, solve, practice	self-reliant; behave consistently with personal value set

Stage 4 and 5: Participatory learning, timelines, ownership, and course delivery

The emphasis in an academagogical framework is on participatory and social learning. With the completion of activities up to stage 3, entire course structure, with objectives, outcomes and methodologies is expected to be finalized and available.

In stage 4, the facilitator along with the learning consultant must discuss with the participants the expectations, modalities of delivery, and assessments to guarantee the objectives set for the course. Participants should be allowed to make choices as to how the course will be delivered, and by whom?
For example, some portions related to the cognitive domain can for example be delivered by the participants as seminars, term papers, articles or newsletters. Learning components related to the psychomotor domain may be delivered as group project work along with peer reviews, on-the-job mentoring or internships; or, developed as open projects in the wiki which may be open to the expert forums for critique and feedback.

The end-result of such discussions with the participants must result in a course schedule that reflects the scope of content, timelines, methods, and accountability. Aspects such as risks, and risk mitigation procedures may also be incorporated in such a course plan. The course delivery must be periodically reviewed both for progress and performance and suitable corrective measures taken to keep the course on-track. A third-party audit will immensely help in maintaining the integrity of procedures, and the quality of training.
The format for creating course schedules and delivery document must at a minimum include:

- Course topic;
- Expected outcomes and type (cognitive, psychomotor, or affective);
- Start and end dates;
- Method of delivery (seminar, group discussion, lecture, demonstration, simulation, case-study, project work, role-play etc.);
- Who will deliver – facilitator, expert from industry or academia, or the participant as an individual or in group;
- Who will assess and how? A structured assessment format must be devised for every course delivery instrument, which is consistent and transparent. The assessment strategy must align to the targeted learning outcomes. A sample of participant's assessment card is shown in Table 4, which can be refined to suit the context of a course;
- Feedback report after assessments to be used as a de-brief tool;
- Quality check on the performance and achievement of outcomes.

Stage 6: Review, feedback and continuous improvement

A well-designed course with near faultless delivery will still have plenty of room for improvement. The improvements may be necessitated due to changes in technology, revision in software versions, new laws and regulations, environmental imperatives, or simply, because of changed expectations of the end-user. An effective training evaluation system can help in:

- Curriculum/Course Design;
- Curriculum/Course Delivery;
- Assessment;
- Learning Environment.

TABLE 4: SAMPLE OF PARTICIPANT'S ASSESSMENT CARD [15]

Competency Descriptor	Beginn-ing	Develo-ping	Comp-etent	Accomp-lished
An ability to apply knowledge of mathematics, science, and hydrographic Surveying				X
An ability to plan and execute a hydrographic survey project to meet specified needs		X		
Knowledge of contemporary issues	X			

An ability to use the techniques, skills, andtechnical tools necessary for professional practice			X	
An ability to use the Software and computing tools necessary forprofessional practice			X	
An ability to function on teams or multi-disciplinary teams		X		
Ability to write technical reports (content, grammar, spelling, formatting, referencing)			X	
Ability to make oral presentations (organization, content, delivery)		X		
An ability to consistently demonstrate professional and ethical responsibility		X		
Recognition of the need for, and the ability to engage in lifelong learning		X		

An example of evaluation criteria for ability to write technical reports can be as follows:

- More than 10 grammatical and spelling errors: Beginning
- 6-10 grammatical and spelling errors: Developing
- 2-6 grammatical and spelling errors: Developing: Competent
- Less than 2 grammatical and spelling errors: Developing: Accomplished

Please note – each of the competency descriptor can be sub-categorized to make the assessment more objective. For example, ability to write technical reports can have four sub-categories:

- ability to write technical reports (spelling and grammar)
- ability to write technical reports (references)
- ability to write technical reports (formatting)
- ability to write technical reports (content)

Participants' feedback along with performance reports, the granularity of which can provide great insights on the course content, delivery and assessment methods is conventional practice. However, to assure the return-on-investment, and more importantly, the return-on-expectations, the Kirkpatrick's model [16] is useful. The four-stage Kirkpatrick's training evaluation model in Fig 4 shows the following:

- Descriptor of the four evaluation levels;
- Leading question on training evaluation;
- When should the evaluation be conducted?
- What instruments can be used to conduct the evaluation?

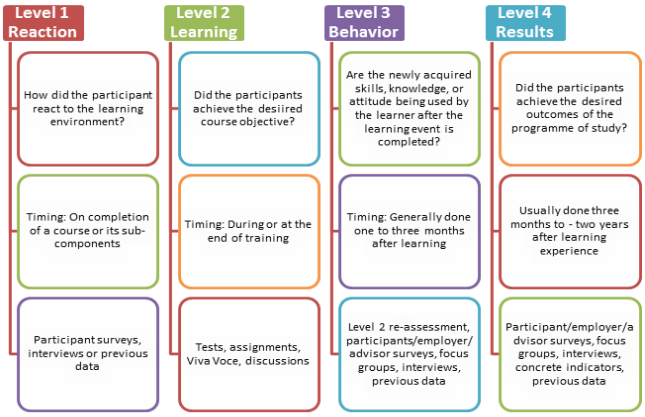


FIG. 4: FOUR-STAGE KIRKPATRICK'S TRAINING EVALUATION MODEL

Challenges and limitations of the framework

The crucial challenge in implementing an academagogical framework is to gain the acceptance of faculty and participants. Especially, faculty members in academia who have got used to the so-called *Sage on the Stage* paradigm, it indeed may well be difficult to accept learners as equal participants in the process of teaching.

Outcome based learning involves intricate level planning and execution in the creation of appropriate tasks, case-studies and project work that have realism in application. The effort should be to incorporate the higher levels of learning of Bloom's taxonomy (analysis – evaluation – creation) within cognitive domain, and with emphasis on learning by doing for the psychomotor domain.

The main challenge at hand therefore, is that of change management. In this context, the introduction and implementation of an academagogical framework might follow Lewin's model, as revised and extended by Schein [17].

The key to success of an academagogical framework lies in the quality of the mentoring done by the facilitators. The faculty should be ready to don this new role and earn the confidence of their mentees. Therefore, the framework should initially be restricted to a small class size of where meaningful interaction and mentoring by faculty can take place. Scalability of the model is therefore open to debate.

The learning methodology used in the model puts great onus and accountability of learning on the students. The model assumes that the students are capable of self-directed learning. It is therefore recommended that the initial deployment of this model be applied to technical or professional courses where the learner's maturity is higher.

The university or the institutes employing the model should have requisite technologies and bandwidth to support eLearning, wiki, blogs and other collaborative learning spaces in the internet.

There should also be adequate flexibility in the university or institutions to experiment with fresh approaches and plug and play content and delivery methods to suit a new style of learning.

Lastly, the framework demands an open mindset where innovative ideas thrive.

Conclusions

The learning approaches for building competencies in a knowledge-driven society and meeting the aspirations of millennial learners requires paradigm shifts.In fact, some of the career descriptions in the organizations of the future do not exist today! Therefore, it becomes pertinent that the learning environs remain agile and flexibly respond to the developments, not merely technological, but more importantly, environmental, cultural and societal. The value shifts in the millennial society become powerful drivers of learning impetus and direction.

The academagogical framework presented in this paper is one such effort to bridge competency-gaps while remaining aligned to technology, environmental and societal changes. The framework needs to be validated, and fine-tuned, both in university and higher education settings, as well as, corporate training, especially for entry level professionals.

The authors invite academia and corporate trainers to invoke and experiment with this suggested academagogical framework and build on it from their experiences and feedback from implementation.

References

1. Schiller, L., Böder, V., and Schenke, H. W., 2012, "The Position of Hydrography in a System of Sciences – A Comprehensive Definition and Systematic Subdivision of the Discipline", FIG Working Week 2012, Rome, Italy
2. IHO Publications, 2011, "Standards of Competence for Hydrographic Surveyors", IHB Publication S-5, Eleventh Edition, Version 11.0.1 – May 2011
3. IHO Publications, 2010, "Standards of Competence for Nautical Cartographers", IHB Publication S-8, Third Edition
4. Wirth, K. R., and Perkins, D., 2008, "Learning to Learn", Retrieved from: http://www.macalester. edu/geology/wirth/CourseMaterials.html (version 16 September 2008)
5. Gardiner, L., 1994, "Redesigning Higher Education: Producing Dramatic Gains in Student learning", ASHE-ERIC Higher Education Report 7, Washington D.C., George Washington University.
6. Prensky, M., 2001,“Digital natives, digital immigrants - A new way to look at ourselves and our kids,” From On the Horizon (NCB University Press, Vol. 9 No. 5, October 2001), http://www.marcprensky.com/.
7. Liesbeth K. J., Baartman, Elly de Bruijn, 2011, "Integrating knowledge, skills and attitudes: Conceptualizing learning processes towards vocational competence", Educational Research Review, Vol. 6, Issue 2, Pages 125–134
8. Gitterman, A., 2004, "Interactive Andragogy: Principles, Methods, and Skills", Journal of Teaching in Social Work, Vol. 24(3/4)
9. Winter, A., Mcauliffe, M., Hargreaves, D., and Chadwick, G., 2008, "The transition to academagogy", Conference Presentation, Philosophy of Education Society of Australasia
10. Hamat, A., and Embi, M. A, 2010, "Constructivism in the Design of Online Learning Tools", European Journal of Educational Studies 2(3)
11. Murthy, S., 2011, "Academagogical Framework for EffectiveUniversity Education: Promoting Millennial Centric Learning in Global Knowledge Society", IEEE International Conference on Technology for Education - T4E 2011
12. Dave, R. H., 1970, "Developing and Writing Behavioral Objectives", (R J Armstrong, ed.) Tucson, Arizona: Educational Innovators Press
13. Callister, P. D., 2010-12, "Time to Blossom: An Inquiry into Bloom’s Taxonomy as a Hierarchy and Means for Teaching Legal Research Skills", Law Library Journal Vol. 102:2
14. Bloom, B. S., Masia, B. B. and Krathwohl, D. R., 1964, "Taxonomy of Educational Objectives Volume II: The Affective Domain", New York: McKay.
15. Department of Geomatic Sciences, 2007, "Land Surveying and Mapping Program," College of Engineering and Geomatic Sciences, PolytechnicUniversity of Puerto Rico
16. Kirkpatrick, D. L., 1994, "Evaluating Training Programs," San Francisco: Berrett-Koehler Publishers, Inc
17. Pryor, M.G., Taneja, S., Humphreys, J., Anderson, D., and Singleton, L., 2008, "Challenges Facing Change Management Theories and Research," Delhi Business Review X Vol. 9, No. 1 (January - June 2008).

The Quaternary Geological Map of North Bengal

Arunabha Das
Geological Survey of India

Abstract

The resulting effect of the Quaternary processes at work in the Eastern Himalayas and to its south lie spread over Bihar, North Bengal and Sikkim. It is observed as complex of landforms units indicative of glacial, fluvial and lacustrine regimes. Mapping in Darjeeling and Sikkim indicate eroding hills that provide glacial and fluvio-glacial debris which gradually carry on the depositional plains through coalescing fans and flood plains. The latter continues south into Bihar and West Bengal. It is interrupted by the Ganga in Bihar and by the Barind uplands in West Bengal and Bangladesh. The deposits are classified Morphostratigraphically into seven units. The seven cycles of erosion-deposition and soil formation indicate unstable and stable phases. The many landform units that characterise a geomorphic process in each terrain ranging from 600m to 920m above msl with a gradient decreasing from north to south is characterised by a distinct lithology, soil and vegetation. Numerous lineaments in the area assume significance when viewed in conjunction with the possible share of tectonic impulses that cause repeated cycles of erosion and deposition. Frequent changes in drainage and river migration affect human activity with havoc floods.

Introduction

The ancient physiographic divisions of North Bengal include (i) the northern hill ranges of the lesser Himalayas, (ii) the low foothill hill ranges followed by the (iii) Bhabhar zone where streams disappear into permeable sediments, and emanate at the surface of (iv) Terai or Duars zone to the south where coarse alluvium gives way to less permeable silt and clay passing into the (v) North Bengal Plains (Map-1)

The east-west trending sub-Himalayas of Darjeeling and Bhutan decrease in elevation from North to South and terminate in jagged arc between 88° and 90° longitude. The arc overlooks the enormous plains to the south and has long been the zone for the debauchment of debris brought down from the Himalayas dominated by increasing uplift with low angle thrust tectonics below the mountain arc at the rate of 1-2cm per year (Hailer, J. 1980).

The landform encompassed by the area has a relatively steeper gradient. Compared to the southern plains, the gradient falls from 600m above mean sea level (MSL) at the front of the Himalayas to 150m above MSL over a distance of 50km southwards. Further south, over the next 95km it falls to 60m above msl. To the north the study area constitutes the debauchment zone for a number of rivers like the Mechi, Mahananda, Teesta, Torsa, Raidak, Jaldhaka, Sankosh and several other small rivulets The distinctive features to the south are the highland patches of the Barind showing an elevation of 20-22m above the surrounding landscape (Map -2).

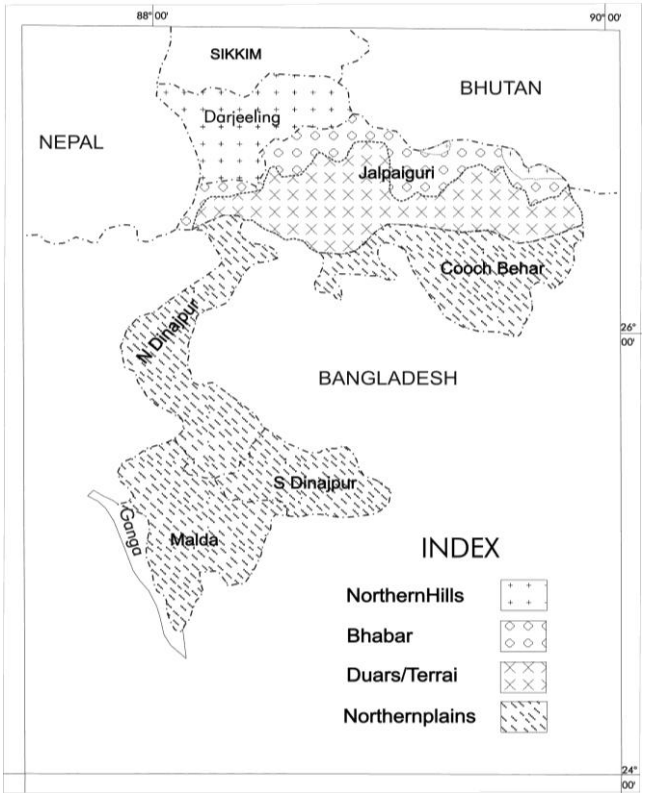
The *Terai or Duars* region politically constitutes the plains of Darjeeling District, whole of Jalpaiguri District and upper region of Cooch Behar District in West Bengal (Map –1). The slope of the land is gentle, from north to south. The general height of the land is 80 to 100 m. The entire region is made up of sand, gravel and pebbles laid down by the Himalayan Rivers. West of Teesta is known as the Terai while to its east, it is called the Duars.

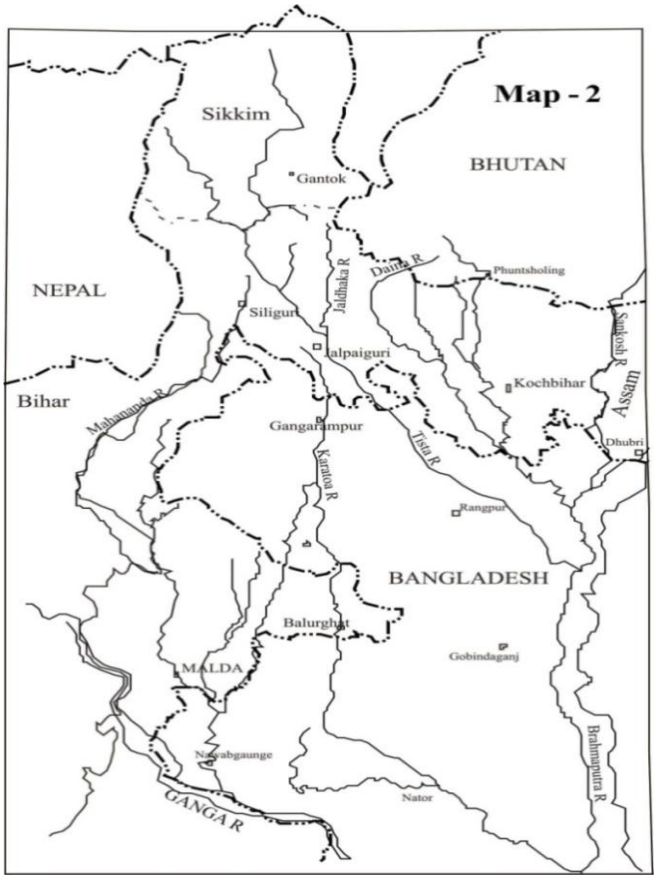
Of the many glacial fed rivers the Tista is of major importance. Emerging out of a state of confinement within the Himalayas at Sevok, the Tista debouches its load to the south. The Tista, which derives its name from Trisrota, "possessor of three streams once ran south of Jalpaiguri into its distributaries, the Punarbhaba, Atrai and Karatoa Rivers. These are now observed only as minor streams since after the destructive floods of 1787 the Tista swerved SE passing into the Bramhaputra. The historical distributaries proceed southward into the Ganga dissecting the Barind uplands. West of Tista the Mahananda flows southwest. It also gives out a number of distributaries, two of which are active. The Tista and the Mahananda (Fig. 2) are visible as two wings of an enormous fan larger than that of the Kosi.

The ancient system is defined in Rennels Atlas of 1772. (Fig. I) The Karatoa finds mention in the Mahabharata and in the writing of Huan Chwang. In "Karatoa Mahatya" a work composed not later than the 15th century it mentions that the Karatoa once went independently to the sea. On its bank stood the ancient city of Paundravardhan now in ruins at Mahasthangarh in Bogra District of Bangladesh. The antiquity of this city and also of Bangarh near Gangarampur dates back to the, Mauryan period.

The river Kosi that now flows along the western margin of its basin in Bihar at one time joined the Karatoa River along with the Mahananda River. History records the major changes in the course of the rivers that at various times marked the boundaries of the various provinces.

Map – 1: PHYSIOGRAPHIC DIVISIONS OF NORTH BENGAL





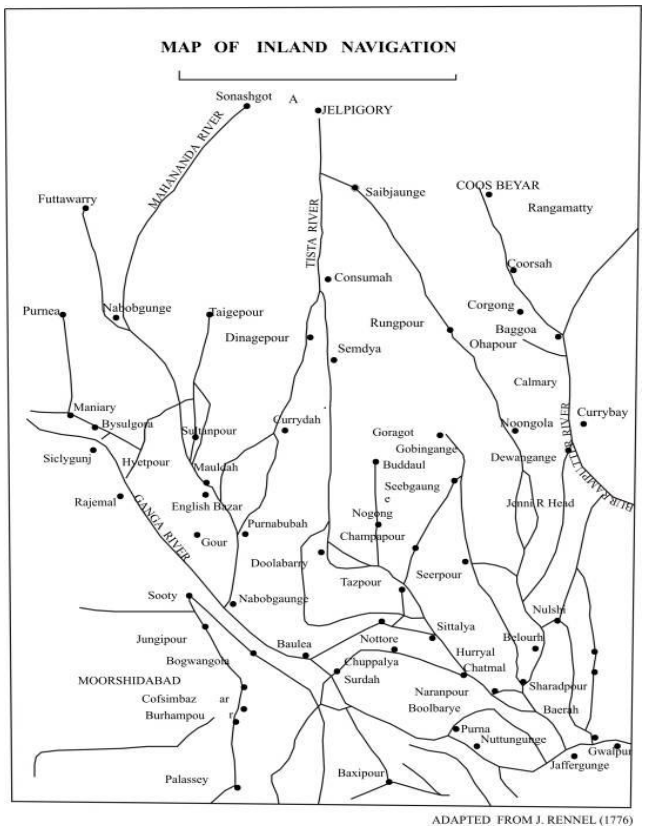


Fig. 1

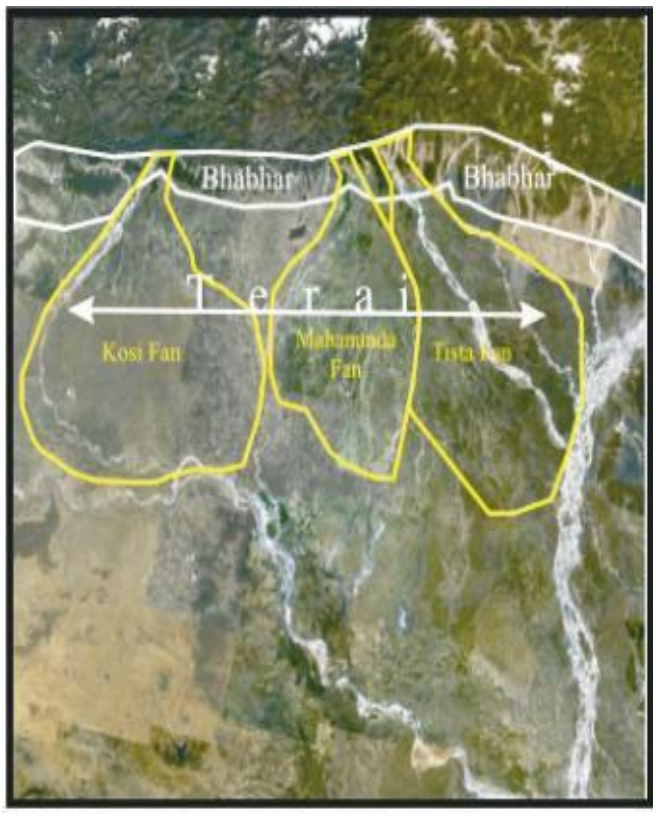


Fig. 2

Thus the KosiRiver marked at one time the boundary between the Vedehas to the west and the Paundra to the east. When the Kosi shifted to the east, the Ganga became the dividing line in the 10^{th}-11^{th} century. The ancient city of Ramavati situated in and around the ruins of Gaur south of Malda was then situated on the banks of the GangaRiver.

Geomorphology

The hill ranges to the north in Sikkim exhibit prominent glacial landform features in the higher reaches where remnant of cirques, arêtes, horn peaks, hanging valleys and dissected U shaped glacial valleys exist. River terraces of two depositional phases are observed along the courses. Besides waterfalls, glacial moraines, alluvial fans and alluvial cones of minor streams are also observed along with talus slopes and debris.

The enormous Mahananda-Tista conjugate fan, flanked by some minor fans to the east and west, dominates the geomorphology of the northern part of the terrain. These have coalesced to form the piedmont zone between the borders of Nepal and Assam and are known since ancient time as the *Terai or Duars*. North of this piedmont zone up to the south of Bhutan Himalayas, are remnants of older glacial and fluvioglacial and fluvial fan deposits that also coalesce as an older piedmont that together form an ancient geographic entity known as the ***Bhabhar*** of North Bengal (Fig. 1). The underground water level is deep in this region. Here streams disappear into permeable sediments, and emanate at the surface of the Terai to the south where coarse alluvium gives way to less permeable silt and clay.

Glacial deposits are observed in the upper Duars of North Bengal. Situated above 600m altitudes, they are seen as dissected remnant patches south and west of Samsing, south of BamanpokriReserveForest, and on top of Gorubathan hill (Q_1s in Map-3). The depositional unit has a more or less flat surface. It abuts against the hills to the north and terminates abruptly to the south with a radial scarp face. Distinguished with a chocolate brown soil cover (when present) overlying massive angular boulders contained within highly weathered and oxidised pebbly grit matrix, this unit has been denoted as the ***Samsing formation***. It is the oldest depositional unit in the area and indicates just how far south, the last glaciers progression took place.

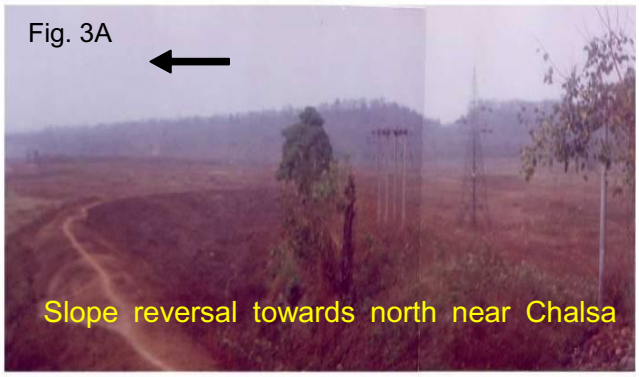
Boulder & gravel beds of older fluvioglacial deposit (Q_1m in Map -3) are exposed in segments skirting the foothills and underlie the piedmont zone made up of coalescing older alluvial fan deposits. It has an undulatory surface dissected by number of rivers that have produced depositional and erosional terraces. Distinguished by *a brick red soil cover (Fig. 4, 5),*the sediment package underlying this surface is denoted as the ***Matiali formation***. Skirting the Matiali formation to the south pebbly, cobble and coarse-grained fluvial deposits overlie the Matiali deposits. Distinguished by *a brown grey (Fig. 4 and 5) soil cover,*the sediment package underlying this surface is denoted as the ***Chalsa formation***.

Spectacular scarps flanking the rivers are common in the Bhabhar and Terai region as is another set of scraps that cut across the rivers. These are morphotectonic features that constitute an important aspect of the geomorphology of the *piedmont terrain* (Chattopadhyay et. at 1987; Das and Chattopadhyay, 1993). It gives the terrain a stepped appearance. This along with unpaired terraces and slope reversals indicates the tectonic process at work in the creation of the landscape.

South of the Duars, the Terai constitutes the lower and younger fluvial piedmont zones of Jalpaiguri and Cooch Behar districts and flood plains of Dinajpur, Bangladesh and Cooch Behar districts (Map – 1). The monotonous flat topography contain a network of present and past channel courses besides landforms such as levees and back swamps, point bars, meander scroll complexes and oxbow lakes. (Bose, 1986; Das and Ghosh, 1987; Pal, Das and Biswas, 1988; Pal et at 1992; Pal and Das, 1991) Grit, coarse to fine sand predominate (Fig. 8 & 9) giving way to silt and clay southward.

The landscape of this fluvial terrain is terraced. The terraces are sharp and easily distinguishable smoothen out and become gradational southward. None-the-less the oldest unit stands out as a predominantly as a sandy unit in Jalpaiguri district. It gradually passes into fine sand in North Dinajpur and yellowish grey silt and clay with calcrete nodules in South Dinajpur. The unit is observed to overlie the Chalsa member to the north and the red Barinds to the south. Distinguished by a black prairie soil cover to the north,the sediment package underlying this surface is denoted as the ***Baikunthapur formation***(Q_{12}b). Two younger terrace units besides the vast present day floodplain are

Fig. 3A



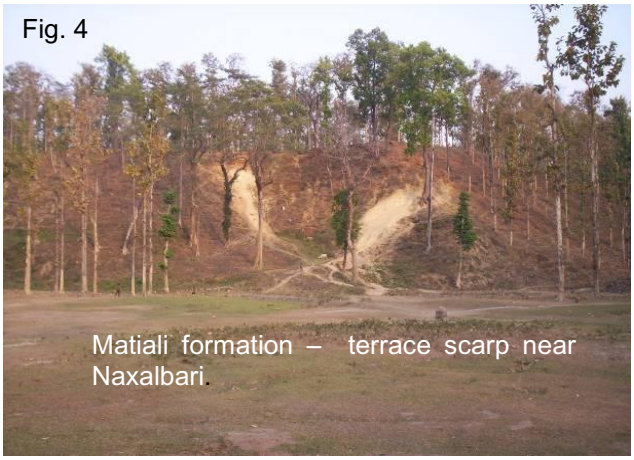
Slope reversal towards north near Chalsa

Fig. 3B



Terrace scarp on east bank of NeoraRiver.

Fig. 4



Matiali formation – terrace scarp near Naxalbari.

Fig. 5



Matiali formation surface – Red coloured soil south ofMatiali.

Fig. 6



Chalsa formation terrace - Chandmani T.G.

Fig. 7



Chalsa formation deposit overlying Matialisoil surface below Lookshun Tea factory

Fig. 8



Jalpaiguri and Baikunthapur depositional terraces – Karela T.G. Northwest of Jalpaiguri

Fig. 9



Baikunthapur palaeosoil overlapped by Jalpaiguri formation sand deposit

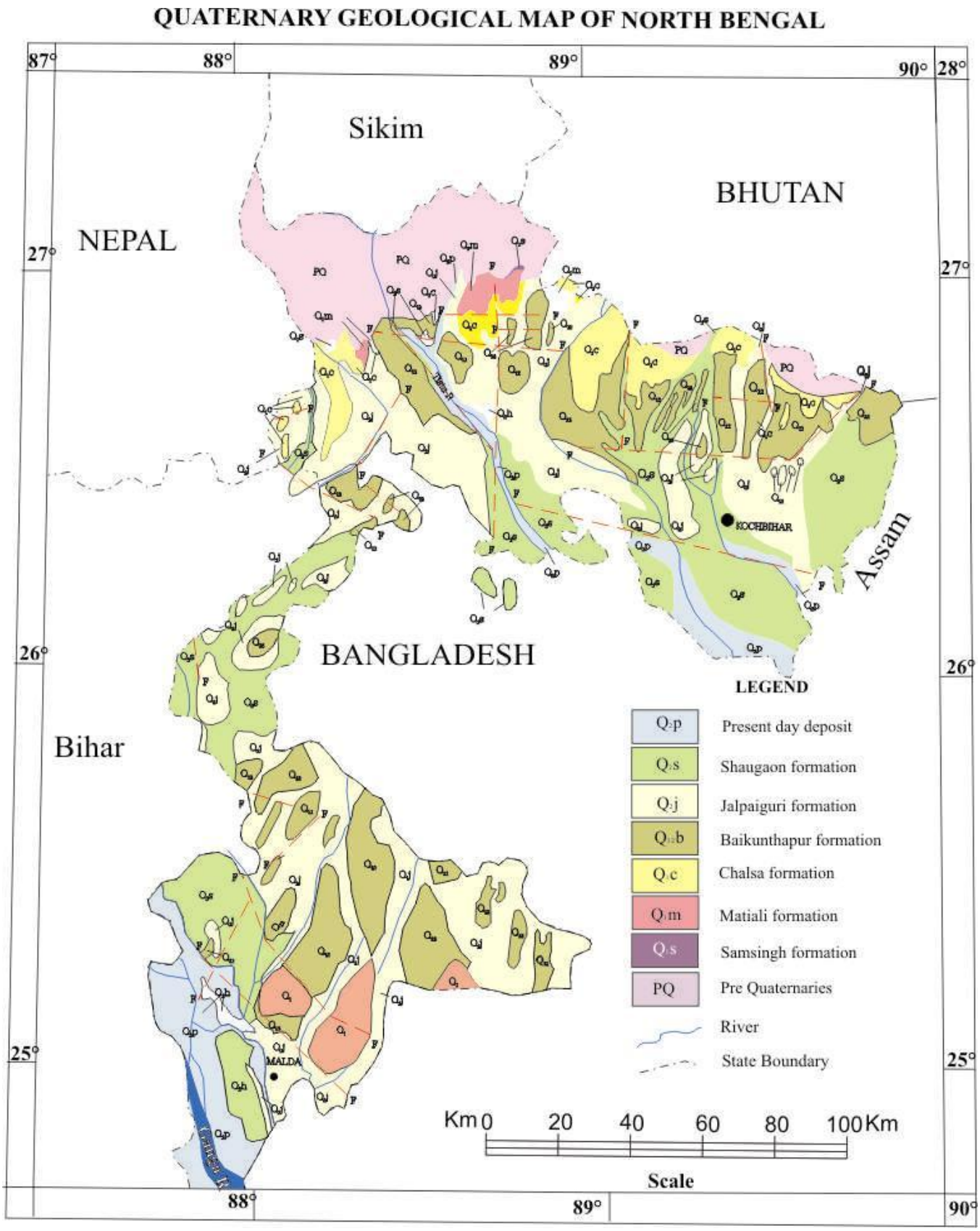
TABLE 1

Genetic Class	Terrain unit	Landform	Geomorphic unit	Soil Colour index	Morphostratigraphic unit	Age
Fluvial	Floodplain	Levees Back swamp Channel bar Point bar Meander scroll	Active Floodplain	Entisol	Present day deposits Q_2p	Holocene
Fluvial	Floodplain	Levees Back swamp Channel bar Point bar Meander scroll	Inactive Floodplain (active in high floods)	Entisol	Shaugaon formation Q_2h	
Fluvial	Floodplain	Channel (Aggraded bed) Levees Back swamp Point bar Meander scroll	Inactive Floodplain	Inceptisol	Jalpaiguri formation Q_2a	
Fluvial	Piedmont	Fan Fan cut terraces	Uplifted piedmont	Black chernozem soil	Baikuntapur formation Q_{12}	Lower Holocene to Up Pleistocene
Fluvial	Floodplain	Channels & Flood basins	Uplifted Flood basins	Calcrete bearing khaki coloured soil	Baikuntapur formation Q_{12}	
Fluvial	Floodplain	Flood basins	Uplifted Flood basins	Red clay with iron nodules	Barind formation Q_1b	Pleistocene
Fluvial	Piedmont	Fan Fan cut terraces	Uplifted piedmont	A Horizon – Brown B Horizon – Yellow	Chalsa formation Q_1c	
Fluvio – Glacial		Ice contact deposits; Outwash deposits; Proglacial deposits; Erosional terrain	Uplifted stratified drift	A Horizon – Red B Horizon – Orange	Matiali formation Q_1m	
Glacial	Glacial Drift	Till	Uplifted Till	A Horizon Chocolate B Horizon – Red	Samsing formation Q_1s	

TABLE 2

Morphostratigraphic unit	Phase	Process
Shaugaon formation	Contemporary erosion and deposition	Slight channelling in Jalpaiguri stage soil and deposits and deposition of stratified gravels, sands and clays. No soil formation.
Jalpaiguri formation	Stable	Soil development on depositional and erosional surface; minimal pamic soil formed with A/C profile
	Deposition	Deposition of sediments similar to Baikunthapur formation
	Erosion	Truncation of Baikunthapur Sub stage
Baikunthapur formation	Stable	Soil development on depositional and eroded surfaces; Grey black prairie soil formed with A/c profile
	Deposition	Mantle in upper stream channels of weekly sorted non-bedded sediments. Thickening of the mantle cover down stream with well sorted and bedded sediments-Baikunthapur formation deposits.
	Erosion	Truncation of Chalsa soil and deposits
Chalsa formation	Stable	Soil development on depositional and eroded surfaces. Brown coloured A horizon overlying yellow coloured B horizon
	Deposition	Deposition of an even mantle over corded hillsides and thick deposits in upper stream channels. Sediments are poorly to weakly sorted. Poorly bedded to well stratified. Chalsa formation deposits.
	Erosion	Truncation of Matiali soils and deposits considerable stream channelling of glacial drift up to bedrock at places.
Matiali formation	Stable	Soil development on depositional and eroded surface podzolic soil formed with strongly differentiated profile. Red A horizon overlying orange B horizon.
	Deposition	Deposition of an even mantle over eroded hillsides and thick deposits in upper stream channels; sediments are poorly sorted and stratified -Matiali formation.
	Erosion	Truncation of some Samsing soils and till deposits, considerable stream channelling.
Samsing formation	Stable	Soil development on deposition and eroded surface; podzolic soils formed with strongly differentiated profiles.
	Deposition	Deposition of thick glacial drift material over eroded hillsides and very thick deposits in upper stream channels. Material unsorted and unstratified.
	Erosion	Complete truncation of bedrock and pre-existing soils; very deep glacial channelling.

Map-3


QUATERNARY GEOLOGICAL MAP OF NORTH BENGAL
87°
88°
89°
90°
28°
27°
26°
25°
Sikim
BHUTAN
NEPAL
BANGLADESH
Bihar
Assam
KOCHBIHAR
MALDA
LEGEND
Q2p Present day deposit
Q2s Shaugaon formation
Q2j Jalpaiguri formation
Q1-2b Baikunthapur formation
Q1c Chalsa formation
Q1m Matiali formation
Q1s Samsingh formation
PQ Pre Quaternaries
River
State Boundary
Km 0 20 40 60 80 100 Km
Scale

also decipherable throughout the North Bengal. Of the two the older ***Jalpaiguri formation***(Q_2j) with an incipient soil cover is a completely *abandoned* floodplain, while the ***Shaugaon formation*** (Q_2s) lies just above the active Present day deposit and is devoid of soil cover. A vast spread of the Shaugaon formation is observed east of the abrupt N-S bend of the TistaRiver at Haldibari that occurred in recent *history*.

In Malda district, the southern part of North Bengal, the *Barind uplands* form an important aspect of the landscape. They occur as vast elongated lobes stretching NE - SW with an undulatory topography. Incised by the rivers Cheeramoti, Punarbhaba and the Atrai that separates the lobes, the uplands gradually rise just 15 to 20 m above the surrounding landscape. Red clay containing iron nodules forms the higher central part of the upland. Their highly oxidised nature distinguishes it as an older deposit that has been subsequently exposed. Distinguished by highly oxidised iron nodule bearing thick weathered clay,the sediment package underlying this surface is denoted as the ***Barind formation***.

This Barind formation is skirted by greyish-yellow (Khaki) coloured clay with calcium carbonate nodules (Calcrete). Although a part of the upland, it is observed that insitu calcrete-bearing clay overlies iron nodule bearing red clay of the Barind formation. Northward the calcrete bearing deposit merges and gradually passes into the coarser grained Baikunthapur formation indicating that the calcrete bearing clay is a facies variant of Baikunthapur formation.

Older to the Baikunthapur formation, the Barind formation is equated with the Chalsa, Matiali and Samsing formations. The thick iron rich clay deposit indicates quiet deposition under shallow water oxygen rich conditions. The occurrence of calcrete in the deposit following it indicates that a dry (arid) condition followed a wet (tropical) condition. The Barind uplands terminate abruptly to southwest where its southern boundary is aligned with the distributaries of the Mahananda, Kamli and Kalindri rivers (Map-3).The abrupt terminations, besides its surface having a north-easterly slope, are the morphotectonic elements that indicate up-faulting to the north of the alignment that are post Baikunthapur formation in age.

Neotectonics

In Quaternary time the Himalayas has witnessed continuous uplift (with low angle, fault tectonics below the mountain arc (15°-5°) Warsi & Molner 1977) roughly parallel to the trend of the Himalayan arc, along the MFT, MBT and MCT. Subsidence accompanying the Himalayan uplift occurs along the northern periphery of the Indian Shield where clasts brought down from the rising Himalayas form a 16 km thick pile ranging from Miocene to Recent beneath the foredeep. Seismic data suggests normal faulting parallel to the Himalayas (J. Haller, 1990). Block adjustment within the, southward migrating and still widening mountain are, has possibly also given rise to faults transverse to the Himalayan trend, both normal and strike slip.

Such parallel and transverse faults are known throughout the foredeep region. Das and Chattopadhyay (1993) attempting and explanation in terms of plate tectonics paradigm, indicate that the features are a result of the tectonic regime in the frontal region of a subducting plate. It would cause folds that tighten towards or close to the zone of collision and also necessitate the seismic thrust viz. MCT & MBT for adjustment of the continuous push. The continued arching after the scaling of the thrust should produce a set of sympathetic faults as is observed in the area.

Faults transverse to the Himalayan trend are generally the routes along which the rivers pass to debauch onto the planes. River migration results due to the tilting of blocks to the east and west. This in turn causes extensive erosion as is also evident during floods. Thus Fergusson (1863) in his early description of the Bengal Delta believed that the Madhupur region in Bangladesh (akin to the Barind uplands) has been uplifted in very recent times. He also indicated that the earthquake of 1762 was accompanied by elevation and subsidence of large tracts of land. Hirst (1916) citing numerous geomorphic evidences advanced the concept of a zone of sinking along a line passing approximately from Jalpaiguri to east of Barisal and a compensatory upliftment of Barind and Madhupur tract which he considered to the Old Alluvium. Moran & McIntire (1969) positively re-evaluated the concept of Hirst (1916). Photo geological citing of enechelon faults on the western face of the Madhupur tract and the Karatoa fault on the northeast tract of the Barind indicated that the intervening area, the floodplain of the BrahmaputraRiver, has been actively subsiding. Morgan McIntire concluded that the "Alluvial Processes in N. Bengal are controlled by Quaternary structural activity".

Morphotectonic features like scarps (Fig. 3B) caused by antecedent rivers that incise to keep pace with the upliftment besides slope reversal are characteristic features (Fig. 3A) are observed north of Chalsa, Nagrakata and at Caron tea garden in Jalpaiguri District and the Barind uplands of Malda District. Spectacular fault scarps cutting across streams and rivers as at Samsing, Matiali and Chalsa with an angle of repose approximating the dip of the fault plane are common in the boulder, pebble, cobble horizons within the glacial drift and piedmont zones (Das & Chattopadhyay 1993).

Upliftment on the downstream side invariably results in a temporary barrier to the flow of water. Depending on

the lithologic conditions the barrier may reveal itself as a scarp face as at Thalijhora and Gorumara or as a lineament traceable along preferred orientation of streams and rivers or in the development of swamp belts, e.g. north of Barind uplands.

Many of these responses have led to environmental hazards in the past as witnessed by the changes of the river courses during the historical period. The movements are documented by scraps running across the flow of rivers, identical bends in river courses, hydrological variation and changes in geodetic level (Das & Chattopadhyay 1993; Das & Panja 1999). The responses also include selective terracing and gully erosion in uplifted blocks and recurrent floods and water logging at the lower level (Bose, 1986; Das and Ghosh 1988; Pal, Das and Biswas, 1989; Pal et al 1991; Pal and Das, 1992; Sural, Das and Chatterjee, 1997).

The tectonics at work has resulted in (Das & Chattopadhyay, 1993) various phases of upliftment. This in turn has caused erosion on the uplifted surface and deposition on the down faulted surface. In the stable phase soil formation takes place.

It is thus obvious that the effect of the Neotectonic processes on the ground surfaces contribute a great deal to the instability in the region such that the maze of streams and rivers keep constantly changing direction. Erosion of material from the uplifted side and deposition on the down faulted depression has been a constant cause of aggradations and shifting of rivers. The possibility of continuing tectonic readjustment and particularly its relation to controlling erosion, floods and undermining engineering structures has been persistently observed during fieldwork. The collapsed bridge on Mal Khola (West of Chalsa) and Nagar River (North of Raigunj); collapsed Malior embankment at Kantha and Balurghat and the collapsed embankment of the Ganga north of the Farakka Barrage are some such engineering structures that have been build across channel and palaeochannel courses which occur on fault controlled lineaments (Pal and Das 1992; Pal, Das and Biswas, 1989; Das, 1994).

Reactivated rivers cause floods. In the densely populated area of North Bengal recurring floods cause enormous damage. The conditions are aggravated every year as the rivers get more and more aggraded and are thus more easily flooded. Palaeochannel courses particularly those that are fault controlled and connected to the main stream are easily activated. Towns like Jalpaiguri, Cooch Behar, Alipur Duar, Dalkhola, Ratua, Kaliacha, Barsoi and Mathurapur besides the interconnecting transportation corridors are as a result perpetually prone to flood damage, and will continue to he so as long as effective steps are not taken with the help of compatible geomorphic engineering methods to mitigate their conflict with the established Neotectonics.

Conclusion

The transition between the stable and unstable phase implies gross changes **(**Table 2). The differentiation of normal soil horizons in layers could not have occurred without a well-vegetated surface and a climate suitable for the maintenance of vegetation. The phase of instability with sheet wash and gully activity could not have occurred other than in a situation of sparse vegetation and/or topographic disturbances. The map illustrates the precise application of Morphostratigraphic principles and demonstrates the geomorphic, neotectonic and environmental synthesis that is possible as depicted in (Table1).

The ongoing tectonic readjustment as observed from the wide spectrum of responses viz., bank and gully erosion, recurrent floods, undermining of embankment and transportation corridors warrants compatible geomorphologic engineering methods in environmental planning to mitigate the conflict of human interests with the established neotectonic controls.

References

1. Bose, S.S., 1986 - *Quaternary Geology and Geomorphology of parts of Mahananda basin, Darjeeling, West Dinajpur districts, West Bengal and Purnia district, Bihar.* Unpublished Geological Survey of India, Report, Field Season 1985-86
2. Chattopadhyay G.S. & Das A., Majumdar, S. and De P., 1987 - *Quaternary Geological and Geomorphology of the Tista, Jaldhaka and Torsa River Basins, Darjeeling, Jalpaiguri and Cooch Bihar districts, West Bengal and Tista - Rangit River Basins, Sikkim.*(Unpublished Geological Survey of India, Final Report)
3. Chattopadhyay G.S. and Das A., 1992 - *Quaternary Geology and Geomorphology of Tista-Torsa Interfluve area - A Brief Review*(G S I Records Vol. No.118, pt.3-8,pp.115124)
4. Das A. 1994 - *Study of Neotectonics in the Himalayan foredeep belt with reference to seismicity and natural disasters*. (Unpublished Geological Survey of India Progress Report) Field Season 1992-93, Extended Abstract Geological Survey of India Records, Vo1.127, pt-3, pp.109-110.
5. Das A. & Chattopadhyay G.S., 1993 - Use of *Soil in Building up the Quaternary Stratigraphy of North Bengal*(G S I, Record Vol. NO.121, pt.2-8, pp.87-91)
6. Das A. & Chattopadhyay, G.S., 1993 - *Neotectonics in the Tista, Jaldhaka and Torsa Interfluve belt of North Bengal.*(G S I, Record Vol. NO.121, pt.2~8, pp.81-91)
7. Das A. & Ghosh, M., 1987 - *Quaternary geology and Geomorphology in parts of Mahananda*

*Basin, West Dinajpur district, West Bengal.*Unpublished Geological Survey of India, Report, Field Season 1986-87.

8. Das A. & Panja S. 1999 - *The Cultural History of Malda and South Dinajpur Districts, West Bengal - A Geoarchaeological Perspective.* Nat. *Symp. Quaternary of India - Gondwana Geol. Magz. Spl. Vol. 4, 1999, pp 347 - 349.*

9. Das A, 2006, - *Report on the Compilation of the Quaternary Geology of the area including parts of Jalpaiguri, Darjeeling and north Dinajpur districts of west Bengal with the help of remote sensing and limited Field checks in 1: 50, 000 scale & A note on Siliguri urban area.*Unpublished GSI, FSP.

10. Das A., 2006, - *Report on the Compilation of the Quaternary Geology of Quadrangle 78F in 1: 50, 000 Scale Including Parts of Jalpaiguri, and Cooch Behar Districts of West Bengal and parts of Kokrajhar and Dhubri Districts of Assam with the help of Remote Sensing and Limited Field Checks*Unpublished GSI FSP Report.

11. Hallar, J., 1980 - *Himalayan Orogenesis in Perspective in Metamorphic Rock Sequence in Eastern India*; Editor P.K. Verma, pp.i-xxix.

12. Pal S.K., Das, A. & Biswas, J., 1988 - *Quaternary geology and Geomorphology of a part of MahanandaBasin in parts of Katihar arid Santal parganas district, Bihar and Maida district, West Bengal.* Unpublished G S I Report, F. S.1987-88.

13. Pal S.K. & Das, A., 1992 - *Quaternary geology and Geomorphology in parts of Maida district, West Bengal.* Unpublished Geological Survey of India Report, F. S. 1989-90. Extended Abstract G S I, Vo1.123, pt-3, pp.64-65.

14. Pal S.K., *et al,* 1991 - *Quaternary geology and Geomorphology in parts of Mahananda Basin in parts of Katihar and Santal Parganas district, Bihar and West Dinajpur and Maida districts, West Bengal.* Unpublished Geological Survey of India Report, F. S. 1988-89. Extended Abstract G S I Records, Vo1.125, pt-3, pp. 25.

15. Pal, S.K., Das, A. & Biswas, .J., 1988 - *Quaternary geology and Geomorphology of a part of Mahananda Basin in parts of Katihar arid Santal Parganas district, Bihar and Maida district, West Bengal.* Unpublished Geological Survey of India Report, F. S. 1987-88.

16. Pal., S.K. & Das, A., 1992 - *Quaternary Geology and Geomorphology in parts of Malda district, West Bengal Unpublished Geological Survey of India Report, Field Season 1989-90*Extended Abstract Geological Survey of India Records, Vo1.123, pt-3, pp.64-65.

Identification of Potential Stone-Quarry Sites for Sustainable Infrastructural Development in Mizoram State, using RS and GIS.

Swati Singh*, Ajoy Mondal and A. Jeyaram
Regional Remote Sensing Centre (RRSC-E), Kolkata
National Remote Sensing Centre (NRSC)
Indian Remote Sensing Organization (ISRO)
**Email: swati.isro@gmail.com*

Abstract

The development of transport infrastructure is a key prerequisite for economic growth of the remotely accessed hilly state of Mizoram. The National Highways are the lifeline for the state which connects Mizoram to other parts of the country. Expansion of present road network is required for promoting various developmental activities in state. The raw materials required for road and building construction is fulfilled by Stone Quarrying, which have been the common practice as well as sole mining activity in Mizoram state. Due to lack of scientific planning, lots of quarry sites have been developed in hazardous and led to slope failure. Hence, the present study is carried out with the specific objective of identification of suitable sites for sustainable quarrying of stones along the National Highways (NH-54, NH-150, NH-44A) of MizoramState for expansion of infrastructures using Remote Sensing and GIS. Different thematic maps viz. Lithology, Lineaments/Fault, Slope, Drainage network, Forest cover, Settlements, Road Network have been generated using high resolution LISS IV (MX) and collateral data. Further, these thematic layers were analysed in GIS environment using multi-criteria analysis technique. The present study has helped in identifying around 16 probable sites where stone-quarrying may be carried out in sustainable environment. These sites are identified within 2 km buffer zone of National Highways so that it can facilities the speedy transportation of the raw material to different constructional sites for expansion of road network in the Mizoram state.

Introduction

Mizoram is one among the North-eastern hilly state with difficult terrain and climatic conditions as well as geographically it is cut off from the mainland. Transport infrastructure in Mizoram is essentially road based. The development of infrastructure, particularly transport infrastructure, is a key prerequisite for economic development. However, in Mizoram, the lack of adequate transport infrastructure has been the major inhibiting factor on its economic growth and development. Although the State has good potential in terms of areas of agriculture, horticulture, tourism, handicraft, etc. still it is industrially backward state with the vast majority of its people living below the poverty line. National Highways are the lifeline of the state which connects Mizoram to other parts of country.

Expansion of road network is required for providing a well spread means of communication all across the state. While there has been 7.81% increase in road density in the state during the last ten years, the current road density of 32.43 kms / 100 sq.kms is below India's national average of 48.80 kms /100 sq.kms. (*Mizoram State Road Project Report,2011,Issue 1*).Seeing to the topography and geographic setting,construction of new roads requires a scientific and geotechnical understanding of the terrain so that new construction may not disturb the slope stability and may not trigger landslides and other natural hazards.

Stone quarrying is a common practice and sole mining activity of this state which primarily involves the local population. Rock excavations from quarry along hill slopes disturbs the equilibrium condition of the slope. Hill slope in Mizoram ranges from 20^0 to 80^0 in gradient with average altitude of 900m from sea-level. The rocks are dipping nearly 45^0 towards the slope direction with thickness varied between 1.0 to 5.0m.The sandstone formation in the quarry area is cut in several sets of joints trending N 75^0 W with vertical dip, resulting in the blocky formation (*Sawmliana et al, 2001*). These joints are mainly filled with clay and thereby pose a threat as these forms weak joint planes, when saturated with water during rainy season. Due to lack of scientific planning, lots of quarry sites have been hazardous in past and led to slope failure. Several slope failure ranging from local fall to large scale landslides have been reported in in Mizoram in past.At least two persons is killed and several houses gets damage every year due to rock fall from road cuttings and stone quarrying (*Sawmliana et al,2001*).A large scale landslide occurred on 9th August, 1992, involving complete collapse of a stone quarry of 300m length and 250m thick at Hlimen village, about 5 km south of Aizawl city, the capital of Mizoram. Due to this disastrous incident, 67 persons lost their lives including villagers and labourers. Rock falls from Tlungvel quarry along NH-54 frequently block the road thereby hampering the normal transportation.

Thus, for sustainable infrastructural development of the state, avaliability of quarry material will be of prime concern for the state administrative departments.Using Remote Sensing and GIS framework, the display, integration and analysis can be carried out in an effective way to evaluate layers such as Geology, Structure, Slope, Landuse, distance from roads and Drainage network etc., for identification of probable sites where quarrying can be done in sustainable environment without causing threat to the population in terms of life and property

Study Area

The present study is carried out with the specific objective of identification of suitable sites for sustainable quarrying of stones along the National. Highways of state. These quarry material are used as raw material for the expansion of road network in state. The NH-54, NH-150 and NH-44A together forms the East - West and North –South extent of the state, is taken for identification of sites along these National Highways within 2Km buffer region on both side of road.

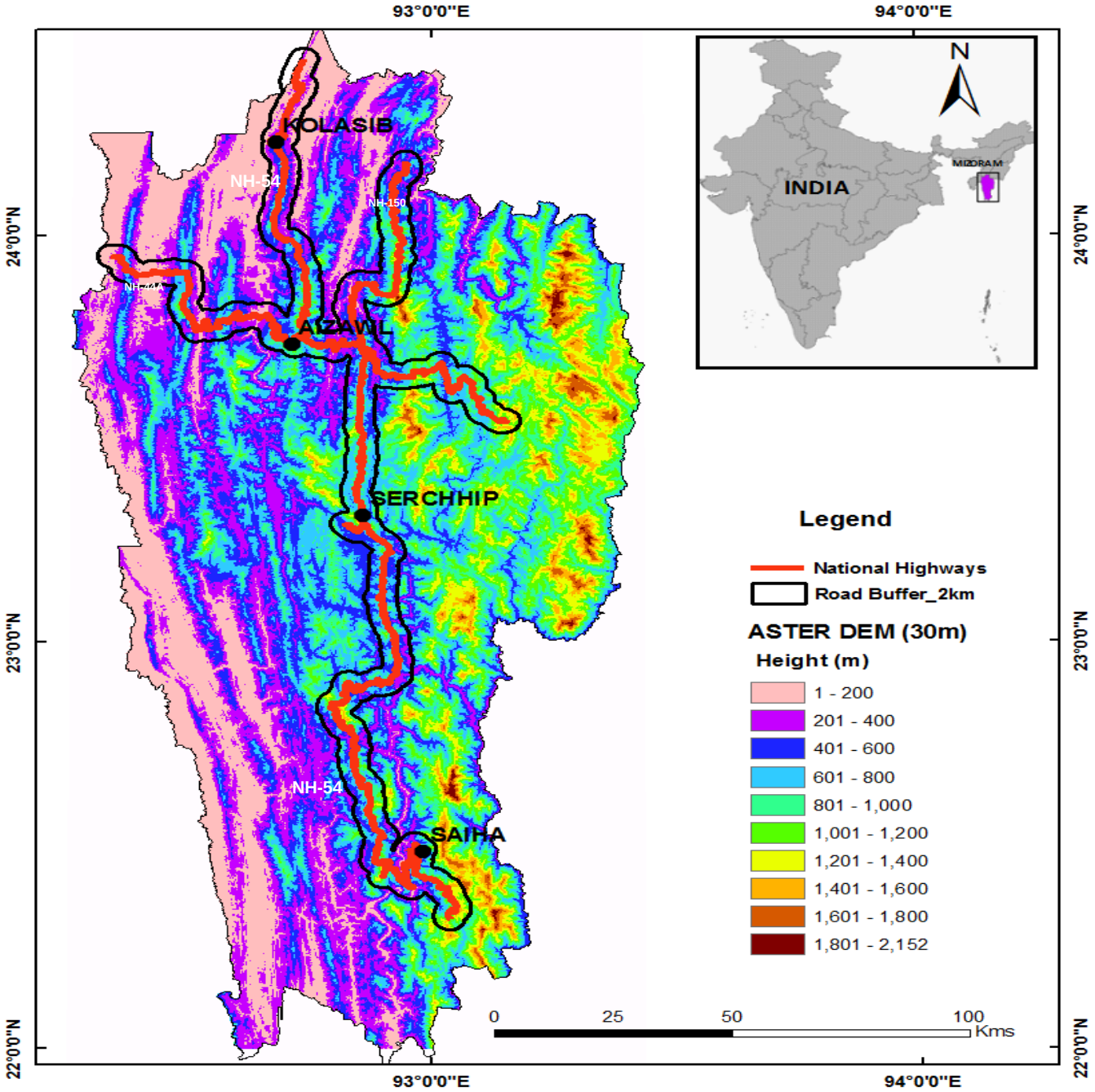


Fig.1: *Study area located within 2Km buffer along National Highways.*

Geology, Geomorphology and Tectonic setting of the Area

Geology

The area forms the major part of the Neogene Surma basin to the west of the Arakan Yoma subduction-collision zone, which represents the northward extension of the eastern margin of the Indian plate. The basinal sediments are folded into long arcuate belt in a series of linear narrow N-S trending anticlines and synclines forming a unique foreland foldbelt in the Indian sub-continent representing the "valley and ridge province". The area is very significant in respect of regional tectonic evolution and its set-up in relation to the development of the eastern margin of the Indian plate. The general geology of the area exhibits repetitive succession of Neogene sedimentary rocks of Surma Group and Tipam Formation. The lithounits include mostly sandstone, siltstone and shale. The topography on the area has close affinity with the lithological expression in this region. The arenaceous and argillaceous group of rocks occupy relatively higher and lower grounds respectively. Based on the work carried out by Geological Survey of India, a generalised lithostratigraphic succession is given in Table 1:

Table 1: Lithostratigraphy of Rocks in Mizoram

Group	Formation	Lithology
	Recent	Loose, friable and unconsolidated pebbles of sandstone and fragments of shale in sandy matrix
	~~ unconformity ~~~~~~~~~~~~~~~~~~~~~~~~	
Tipam Group	Tipam Formation	Mainly arenaceous rocks consisting of medium to coarse, buff coloured loose, friable micaceous sandstone with subordinate shale and siltstone.
SURMA GROUP	Bokabil Formation	Mainly argillaceous rocks represented by shale/siltstone and thinly bedded sandstone alternations with subordinate buff coloured, fine to medium grained soft, friable sandstone
	Upper Bhuban Formation	Mainly arenaceous rocks which includes mainly thickly bedded, grey, khaki, buff coloured fine to medium grained, at places friable, kaolinised sandstone with very fine grained sandstone, siltstone, shale (grey, olive green) interbands, with shell limestone as lensoidal bodies, conglomeratic at places, grey, very fine grained to fine grained, hard compact, calcareous sandstones
	Middle Bhuban Formation	Mainly argillaceous rocks which include grey, khaki shale, silty shale and siltstone/ shale interlaminations with grey, buff coloured hard, compact, micaceous, fine to medium grained, thinly to moderately bedded sandstone with a few thick, grey, hard, very fine grained, micaceous sandstone bands.
	Lower Bhuban Formation	Mainly arenaceous rocks which includes fine to very fine grained, compact, blue, ash, green coloured, massive to well bedded sandstone exhibiting turbidite features and well laminated siltstone, olive green silty shale/shale interlaminations.
Barail Group		Shale and siltstone with bands of weathered and micaceous, medium grained yellowish greywackes. Locally, a few hard, dark grey compact, medium to fine grained quartzwacke bands are present.

Geomorphology

Mizoram exhibits an immature first order topography and the part of is expressed by the dissection of several almost N-S trending longitudinal valleys containing series of small and flat hummocks located between the N-S trending long parallel to sub-parallel hill ranges. The major landforms includes Antiformal Hills, Strike Ridges, Synformal Valley, Valley Fills, Younger Alluvial Plain etc.

The hill range forms the water divide and flows towards the west. The drainage network in this region shows increase in drainage density towards Eastern margin of the area. All the rivers are tributaries to the major rivers of Bangladesh. The drainage patterns are dendritic, parallel to sub parallel and rectangular types.At some places the drainage lines follow east-west trend, flowing along the transverse fault.

Regional Tectonic settings

North-eastern region of India lies at the junction of the Himalayan arc to the north and the Burmese arc to theeast and is one of the most seismically activeregions of the world. Eighteen large earthquakes with magnitude >7 occurred in this region during the last hundred years (Kayal, 1996). The folded structure of Mizoram is a synclinorium consisting of broad synclines and narrowly folded antilines, dislocated by longitudinal faults. Earthquakes in this region are generally shallow, though a few earthquakes of intermediate depth have been reported.

Data and Methods

Data collection and Preparation using GIS and RS

Data preparation is the first fundamental and essential part of the study. GIS database mainly composed of base maps; geological map etc has been used as criteria for selection of sites. In this study, digital geology map and structural data of the area were prepared based on combination of geological maps for Mizoram at 1:100,000 scale and IRS Satellite Image interpretation. Slope thematic map was derived from ASTER Digital Elevation Model (DEM) of the area with spatial resolution (30m). The base layers like the road layer, drainage layer and settlement boundary were derived from toposheets as well as image interpretation of high resolution LISS IV (5.4 m) multispectral data. Using unsupervised classification of Landsat TM satellite image (30x30m resolution) landuse thematic map of the study area was created to delineate and exclude the forest and agricultural area while selecting quarry sites.

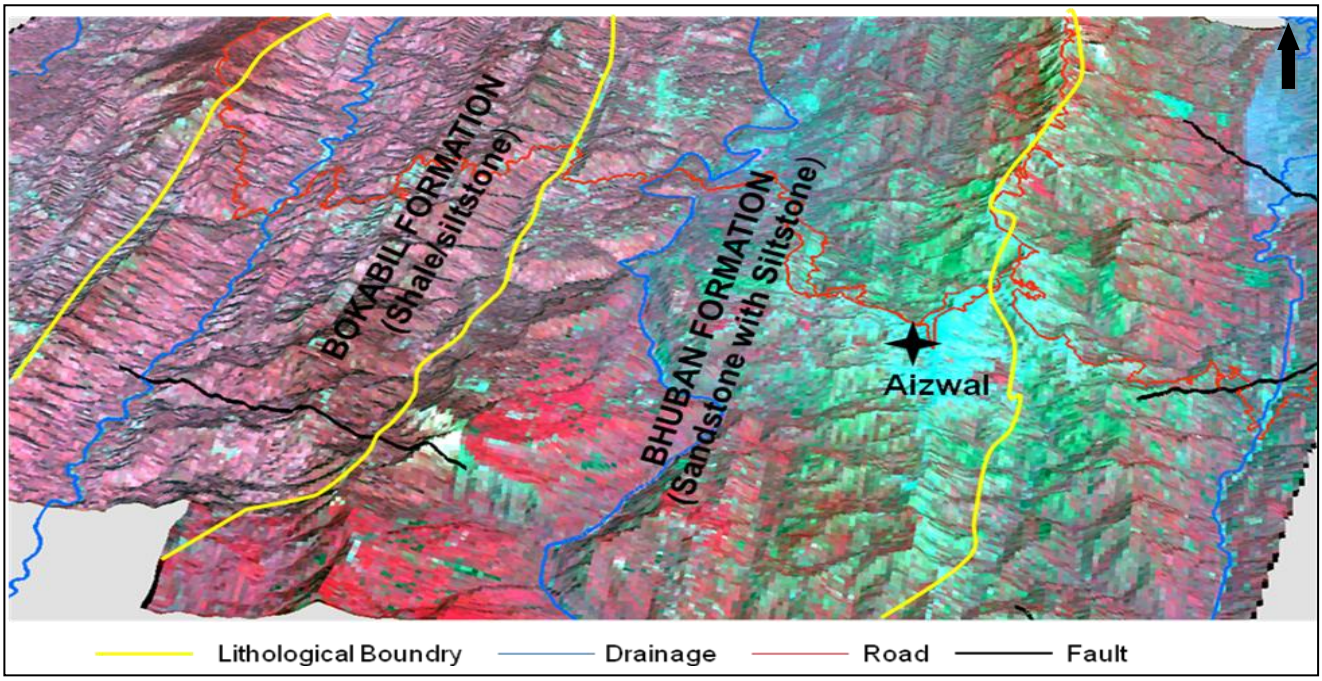
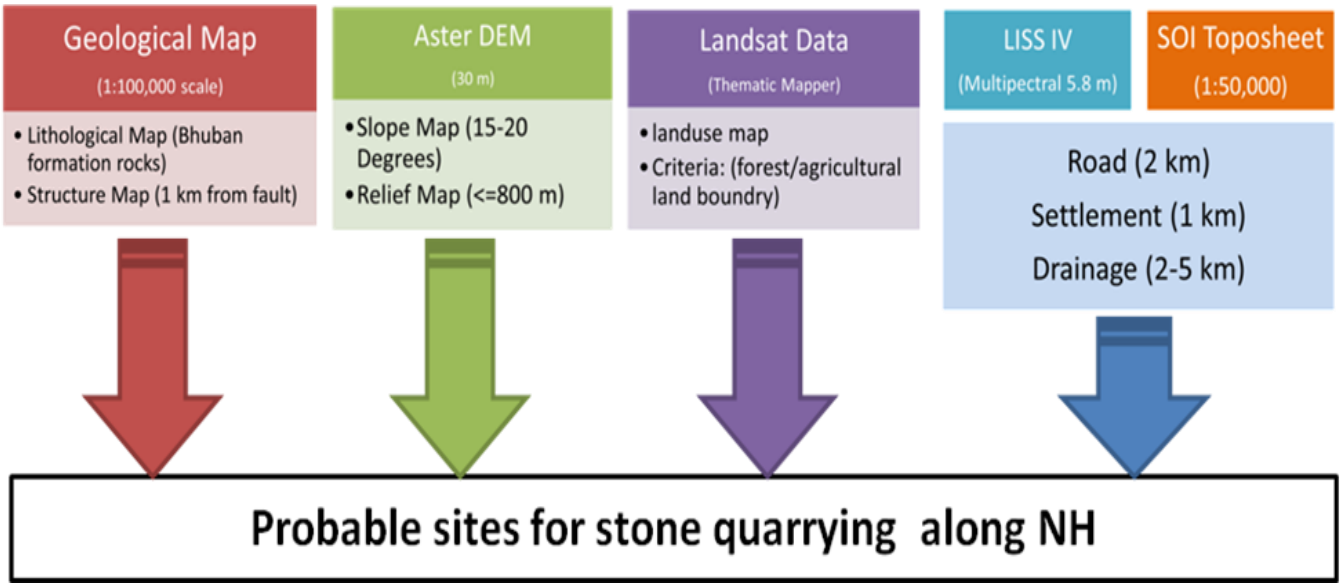


Fig. 2: LISS IV image draped on DEM showing strong lithological control over landforms. (Highly dissected structural hills-Bokabil Form.; Low Dissected Synformal Valley-Bhuban Form.)

Factors considered for suitable site selection: Depicted in form of flow diagram below.



Result and Discussion

Based on multi criteria analysis using various thematic layers generated using Satellite data in conjunction with the GIS approach, 16 probable locations were identified which further requires field validation before considering these sites for operational quarrying of building material. The terrain of the state is the governing factor in terms of soft rock, immature topography and steep dipping beds. Since local geology and topography favours the slope instability thus strong emphasis is been given in terms of favourable slope selection as well as other factors like favourable Lithology along the road, preservation and protection of biodiversity etc has been further discussed below in relation to the derived output (Fig.3).

Stability of Hill slopes along the Road

The topography of the region as well as the heavy rainfall makes the slope vulnerable to slope failure .The average slope of the region is 45^0 whereas the slope of the probable locations is insures to vary from 15-20 degrees in order to avoid threat to slope failure.

Favorable Lithology

Along the road, the lithology mainly varies from Bokabil formation to Bhuban formation .In view of the great dearth of hard rocks in Mizoram, the massive, hard compact, grey, calcareous sandstone of Lower and Upper Bhuban Formation is suitable for use as road metal and building material. Thus all the 16 sites are located within the Bhuban Formation rocks based on geological map and satellite data interpretation.

Protecting Rich Biodiversity

The state of Mizoram is the part ofIndo-Burmese hotspot. Along the road side thick forest supports rich variety of native flora in form of rare medicinal plants and are home of some endangered fauna. The agricultural land is also the backbone of the local people as agriculture is their main practise. Thus, using landuse data the forest boundary as well as the agricultural area is segregated while selection of sites in order to protect the productive area and rich biodiversity of this hilly state.

Speedy transport of raw material

For speedy transport of quarry material, the proposed location of quarry is taken within 2km buffer on both sides of National Highways**.** The sites are located with a minimum distance of 1km from the nearest settlement in order to facilitate the local labour requirement at quarry sites.

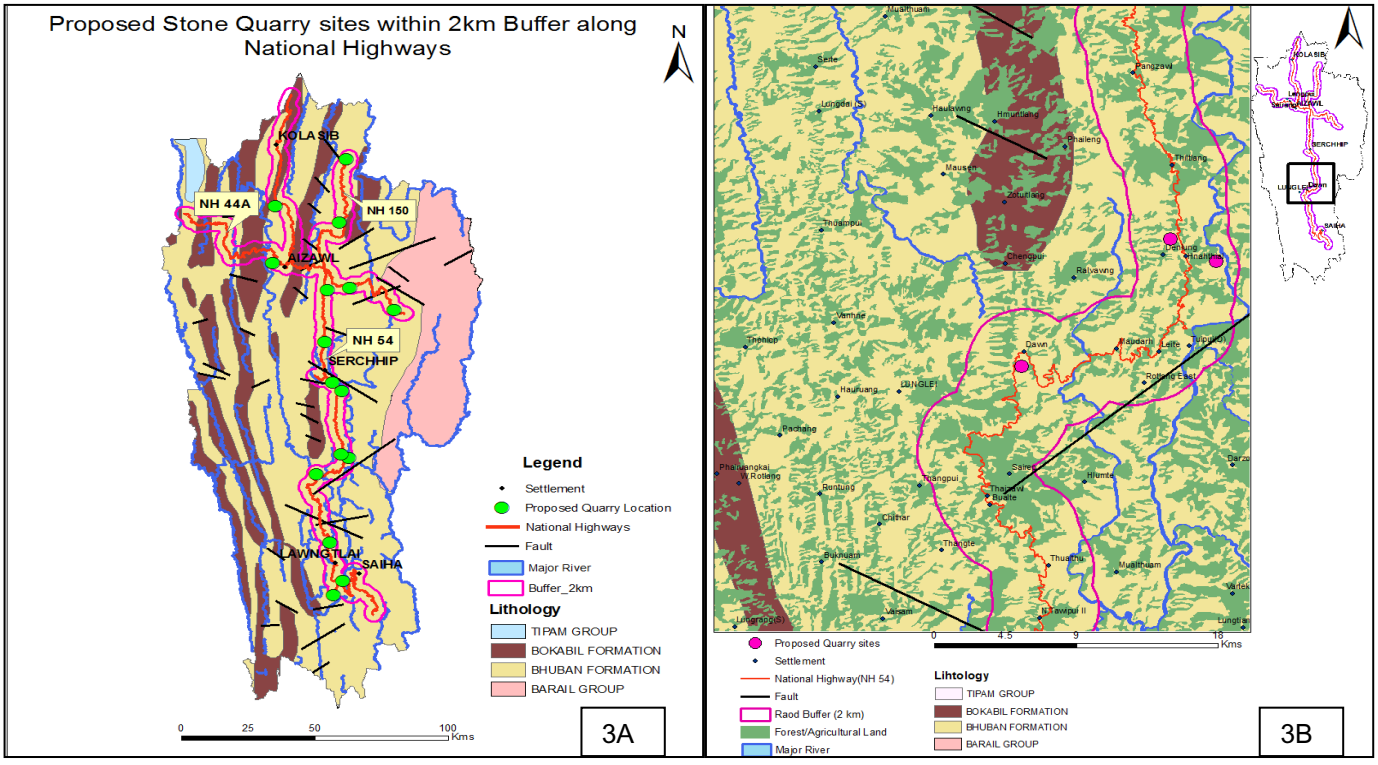


Fig.3A: Geological Map with 16 probable quarry sites.

Fig.3B: Lithology map showing probable stone quarry sites locations.

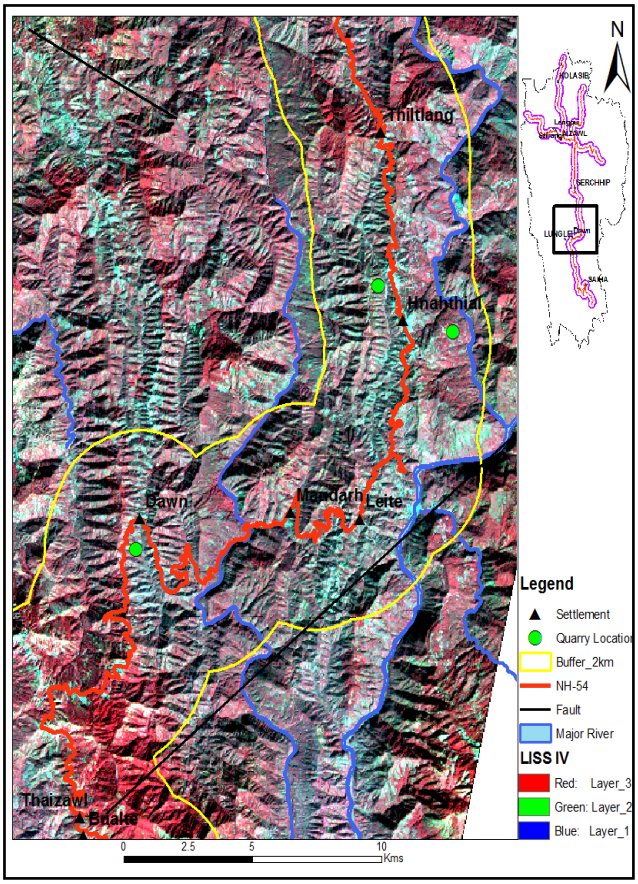


Fig. 3C: LISS IV image (RGB bands) with the quarry locations.

Future Scope

The present study is was taken as a preliminary work leading to lots of scope in the direction of sustainable development of North Eastern state in general and Mizoram in particular. The locations are the subject to filed validation which has to be carried out for precision. Further, the thorough understanding of the localized activities of Neo-tectonism in this tectonically active zone can provide meaningful information to the development activities in this region, by delineating the vulnerable sites in order to avoid the disaster due to anthropogenic activities. The field based information in conjunction to the satellite based study can be an answer to the increasing demand of well planned scientific approach for sustainable development of the remotely assessed part of the country.

References:

1. Sawmliana, C., Roy P. P.,(2001): "Importance of slope stability in hilly Region with reference to stone quarrying in Mizoram, National Seminar on Geomechanics and Ground Control"pp258-263.

2. Kayal, J.R.,(1996): Earthquake source processes in northeast India-a review. J Himalayan Geol 17:pp 53-69.

Mapping in National Waterways for Sustained Development

Cdr. P. K. Srivastava and Sh. G. Prasanth Nair
Inland Waterways Authority of India

Introduction

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.

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.

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 CoastCanal 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 CoastCanal, Charbatia-Dhamra stretch of MataiRiver and Mahanadi Delta

Rivers (588 km) as National Waterway-5

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. Developments of commercially viable stretches of NW-4 & NW-5 are being taken up under PPP mode with Viability Gap.Funding Scheme of the Government as well as through Pilot Project Initiatives of Asian Development Bank (ADB) and Department of Economic Affairs (DEA).

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.

Mapping in National Waterways

Digital mapping for hydrographic surveys:

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 and digital charts generated based on the satellite images form 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.

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 have been 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 water levels start decreasing, shoal areas 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.

All the above bathymetric surveys in National Waterways are being carried by using digital maps as base charts.

Digital Mapping for Publication of Navigational Tools:

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. The chart is prepared using Caris software as per the international standards stipulated by IHO at par with the NHO charts.

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.

RiverPilots-River Pilots have already been published for NW-1, NW-2 & NW-3. River Pilot for Sunderbans is under preparation. This will act as supplements to the RNC by way of providing sailing directions to the Mariners/ Users & Masters just like the Bay of Bengal Pilot.

Real-time Navigational Display software-IWAI is in the process of making a modern real time software (IWN software) similar to that of Inland ECDIS. Initially this is proposed for the stretch Sagar- Farakka of NW-1.In-house testing of the navigational display software for ensuring safe navigation in NWs is going on and would be made available shortly to prospective users on commercial basis. 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 River Charts of the waterway

GPS/ DGPS for Navigation in National Waterways:

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 stretch 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.

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.

Accordingly IWAI has already commissioned DGPS stations at Swaroopganj, Bhagalpur and Patna in NW-1 &Jogighopa and Dibrugarh in NW-2. Commissioning/ Setting up of Varanasi station in NW-1 &Dhubri and Silghat stations 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.

Mapping for Sustained Development

Consequent to the publication of accurate maps for NWs, it has been easier for IWAI to plan and execute developmental activities in NWs in a sustainable manner. As charts supplemented with latest satellite images gave correct information on the change in course of the navigational channel, appropriate actions for maintenance of fairway with required width and depth could be taken up easily. Accordingly suitable river conservancy works (like dredging, bandalling etc.) and river training works is being executed. Similarly nature and extent of bank erosion, change in alignment of approach channel to terminals/ jetties also can be assessed with accurate charting.

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.

In short, adoption of modern mapping techniques facilitates improvement in safety of voyage of vessels while navigating through NWs and at the same time IWAI can plan and execute developmental activities in a methodical manner thus providing economically sustained development of NWs.

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.

Setting up of River Information Services (RIS) System

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 Dec, 2012. 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-1during the current financial year.

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.

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 onsmall 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.

Conclusion

- By adopting the modern/ innovative technologies in mapping IWAI is committed to provide and facilitate smooth and safe navigation in National Waterways
- 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.
- The accurate & improved charts of IWAI prepared by using latest surveying systems coupled with contemporary technologies provide an economically viable option for transportation leading to sustainable development of the country.

Web-Mapping and Cartography for Sustainable Resource Management

Sujata Ghosh*, PVSP Prasada Raju, J Saibaba and Geeta Varadan
Advanced Data Processing Research Institute (ADRIN), Dept. of Space, Govt. of India
203, Akbar Road, Tarbund, Manovikasnagar PO, Secunderabad – 500 009
*Email: sujata@adrin.res.in

Abstract

Recent developments in Geospatial technology have influenced the definition of cartography beyond conventional mapping. As map evolved from a product to large-scale service, cartography enters into a domain of mapping along with management, modeling and spatial reasoning. Decision makers' preference for quantitative and comprehensive map analysis revolving around socio demographic data leads to emergence of decision-maps to promote improved coordination and sharing across multiple levels.

Cartography, as the communication interface of different user/ decision makers, has evolved along with strength of geo-visualization, open source software, rigorously evolved hardware and data capturing mechanism, and a common, shareable participatory environment (example- Google-earth, Bhuban, Wikimapia, Virtual earth, Tagzania and Flickr etc). The focus of web mapping is to understand system along with its internal coherence i.e relationships between spatial objects, using the techniques of Geo-communication and new digital presentation. The accuracy of crowd-sourced data may not be adequate for all applications but are evolving towards standardization.

Combined effect of open source data/ software, web 2.0, and crowd sourcing with mash-up & APIs integrated with real time dynamic measurements, server based architectures, easier-to-use user interfaces/applications promote emergence of distributed web-services with different kind of output maps. This promotes maps being augmented in new platform like mobile phones with GPS/GPRS, which is a paradigm shift from conventional cartography. Visualization, symbolization, feature generalization, standardization in 2D / 3D cartography are new dimension of cartographic representations. This paper explores the present scenario and its evolving nature towards future direction.

I. Introduction

Recent developments in Geospatial technology have transformed map as a communication interface of different user/ decision makers. Cartography emerged as symbolized digital view of geographic realities in different medium, modeling in near real time and interface of spatial reasoning. Geospatial technology has evolved in three evolutionary phases— Computer Mapping (70s), Spatial Database Management (80s) and Map Analysis (90s). The Third phase leading to exploration of digital cartography. Initial web - mapping environment started by geo-concerned people in late nineties with geo-visualisation invoke to ask about space, time and subject towards integrated understandings of the relationships. Its major benefits are -

- *Exploration of geographic data* – organization and Integration of unstructured data into structured format (maps, tables and charts) depict powerful patterns
- *Analyze geographic information* - Focus on relationships turning data into knowledge, to make informed decisions.
- This exploration and analysis along with decision maker's preference for quantitative/ thematic map is enabling sustainable natural resource management where depiction and dynamism of natural resources can be monitored and managed in a comprehensive way through web mapping.

II. Web-Mapping - Some Insight and trends

Web-mapping is the platform /language on internet based systems and services which facilitates/ performs the task of visualizing, analyzing & disseminating space related data, functions of GIS and access to it via internet/ web. It is evolving as a distributed enterprise, service - oriented architecture and fully interoperable which makes it easy accessible and collaborative, by functionally connecting GIS professionals/ decision makers with web community.

A) Web-Mapping with Geovisualisation -

Web mapping started with Geovisualisation in participatory environment along with strength of high-resolution satellite imagery, open source software, rigorously evolved hardware and data capturing mechanism. Google earth, Bhuban, Virtual earth, Bing maps, Global mapper, Tagzania and Flicr etc named to be a few in this context. Passive way public participation is evolved into a platform for exploration, understanding, query and sharing.

- ***Google Earth*** has changed the perception of GIS to common man. This application explores the Earth as a flat 2-D image or 3-D experience along with geovisualisation functions and high resolution time series imageries. All the GIS functions done on Google Earth Enterprise Server back-end with a front end web browser thin-client having minimum functionality (main mapping interface). User's participation started through a KML and KMZ file.
- **Bhuban** is (an Indian) earth observation visualisation with IRS imageries along with government /authorized data of India for planning / development and alert. Public participation is encouraged in Indian region along with Natural resource database (NRDB) and DEMs. Interactive support provided for users to select / download data, products and derived maps (like Landuse). In future, this platform may support to augment govt data/ product for development and disaster alert (Forest fire is alerted to the concerned authorities).
- **Microsoft Surface Globe** is based on Microsoft Bing Maps *(earlier Virtual Earth)* content and technology along with windows-7. The Multi-touch pack can interact with Microsoft Surface Globe. *'Zoom into 3-D locations'* along with Microsoft Silverlight, '*Visualize location-based data'* are other functionalities.
- **Tagzania** and **Flickr** are the online photo management and sharing applications with query in the time and spatial domain.
- **iPhone Navigation** with Motion X (around Bing-maps) allows to lookup businesses and visualize demographic information on and around a respective company. For example, an insurance company can use it as an agent locator application to visualize the locations of their respective agents by putting a particular icon and photo at a particular location on the map. This will support the query "Find Agents Near You" in a particular postal code. Listed results will have link of contact information and links for directions and emailing the agents.

B) Web-Mapping - With Analysis & Editing –

With inherent strength of GIS, geo-visualisation is accompanied by processing, analysis of data and symbolizing them in ways that communicate a message. These new entities are more of web mapping evolving themselves towards data creation, editing and maintenance environment for public participation.

- The visualization focus of Google earth is supplemented by **Google maps and Google street view.** They explore the earth in terms of network analysis along with alternate paths supported by panoramic road view and roadmap, landmark, location names. This gives an idea of 2D and 3D panoramic cartography with geo-visualisation and a supporting cartographic environment allowing user the opportunity of mix and mash. Google map maker supports overview, attribute and description of the user added features along with the history of edit (temporal metadata).
- '**Open Street Map**' is a wiki-style map that user can edit. Walking Papers is made to help user easily create maps, mark them with things they know, and share that knowledge with Open Street Map.
- **Oakland Crime spotting geospatial analysis** enables user to addresses complex questions of patterns and trends, to locals on a block-by-block basis for crime analysis in space and time domain,
- **Mapzen editor cloudmate** -- POI Collector is the world's first iPhone Open Street Map editor which lets iPhone users to add and edit Open Street Map places of interest (POIs) on the iphone on the go.

C) Web Mapping With Crowd Sourcing –

The power of 'getting users to create database' in a participatory environment enables new forms of intelligence to be added to data by capturing individual knowledge of users. Collaborative geospatial Platforms are being developed for natural resource management through consensus building and conflict resolution which provide insights in –

- Understanding the threats to local/global environment, i.e species extinction and pollution.
- Conserving earth's natural resources and wildlife (conservation projects) i.e tracking wildlife, studying wildlife habitats and monitoring forests.
- Developing critical thinking skills by giving spatial perspective to theoretical learning.

Few examples of public interest and global environmental impact with mass effects are mentioned here

- Ocean Conservancy lead an international ocean clean-up effort to collect trash from and along the waters of the world, and educate people about the need to be more responsible for our impact on the planet. Nearly 400,000 volunteers collected *more than 6.8 million pounds of trash* in 100 countries.
  Ref- http://www.oceanconservancy. org/
- Algalita Marine Research Foundation has been doing analysis about the level of plastic debris in the ocean and *reporting their findings through analytical maps.*
  Ref - http://www.algalita.org/Maps_Home.html
- The National Oceanic and Atmospheric Administration (NOAA) released a report on September 16, 2009 showing global sea-surface

temperatures for August and its comparison with other months.
Ref- http://www.noaanews.noaa.gov/ stories 2009/ /20090916_globalstats.html

D) Web Mapping Components –

Distributed cloud computing, web-services, mash-ups and mobile GIS are a few that have acted as the game changers.

i) Cloud architecture*:* Cloud computing is the movement of applications, services, and data from local storage to a dispersed set of servers and datacenters, resulting a "hosted elsewhere" environment for data and services. It is not a technology. It is a concept of distributed computing, which is advantageous for data heavy and computationally demanding applications. Three characteristics defining it—

- Virtualized resources – workload allocated to multitude of interconnected computers acting as a single device.
- Dynamically scalable - can be readily enlarged.
- Acts a service - software and data are shared over web Two types of clouds are there based on their applications:
- "Software as a Service" (SaaS) - delivering an application through browser to a multitude of users/ customers.
- "Utility Computing" - offering storage and virtual servers accessed on demand by combining together memory, I/O, storage, and computational capacity.

ii) Crowd sourcing and crowd casting: Crowd sourcing is a 21st century phenomena to generate user driven (a crowd) collective data/ intelligence by receiving asserted information from individual action voluntarily or from authoritative sources with / without authoritative guarantee (bottom up approach) and is accessible / sharable as a web-based databases, services and maps. Crowd sourced spatial data collection is facilitated by devices like handheld GPS devices, digital notebooks, mobiles/ smart phones. Crowd casting is union of broadcasting and crowd sourcing with the potential crowd being 'pulled' in as a direct result of the 'push' in the form of incentive. Facebook and Flickr is example of crowd sourcing. Few market based product survey adopted crowd casting with push of incentives which can be implemented for resource monitoring also.

iii) Mashup and API - Mashup is a web application that combines data from one or more sources (including authoritative /govt and crowd sourced data) into a new interactive product, by people with little or no programming knowledge. This enhances the value of the source datasets and often originally not envisaged by source data providers. The mashup creator is freed from having to host, maintain, and update the data. An example is flickrvision.com combines Google Maps with Flickr photos to show georeferenced photos on a world map. photos or maps is not maintained at this site, except just the code to combine them. APIs provide a way for mash-up developer that interacts easily with other software without paying license fees or royalties ('open'). Example - Live Earthquake Mashup (http://www. oefiles.de/gmaps/eqmashup.html) combines US Geological Survey feed of earthquakes, with Google Maps background.

iv) Web 2.0: Some of its major attributes are Crowd sourcing, Collective intelligence (the web site / service gets better the more that people use it), web service (not an application), data supremacy and design for flexibility (users can mix and mash data). Web 2.0 have changed the web from a passive to an active experience where user can create content on the web both collaboratively and individually through wikis, blogs, podcasts, photo sharing, and other technologies. Adding geo-component with every bit of information that is feeded into the web is supported by-

- Geotag - It links content (photo, video, or website) to a set of spatial coordinates. (Example: Flickr). The content can then be found by user's location-based queries. Challenges are geospam and user dependant accuracy of content. Usage example - add a Mapplet to Google My Maps, and search/view photos for a given area
- Geowikis and Geoblog - A geowiki is a map based web application that lets users identify, create and comment/edit content on a map. For example, http://wikimapia.org uses Google Maps as the background and supports user creation and editing of places, annotate maps by adding links to local features/landmarks. A geoblog is a web page similar to a diary, that lets a user post text, video, images, links to others web sites and allows users to annotate maps by adding links including interact, read / comment on the blog entries. Geoblogs are a useful tool in tourism.and natural terrain exploration
- GeoRSS feeds - RSS Feeds are XML/HTML files publishes information out to an application like current weather alerts and news articles. A GeoRSS feed adds additional format specifications of coordinate to support tagging content with location information. GeoRSS Simple GeoRSS GML are more under use. GeoRSS feed of earthquakes at http://earthquake.usgs.gov/ eqcenter/catalogs/qs7day-M5.xml. Another example, free ACME GeoRSS Map Viewer site http://www. acme.com/ GeoRSS/ about.html takes any GeoRSS feed and maps it. For earthquakes, the web page http://www.acme.com/GeoRSS/? xmlsrc=http://earthquake.usgs.goveqcenter/

catalogs/eqs 7day-M5.xml shows the feed on Google Maps background.

v) Web Services: some sites let users create their own maps using online mapping Services (APIs combine maps with data from Geo RSS feeds), which can be hosted on user's web site*. Living Science* which is a Google Map mash up located at www.living science.ethz.ch enables user to search geographically a database of scientific papers, generally in Physics which are deposited on the open archive arxiv.org. It allows users identify how many papers of specific categories or in total have been written in different locations (countries, cities) over any period of time and subcategories are shown in cartographic forms.

Many map mashups use free online mapping service by google maps to support webpage with query of geotagged data. Other open source map services providers are Yahoo! Maps (http://maps. yahoo.com/), Microsoft Virtual Earth (http://maps. live.com/), Map Quest (http://www.mapquest. com), Open Layers (http://openlayers.org/) which offers multiple services with their own JavaScript APIs. These APIs are freely accessible for non-commercial / personal use and with some restrictions / costs for commercial use

vi) Mobile based platform – Recent evolution in new generic hardware/ software has paved the way for 'mapping' being deployed on platform like 'smart phones, ipad, tab, with integrated navigation features' for geospatial information services. Addition of 'location capabilities' to mobile Web browsers promotes active as well as passive crowd sourcing (example- twitter with geolocation) for data creation and map display with symbology. Efforts are being given to create open standard geotagged SMS messages. Crowd sourcing of data via mobile phones will generate sources of data in real time which calls for a new level of cartographic requirement in terms of scale, display and symbology. Most potential area is emergency survive and disaster management. A lot of live human sensor feeds / data is going to be available in the future and mapping is the final output of deriving patterns and correlations in interlinked web environments with a good catalogue of web based services for decision makers.

III. Cartography in Action

As map is a symbolized image of geographical reality, Cartography was defined as "representing selected features / characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance." Users understand a map in four processes including detection, discrimination, recognition and identification. In the context of recent developments, the conventional definition of cartography also evolved to accommodate a whole new range of activity and products. As mapmaking tools become more available and user friendly for non-cartographers, the potential of producing poor quality maps increased. Therefore in changing scenario major principles of cartography are looked back to understand its dimension and representation of world reality. Knowledge about graphical representation of geo-information with digital visualization tools, simplification and aesthetics are the main focus in modern cartography.

A) Map Design Principles-

Map design is a process, comprising of various stages with cartographic principles to draw an effective map. It includes making decisions about the selection of geographic features and attributes to be presented on map. The task to create a map is dependent on purpose of the mapping (representation of information), target group with their different experiences and requirements for various information (Fig. 1). The information in reality is divided into following data type-

- Nominal data on nature/identity of things (qualitative)
- Ordinal data with order, not quantitatively determined.
- Interval quantitative information

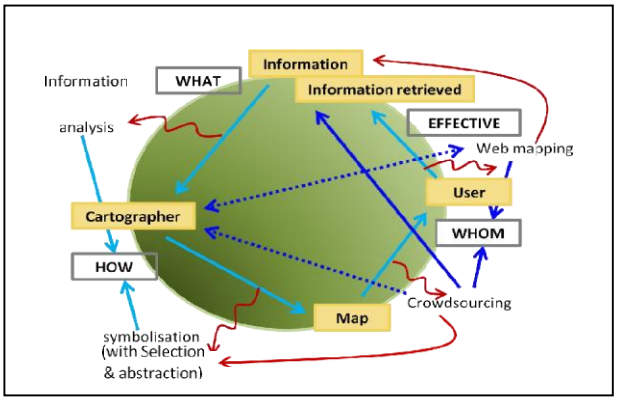


Fig. 1: Cartographic process of communication

In cartographic design, purpose of map, intended audience/user, scale of the map, its contents and amount, design, color used and entire graphic presentation are quite important for effective graphic communication and contextual understanding. Important design principles are -

- Legibility - minimal sizes for symbol and text, graphic density of map elements etc.
- Visual contrast- contrast of the object with its background and adjacent signs.
- Visual hierarchy – important aspect of visual perception which defines a kind of hierarchy in the map contents, assuming that all information is not of equal importance.
- Hierarchical organization – hierarchy between mapped features using different combinations of visual variables (i.e class of features lie at different visual levels, portraying internal

relationship of a hierarchy)

- Plainness – use of conventional rules (blue for water information), organization of hierarchies / symbols (like road classification and building types)
- Accuracy - sign accuracy as well as positional accuracy, Clearness - layer arrangement, simplicity, generalization and contrast among the map objects.
- Aesthetics - beauty and harmony for map design elements which are controlled by colour and expression. Map design is more than the design of individual symbols and more a logical process consisting of a number of steps. There are generally two broad methods that lead to flow of information and finally represent the landscape as maps
    - Data preparation and compilation
    - Cartographic representation

There are three processes that are common to all maps, reduction (determining scale), selection and abstraction of features, and symbolization. Map perception get influenced by the graphic display, (proportions in line, colour or form) which reveals three main elements – a) Harmony - ratio between the different elements and those elements, which are related to each other b) Composition - accounts for the arrangements of accents and the emphasis or weakness of the different elements/ accents of contrast c) Clarity - recognition identification of graphic elements (Fig. 2).

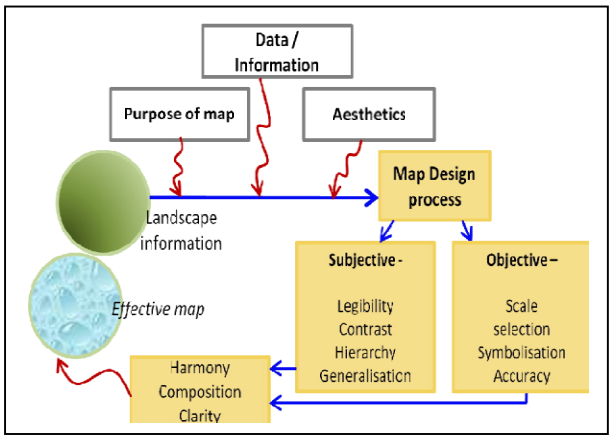


Fig. 2: Map design principles and elements

i) Cartographic Symbolisation Process– Cartographic data analysis to assess the characteristics of data is the primary step to find proper zymology. Point, line and area are used to depict reality in cartography (basic graphic elements). Few graphic/ visual variables for graphic communication on electronic equipment play the permutation combination to distinguish symbol (Fig. 3). They are - Size (large, medium, small boxes), value, texture (grain) /pattern, color (red, orange, yellow, green, blue), orientation/ Direction (rotated 0, 10, 19 etc degree) and form / shape (rectangle, triangle, circle, cross), Density (black, dark grey, light grey, white), Structure (waves, bricks, dots,…), Position (cannot be used, fixed position). The visual variable has certain perception properties, which should be matched with the nature of information to be represented. Effects of different graphic variables and associations determine the effectiveness of a map. For example, colour, an important graphic resource, is generally perceived as something to do with groupings (families) whereas lightness is perceived as something to do with increasing or decreasing values.

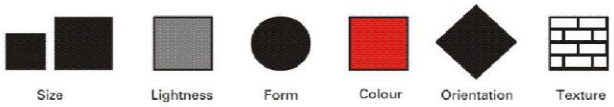


Fig. 3: Graphic variables according to Bertin (1967).

ii) *Typography-* The names/labels on the map are another important component defining its usability. The general font attributes are type style, type form, type boldness, type size, type color, type placement, and type orientation. Type size determines its legibility while type color contributes to overall tone of pages along with contrast. Map reading is significantly affected by positioning of names.

iii) *Generalisation and conflict resolution*
Generalization is process of selection and abstraction/ simplification of represented information according scale /or purpose of the map, by balancing the requirements of *accuracy, information content and legibility.* It deals with symbol conflicts and legibility in map space and requires analysing, recognising and manipulating features with geographic context. Conflict Resolution is management of the extent and placement of symbolized features on maps to improve the quality of multi-scale map display. Automation of both is needed to generate of multi-scale base maps (Fig. 4).

iii.a) *Optimization for generalization* - The optimization approach modifies geographic features based on a series of pre-defined constraints designed to clarify the display of that data at smaller scales. Examples of constraint are -a building cannot be closer than the specified distance from another building or a building cannot move too far from its original location. Since these constraints often conflict, the optimization seeks to find the best overall solution, even if the satisfaction of some constraints may be compromised, leading to making informed compromises about what to display how on a map, at each scale.

iii.b) Geoprocessing for generalization- Geo-processing is data processing component to modify existing spatial features or to derive new features. The steps can be logically chained together or looped in scripts or models to create a complex workflow that can be applied to a range of data to produce multi-scaled databases for print or screen display. A 50,000 scale

topographic map can be updated/ generated by using 1:10,000 scale topographic Map.

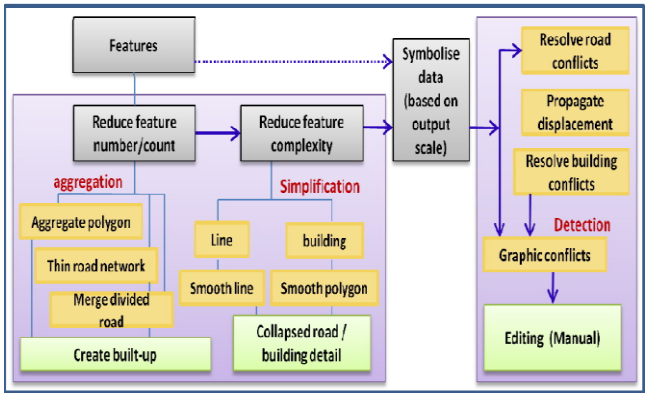


Fig. 4: Flowchart for Generalization and Conflict Resolution

B) Cartographic Adaptability in Web Mapping

Web access of user is through GUIs as a 'browser' which enables users to graphically control their operations in the web environment. Cartogaphic components serves as the interface of combining foreground information from GIS analysis providing multiscale resources, with base information like imagery basemap, streetmap with the spectrum of cartographic styles depending on particular application and type of operational data. Recent technological development has promoted "Dynamic interactive multidimensional maps". At the same time crowd-mapping cause production of low quality maps resulted in new design problems. Along with map design factors (like map content, symbols, standards etc) production cost, time and aesthetic play a determinative role in all map production processes. Modern cartography is evolved by i) Base Map of different types provided by commodity service ii) Multi-scale web mapping iv) Automated generalization v) Greater digital cartographic capabilities and vi) Evolving data sources. Although screen map design is more complicated, it has various special facilities just like interaction, animation, multimedia (audio, video and text). Besides, graphical design and symbols that cannot be produced on paper can be formed on screen with the help of the technology.

i) Topology and MRDB – Each geographic feature is stored as a record (point, line, or polygon) in a database, with a set of geographic attributes. After generalization process, the spatial relationship may be destroyed and the geographic pattern may be distorted. So it is critical to know how features are spatially related with each other and represent such contexts as topology. Topology can be modeled and maintained in database or analyzed and computed. Multiple Representation Database (MRDB), is used to store real world phenomena at different levels of accuracy and resolution, suitable for small display cartography/ screen maps. Now it is possible to add and store symbolization of a single feature to hold multiple representations, to allow the generation of different cartographic products using the same feature data by using rule. A single representation rule can re-use the feature shape geometry multiple times, passing it through one or more 'geometric effects' to cartographically enhance the appearance before invoking symbols. Overrides can then affect the graphical properties (color, width, size or style) of symbols and any of the parameters to geometric effects (offset distance, radial angle). Finally, the override field can store an alternative feature shape (display geometry) to be used just for this representation. The contextual generalisation tools can set their results into individual override fields dependent on target scale, to facilitate clear representation of multi-scale map data.

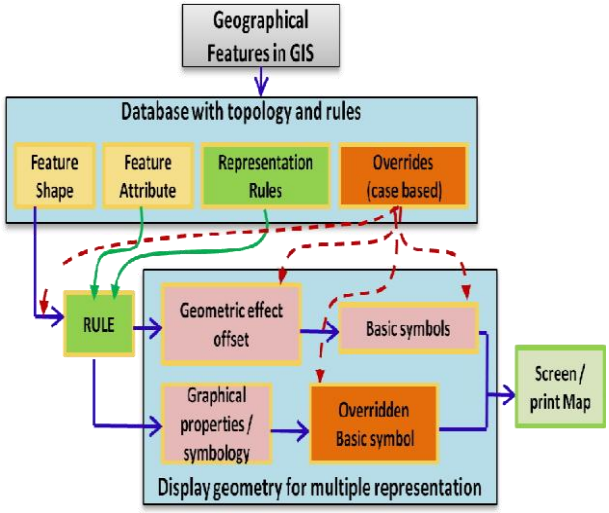


Fig. 5: Data flow and multiple representation

Creation of a range of multi-scale base-maps by automated derivation of intermediate resolutions enable smooth transitions between scales.

ii) Symbol design for digital cartography - With the reduction of map scale the representation of mapped features becomes more and more symbolic. There are point, line and area symbols and texts on a map. Symbols are designed by using graphic variables having different information characteristic and they are sometimes used in screen and classical map design differently. In classical map the symbolized features maintain a minimum dimension to get printed legibly and may no longer be measured to scale or occupy more space than on the ground (below certain scale) causing reduced space / overlap between features. Though digital cartography is linked with GIS, the key issue is cartography is concerned with representation while GIS is concerned with analysis of spatial relationships. Color selection by many GIS operators poses significant departure from standard cartographic practices. For example, strong colors used for area features, though area color has dominating effect and obstructive background for line, point and text occurring in same area. Some aspects of digital symbolsation are mentioned below -

Point symbols -

Category	Character	Nature/ used for	Digital depiction
Pictorial	Do not need legend, frequently used.	Qualitative data Quantitative data (in different size) Shape and color give qualitative characteristics	Pictograms become either illegible or big and bulky (should not exceeds 16 x 16 pixels). Limited use
Geometric (abstract)	need legend		
alpha numerical	need legend		

For small map display devices (mobile) space using simple point symbols (especially pictorial) is preferable for fast recognition with minimum size of 3x3 pixels

Line symbols –

Category	Character	Nature / used for	Digital
Main road	> one lane	Easily recognizable by shape, color Orientation & pattern not preferred for thin / diagonal line Certain font and size applied to each class	Varied by nature in length and width
Secondary road	One lane		
Minor roads	Narrows lane		

Minimum size-10 x1 pixel for small map display devices
Area Symbols -

Category	Character	Nature / User for	Digital depiction
Area object	Pattern used	Designed by color, pattern, shape & orientation Cause semantic errors, Large file size	Used carefully Transparency & shade is used instead texture Minimum size 10 x1 pixel
Data based on area	Texture used		

Minimum size of area object is 8x 4 pixels except building footprint (4x2) pixel

Background – A major challenge of balancing screen map is to keep simple and avoiding too empty areas. This is supported by satellite imagery / digital ortho - photos (background), which prevent "dead" areas (not suitable for small screen map)

Lettering - Readability, legibility, harmony and a distinct visual hierarchy are major requirements of the lettering of a map. Existing rules and conventions doesn't produce good result on screen map because of display resolution and scale. Screen map requires 'Label features' with a shadow around text to discern it from background color map (increase file size). Smallest readable text on the screen is 10 pts. Lighter color for the background and darker text is preferred on small screen map. Visual hierarchy between the lettering of different elements can be established by elements of certain sizes and styles. Few fonts are designed specifically for the screen. *Sans serif fonts* (like Verdana or Tahoma) are more legible in small scales on the screen than antiquas (Times). Again horizontally applied letters look different from sloping and slanting letters along features. In digital map lettering can be switched on and off, according to shifts in theme or scale. "Pop up" labels or spoken "labels" by using voice as a variable instead of texture other options. Viewing distance affects the text size and font too and is an important factor for digital map in small screen.

Color – Bridges the map features with real objects by using natural colors and makes map more understandable Few issues on colors for screen map are – dependent on graphic card, screen resolution and other hardware quality of computer it is displayed

Contrast- Different information should be visualized based on their importance level. Symbolizing maps need to be done with users color choice and moreobvious for small display cartography with poor screen resolution. Optimal amount of color should be used here.

Level of detail–Determination of detail on a map is a function of the map scale. On a digital map, the user can control the data density without the need of generalization. On print maps, different scales imply different levels of generalization of the map contents. These anomalies need to be understood and implemented. A suitable design of the symbols, their hierarchy, similarities and differences relating to the real world features and their arrangement on map with entire map layout are a prerequisite for an effective web map

C) 3D cartography

Cartographic principles of designing, guidelines and representation as 3D maps are in a nascent stage. Usefulness of a 3D map can get affected by different levels of detail and abstraction, depth perception and a constantly changing scale, problems with generalization and defined 3D symbol. Data quality and accuracy plays a crucial role in 3D Map design and symbology along with viewing angles and illumination. Design aspects of 3D Map is mostly focused on two main aspects - abstraction and dimension. Within each step of design process modeling, symbolization, visualisation has to be given priority (Haeberling, 2004),

Sl. No	Design steps	components	Process/
1	Modeling	Modeling of digital terrain model objects, (topographic) map objects, orientating map objects	Handling, converting and merging of different topographic/ thematic data and image data (DTM, vector-based data, raster-based textures)
2	Symbolization	Graphic appearance, Special graphic aspects, Textures, Text objects, Object animation	- Graphic attributes added to single objects - Changed in shape, size, color, brightness, texture - Added sharpness and transparency.

3	Visualization	Perspective (projection), Camera (viewing), Lighting, Shading and shadow, Atmospheric effects and natural	- 3D model display with perspective on screen - Cartographic objects appear to user by projection parameters and interaction of lighting/ shading effects

Abstraction aspect in 3D map

No	Abstraction	Components / benefit
1	Map-like symbolization	- area and linear map objects - familiar and well interpretable 3D map
2	Volumetric3D symbol	improve the perspective perception
3	Point 3D symbols for	- consist of simple geometric shapes - image-like representations
4	Topographic map objects	- natural-realistic appearance - Need to be photo-realistic
5	Structural patterns	- useful textures for area map objects - not too dense and fine. - exhibit good color contrast to terrain.

Dimension aspect in 3D maps

No	Dimension emphasis	Components / benefit
1	terrain character	Exaggeration of digital elevation model.
2	size of topographic map objects	Identified in the foreground and background.
3	Size of linear/point object	Should not cover much of the terrain.
4	size of map objects	Should not hide much of each other.
5	Point map objects	Sized larger than linear or area map objects & appearance not be dominant

Other aspects

No	Aspects	Components / benefit
1	Camera	inclination angle of 45° (average) is preferable
2	Lighting	mainly come laterally or slightly from ahead
3	Atmospheric effects	neutrally colored model background without sky structure haze effects improves the depth perception

Principles on Symbol Sizes also indicates that effective size of symbols, line width, or height of an extrusion effect of area map objects can be defined based on the map's purpose. The terrain exaggeration factor depends on the character of the landscape cannot be defined by numbers). 3D modeling software, such as Google Sketch-UP, are now freely available to non-cartographers for developing regular 3D images, sketches, models with texture drapes. These can be incorporated in 3D mapping environment with coordinate tagging. The Special Interest Group 3D (SIG 3D) have developed a standard for 3D models, called City GML, that builds on the GML 3 standard. It is a language designed for the storage, representation and transfer of 3D geographic information in complex and three-dimensional geo-referenced models and determines geometric and appearance information. But 3D maps elements such as symbology, annotations and perception, are still up to individual (Fig. 6).

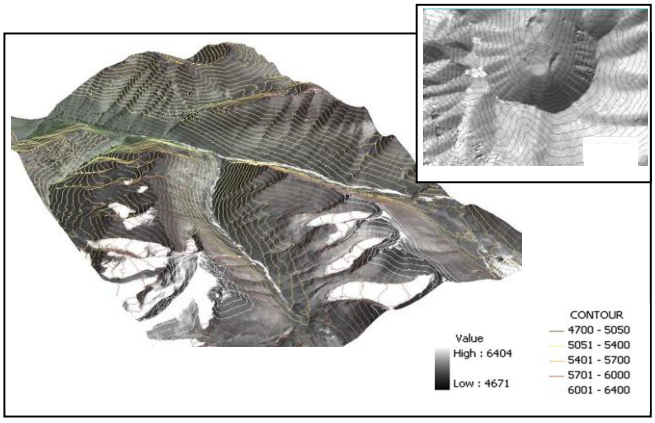


Fig. 6: 3D cartography (6a) and 2D Cartography (6b)

D) Mobile Cartography –

The latest wireless equipment is delivering end users an impressive array of new features, services and applications. Mobile cartography deals with methods and technologies of dynamic visualization and mobile usage of spatio-temporal information as well as the adaptation to this mobile usage (i.e. to the situation, specific characteristics and activities of the mobile user). Visualisation of geo-information on mobile devices is controlled by a) mobile devices, b) mobile communication, c) positioning technology, and d) mobile usage situation (a and c plays crucial role).
Device - Information appliances, personal digital assistants, mobile phone (Smart-phones) with GPS receivers, GSM card, digital cameras etc acts as main device. Mobile device position, are determined by network-based or a handset-based positioning technology. In a network-based case the device needs to be subscribed to a mobile radio communication network. Calculated position is used by the operators. Cell Global Identity (CGI) is needed to guide the phone calls to the cell of individual user location. In the case of handset-based positioning the device holds a sensor (mostly GPS receiver) for position determination. The position is independently calculated in the device itself. This might be important concerning privacy and security issues.

In the context of web mapping user's activity is linked with geo-information-need during mobility and real time which is different from stationary environment as different tasks/ contexts. For mobile cartography it will be crucial to select different modalities. Different user groups differ in their knowledge, information needs, quality requirements, skills, activities (like professionals need analytical functions, data capture and editing functions, and complex visualisation Other users desire more explorative functions, visualizations, Tourists would appreciate multilingual support and multimedia. Apart from context to enhance response time and user characteristics, time has to be integrated in the analysis process for time-critical applications.

Mobile Scalable Vector Graphics (Mobile SVG), a new imaging standard adopted for Multimedia Messaging Services (MMS), is playing a pivotal role in bringing vibrant graphics and images and presentation of spatial information to mobile devices. The Mobile SVG profiles, SVG Basic and SVG Tiny, define XML grammars for describing resolution-independent two-dimensional graphics on mobile devices. This has some advantage over raster format in mobile environment-

- Small file size

- No detail loss while zooming; better text readability

- Open format; XML based; transformable

i)Structuring SVG documents – Structuring allows decomposition of a mobile map into several single SVG documents, including structure of unique or layered elements in one single SVG document. The approach is –

- Separation of the spatial information into two groups- the base map including the geometric reference, (e.g. buildings, major roads, rivers etc) and a superimposed layer of information that will be changed more often and maybe dynamically (e.g. point of interests, routes, point symbols, text/labels).
- Base map and the dynamic maps are stored in separate SVG documents. The dynamic SVG document(s) are then referenced by the base document. In a single SVG document the structure affects order, grouping, and reusability of elements. The order of elements in document has major impact on visualization, which will paint the elements as per the appearance order (rendering principle).

Adaptive functions to user needs include the selection of appropriate language for GUI and map content and map style. This can be achieved by use of different pre-defined style sheets, storing point symbols in database and attachment of appropriate symbol to the SVG document.

ii) Cartographic design for small-display devices

Mobile devices, a part of multi-media (e.g. vision, audio, tactile) cartography, are characterized by high portability, low-resolution, small screens, limited memory storage and low processing power.



Cartographic transmission of information

Cartographic transmission requires design and development of new kind of specialized cartography for small displays. Some ideas / principles for mobile cartography applications:

- Four layers of stacked symbologies – each one containing exclusive element in particular color - Text (black), Navigation elements (yellow), Points of interest (Red), Map background in colors (excluding, black, yellow, red).
- Fewer details and scale based display of details
- Display in pictogram-like symbols
- True type font without ornamentation (aerial, calibri, Tahoma etc)
- Adopted to SVG-specification as a precondition
- Context as reference - street names, place names and other object names e.g. names on a rail station, bus stop with geo-referencing /geo-tagging
- Sequence of layer stacking –text elements layers be on top

Designs of symbols in mobile cartography are accordingly affected by graphic support, device resolution and average viewing distance. For example the sizes of point symbols are handled in SVG-specifications as width and height. Patterns and structures are supported by raster-images. By traditional rule minimum size of a point symbol at a viewing distance of 50 cm is .3 mm or minimum 3 pixels, whichever is higher. This limit would be higher when other features are present on map. Minimum width of a line that can be drawn is .25 mm that is legible at a distance of 25 cm.

E) Issues of web mapping and web cartography

Crowd mapping poses challenges to the professional authorship and normative ontology of cartographic representations. The issues of web mapping are summarized below-

- *Variable mapping quality* - undermines the credibility and authority of the whole map. There is no easy means of judging. Concerns relate to the evenness of coverage, consistency and accuracy of content and metadata, along with ongoing commitment and sustainability
- *Open authorship* - need a degree of centralized command and control for purposes beyond check, correct and assure quality of authorship. In centrally organized cartographic surveys by the state, authorship is consciously rendered anonymous by diverse skilled people for data collection, checking, processing, drawing, labeling, deleting, and designing. In web mapping cartography is polyvocal in authorship and genealogy of author contributions, collaborations and conflicts are publicly recorded and open to scrutiny.
- *Knowledge variation* – Nature of geographical knowledge is varying with respect to authorship, the ontology of place, the partiality of representation and temporality of production.

- *Ontology* – In crowd mapping the ontology is collectively and openly negotiated. With a diverse range of crowd mappers contingencies and selective interests not embodied in ontological decisions. For example ontological constitution of *Google Maps can be defined by company* GI experts, database specialists, interface designers and business managers, along with the various contracted data suppliers concerning what about the world should be mapped. There are debates about naming conventions and what features in different parts of the world should be recorded and tagged (such as physical characteristics or its legal status), which is tied with politics of display and aesthetic conventions.
- *Partiality of representations*--Crowd mapping projects are a 'work in progress' and susceptible to partiality of *all* representations of place. Conventional top maps, assert the propositions of completeness and universality. Open API and free availability of the complete map database allows very different designs and presentation, which support various comparative interfaces can present side-by-side or overlay different dates of OSM/other map data. In contrary cartographic information is constrained by the parameters of capture technologies and filtered through the cartographer's choice of importance. The degree of precision varies across device, geographic context and user proficiency in web mapping (example – GPS use).
- *Temporalities of production* - The 'mapping' happens through time but conventional cartographic representations tend to deny its temporality (e.g., a single date/ year for print publication) and portrays a static world in which dynamic, unpredictable processes are either ignored or frozen at specific time (property is preferred over humans) Open source mapping allows penetrating in individual spatial objects to see its complete genealogy in terms of authorial history and temporal emergence (like first appearance, history of edits etc) and thus connect the viewing to the making of the space. The patterns of temporal emergence can be rendered which may include periodicity of large-scale change, durations, sequences, gaps in editing.

IV. Towards the future

The future of natural and demographic resource management and decision making in is collaboration between government and people with a mutual platform and participation.

- Web mapping is a paradigm shift of data creation and editing. Web mapping in the form of crowd-mapping will take some more time to evolve with necessary symbolization, accuracy standard, metadata and authorization process.
- Geospatial problems, systems, and services for citizens existed in India are too large to build the infrastructure for. Software/ service maintained at single place, with the ability to scale and overflow to the cloud as needs demand and shrink back down to baseline as they retreat, will become a sought after deployment model for citizens services and decision making
- A real-time multimedia view world is available now. A new dimension is location sensing along with the ease of availability of Wi-fi, UWB and GPS etc. Location based services along with smart grid will become a reality for storage, demand response, intelligent device and control system etc.

A) Challenges in Indian Context

Major challenges in implementation (Indian context) –

- How to capitalize on the massive volumes of geospatial data that already exists within various agencies and better coordinate the technology platforms on which they reside.
- Standardize the properties of the data and make them accessible by those who need them across the Web.
- Make sure people can trust the data going out of government Web sites
- How do we bring potential users for crowdsourcing
- Accountability tools will become an important added dimension of the future of geospatial information
- Data-ownership, sensitivity, privacy continue to be an issue.

B) Examples of Resource management

Inspite of existence of sophisticated GIS tools and high resolution data, a good part of the world remains poorly mapped in terms of topographic survey knowledge. Where ever topographic map exists it merely depict recent features, natural resources except a few countries where govt initiations are playing a major role to check, update and refine existing maps. Web mapping and crowd sourcing initiated by Google and other companies now work on 'spot errors' and fix the map by volunteers, through a centralized editorial command and control to assure quality of data and authorship. Few examples of crowd sourcing and government efforts with mass effects are mentioned here-

i) As part of the Obama Administration's Open Government Initiative, a Geospatial platform will provide user-friendly, integrated data collections and map-based tools from federal, state, regional, local and tribal governments, as well as non-governmental contributors. The content of all datasets and services with the Data.gov have been verified by the Agency to be consistent with Federal privacy, national security, and information quality policies. The platform is tied to

Data.gov, the public portal of online Government data depository, a substantial portion of the data now available on the site comes from existing geographic data catalogues. Data will reside with the agencies that created it, which is where it is most accurate, and shared via the platform.

ii) Another example is by US Defense Department in project Pacific disaster center by creating a Disaster Aware platform. It monitors continuously information feeds from meteorological and geological agencies and delivers information and alerts in real time to subscribers. Users can share analyses and situation reports and can query the underlying databases of Disaster Aware, which has a presence on Twitter. The system has been ported to iPhones and iPads and planning release an Android version. Backend components are ArcGIS server, and java applications

iii) Geo- Wiki demonstrates the use of Crowd sourcing to validate data and improve database. Geo-Wiki Project is a global network of volunteers who wish to help to improve the quality of global land cover maps. Since large differences occur between existing global land cover maps, current ecosystem and land-use there is a lack crucial accurate data. Volunteers are asked to review hotspot maps of global land cover disagreement and determine, based on what they actually see in Google Earth and their local knowledge, if the land cover maps are correct or incorrect. Land cover datasets are crowdsourced via a Web Map Service (WMS). Their input is recorded in a database, along with uploaded photos, to be used in the future for the creation of a new improved hybrid global land cover map (Fig – 7).

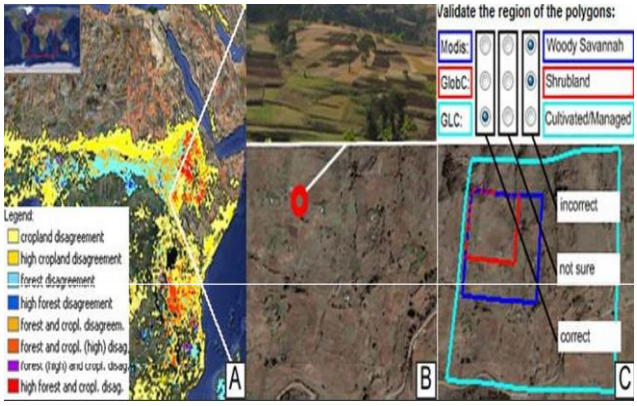


Fig.7: A snapshot of the GUI of geo-wiki validation project

iv) The Gulf of Mexico Oil Spill was one of the worst environmental disasters in recent times. Mobile Crowd sourcing plays a crucial role for collecting geospatial data in the field to record the extent and severity of the Spill. People voluntarily record incidents, capture images and video, and blog on conditions in real time and it is used to prioritize sparse cleanup resources. The reports were submitted from cell phone, web form, SMS or MMS, e-mail, twitter. A central organization was responsible to create reports, mark oil damage locations, add comments, submit photos & video which are sharable in web. Mobile applications and website is free for access to the public.

v) In emergency response situations open and real-time spatial data can be collected involving crowd along with data fusion for integrating information from a wide variety of sources. Recently crowdsourcing is helping to map the infrastructure and devastation caused by natural disasters in Haiti and Pakistan.

vi) Bhuvan started playing pivotal role in good governance, sustainable development and citizen empowerment in Indian subcontinent with an aim to provide nationwide, standardized, seamless and most recent GIS resources of India. Few examples which are associated with Bhuvan are mentioned here-

- Potential disaster information disbursing like Real time Tropical Cyclone Heat Potential (TCHP) is also made available for download. Recent flood inundation of Assam and Bihar can be Visualize in Bhuvan.
- National urban information system (NUIS) database of 130 cities (1:10,000 scale) can be viewed by Selecting the Theme “Urban Land Use (10K): NUIS” (Fig. 8)

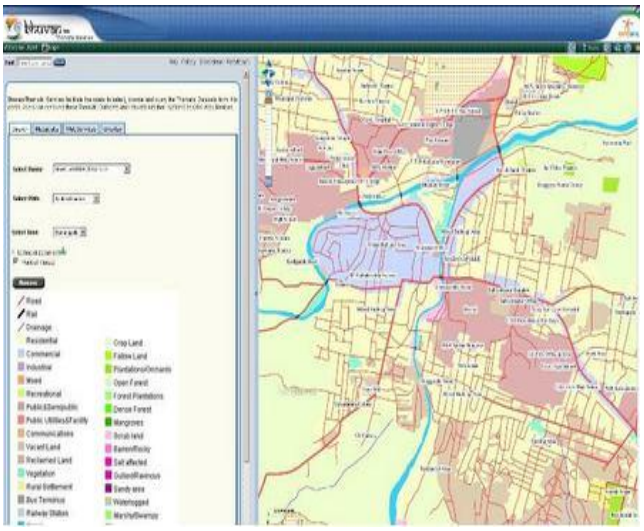


Fig. 8

- Indian satellites open source data archive (NOEDA) will facilitate users to free download of coarse and medium resolution satellite data/ products to users including Cartosat DEM natural resource monitoring and management. Same site started offering derivative products like Vegetation Fraction and NDVI, are depicting ground changes in vegetation and forest covers.
- Tourism Web GIS for Amritsar town is released under Bhuvan Projects towards spatial Mashup, in collaboration with state centers, which is supported by quicklink (Fig. 9)



Fig. 9

V. Conclusion

The process initiated with geo-visualisation for integrating GIS and web mapping is now waiting for cartographer to resolve the existing conflicts in new emerging fields of cartography and define its future course. Defining the set of principles and design guideline for 3D cartography and mobile cartography need to be formulated to generate informative representation benefiting map user and decision makers for resource conservation, management and sustainable utilization

Acknowledgment

The authors are thankful to Smt Archana Mahapatra, ADRIN for providing the High resolution Carosat DEM for exploring different aspects of 3D cartography.

References

1. A. T. Crooks1, S. Wise2, "*Modelling the Humanitarian Relief through Crowdsourcing, Volunteered Geographical Information and Agent-based modelling: A test Case – Haiti"*, 2011
2. Andrew Hudson-Smith, Michael Batty Andrew Crooks, and Richard
3. Milton, *"Mapping for the Masses: Accessing Web 2.0 through Crowdsourcing"*. UCL working papers series- (Paper 143) ISSN 1467-1298, 2008
4. Rajinder singh negi *"cartographic visualisation for mobile application"* submitted to international institutes for geoinformation science and earth observation science.
5. Christian Ha¨berling, Hansruedi Ba¨r, and Lorenz Hurni, *"Proposed Cartographic Design Principles forv3D Maps: A Contribution to an Extended Cartographic Theory"*
6. *Cartographica (Volume 43, issue 3) pp.175-188* doi: 10.3138/ carto43.3.175 , Institute of Cartography / ETH Zurich / Zurich / Switzerland
7. *"Geographic inquiry: thinking geographically"* (2003). ESRI's schools and library's program available online at www.esri.com/k-12
8. Kienberger, S., F. Steinbruch, et al. "*The potential of Community Mapping and Community Integrated GIS: A study in the Sofala Province, Mozambique"*. 10th International Conference on 'Information & Communication Technologies (ICT) in Urban Planning and Spatial Development and Impacts of ICT on Physical Space', Vienna University of Technology, Austria, 2005
9. KMS, National Survey and Cadastre - Denmark/ Flemming Nissen, Anders Hvas, Jørgen *" Small display cartography" on GiMoDig"Project* Münster-Swendsen and Lars Brodersen, 2003
10. Michael Battya*, Andrew Hudson-Smitha, Richard Miltona and Andrew Crooksb, *"Map mashups, Web 2.0 and the GIS revolution"* on Annals of GIS Vol. 16, No. p1–13, March, 2010
11. Michael Batty et al , Suchith Anand et al, "*Data mash-ups and the future of mapping"* on 'Technology and standards watch', 2010
12. Paul Hardy *"Multi scale cartography: maps tools and models"*, ESRI
13. Peter Jackson, *"Thinking Geographically"* conference on Geography, volume 91(3), pp 199-204, 2006
14. Peter Batty *"The geospatial revolution"* Keynote Lecture delivered at AGI GeoCommunity, Sept, 2009.
15. Sujata Ghosh, PVSP Prsada Raju, J Saibaba, Geeta Varadan*"Cyber GIS and Crowd sourcing-a new approach in E governance"* Map world 2012 Conference , New Delhi, January, 2012
16. Sujata Ghosh, PVS Prasada Raju, J Saibaba (2010). *"Geo-visualisation and collaborative GIS-an emerging trend in public participation".* Paper presented in 'National conference on digital geography' Hyderabad, January 22- 23, 2010.
17. Todd M. Pierce, Greg Dobson, Mark Phillips, " *GIS Mash-Ups on the Web Using Google, ESRI, and Open Source to Develop Weather and Climate Applications for the Web,"* in Proceedings of GITA's 2009 Geospatial Infrastructure Solutions Conference, Tampa FL. 19-22 April.

Urbanisation and Resultant Depletion of Water Bodies in Tollygunj Ward, Kolkata Municipal Corporation: 1935-2010

Sreetapa Nandy
Research Scholar
Department of Geography
University of Calcutta

Abstract

In a crowded city like Kolkata, urban water bodies are highly vulnerable. At the same time, here the need for land is always a prime focus. The filling of the water bodies for this purpose has been pernicious practice by the property developers as well as poor marginal people like slum dwellers. The present study highlights the change in area and number of water bodies as well as the problems resulting from such loss in the Tollygunj Ward (Ward No. 94) of Kolkata Municipal Corporation area.

Introduction

Water bodies are used both for storing and supplying water to a community. They help in preserving urban ecological balance. They also help to create micro-climatic regions, which in turn reduce the urban heat island effect over the surrounding area. Water bodies play a significant role in regulating the movement of water within watersheds as well as in the global water cycle. They are helpful in recharging ground water. Not only that,water bodies are directly related to flood control. They facilitate water purification and sediment retention.Urban wetlands are often used for pisciculture. Finally, these water bodies are also important for scientific research, recreation, tourism, their cultural and heritage values, landscape and aesthetic values.

TABLE 1: Role of ponds in Urban and Peri-Urban areas

Urban Environmental Components	Activities	Description
Water Resource	Bathing	A large number of people from lower economic background use them for bathing.
	Washing	Washing of clothes, utensils and other domestic requirements.
	Rainwater Harvesting	Act as rainwater storage and ground water recharge.
Environment	Climate Control	Ponds affect local micro-climate, making it cooler and soothing.
	Open space	Ponds offer open space providing room for air movement and also space for recreational use.
	Trees	Generally the pond banks have tree plantations, preserving urban nature.
	Aquatic Ecology	Ponds support many aquatic and other species, a receptacle of biodiversity in urban context.
Economy	Fish cultivation	Source for local employment and good protein.
Social	Community Gathering	People spend time sitting around these ponds. Many ponds have seats around them and are important venues for local community gathering.
	Clubs	Because of open space, there often exist many clubs by the pond side. These clubs also manage the ponds.
Culture	Temples	Many ponds have temples by their sides. Temple authorities also manage some ponds.
	Holy ponds	Some ponds have a history associated with them and/or are related to some shrines and are considered as holy ones.
	Fair	Due to the presence of temples, fairs are organised in the open spaces adjacent to many ponds.
	Immersion	Immersion of Idols is an important event related to Hindu festivals. A number of ponds are specifically used for that.
Safety	Fire Extinguishing	In congested urban areas, ponds are very useful as a source of water supply for extinguishing fire.

SOURCE:Ray, M., 2010: *Old Mirrors: Traditional Ponds of Kolkata,* Kolkata Municipal Corporation, Kolkata.

The present dissertation scheme proposes to identify the water bodies of ward no.94 (Tollygunj area) and trace their evolution during 1935-2007 periods in G.I.S. platform. The work also highlights the waterlogging problem of the area.

Previous work

Information about the status, use and the impact of the water resources of Kolkata is found in the works of Ghosh (1991). He also has appraised an extensive work on the changes of the water bodies for Ward nos. 101 to 141 of the Kolkata Municipal Corporation area. However, no extensive work on changes in urban and peri-urban water bodies has been attempted before in the time span and resolution envisaged in the proposed scheme. The only work about the description of the water bodies was carried out by Ray (2010). He mainly dealt with the traditional ponds of Kolkata – their location, water quality, significance and the religious and cultural myths related to them. The environmental aspect is also emphasized in his work.

Methodology

The paper concentrates to identify water bodies from maps, space photos and satellite images of four different years in a RS/GIS environment. The maps and images used for comparison in number of water bodies are: Survey of India map of 1935 (1/21,120), a Corona space photo of 1967 (Resolution: ~2 m), IRS-P6 L4mx + IRS-P5 PanA image of 2007 (2.5 m) and a mosaiced Google Earth image of 2010 (~1 m). Firstly, large scale 1935 scanned map has been geo-referenced according to their graticule values and subsequently other maps and images without graticules are also geo-referenced in respect to the previously referenced map. The water bodies were identified by digitising their perimeter pertaining to every mapping/imaging year. Ground survey was done using Total Station and Global Positioning System to prepare elevation profile of the study area and lastly maps and tables showing the decrease in number of the water bodies were prepared.

Objective

Themain objectives of the present study are:

- To study and explain the alterations in perimeters of water bodies in the study area by mapping on the basis of the four survey/imaging years:1935, 1967, 2007 and 2010.
- To prepare a database of such change;
- To assess the relationship between urban water bodies and problem like water-logging;
- To identify the major problems related to the water bodies and to find out solution to these problems.

Study area

The present study area, (22°29'18"N-22°30'05" N and 88°20'51"E- 88°21'50"E), Tollygunj ward (ward no. 94) is located within the boundary of the Kolkata Municipal Corporation (KMC) area (Fig. 1).Tollygunge is named after Major William Tolly, who in 1775-76 started a project to excavate and dredge the Tolly's Nullah (Adi Ganga) as a passage for the people of East Bengal to Calcutta. He was also granted a license to collect tolls from the passing boats and permitted to open a 'gunj' or market on the eastern bank of the nullah (small channel/creek) by the British East India Company.

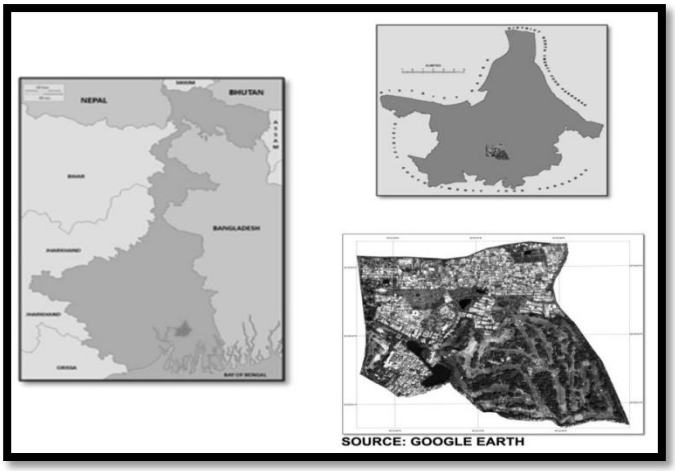


Fig. 1: Location map of the study area

The development of Tollygunj was somewhat associated with the settlement of the Tipu Sultan's family from Mysore. In 1792, after Tipu Sultan surrendered, his sons arrived in Calcutta and were given accommodation in this area.

The area of the ward is 1.39 sq km. and the area is bounded by Prince Anwar Shah Road on the north, Netaji Subhas Chandra Bose Road and Graham Road on the south, Deshpran Sashmal Road and Graham Road on the east and Prince Golam Mohammad Shah Road on the west.

Results

The present study area (ward no. 94, area: 1.39 sq km) shows progressive reduction in number and areal extent of water bodies with the introduction of high rise urban structures (Fig. 2).

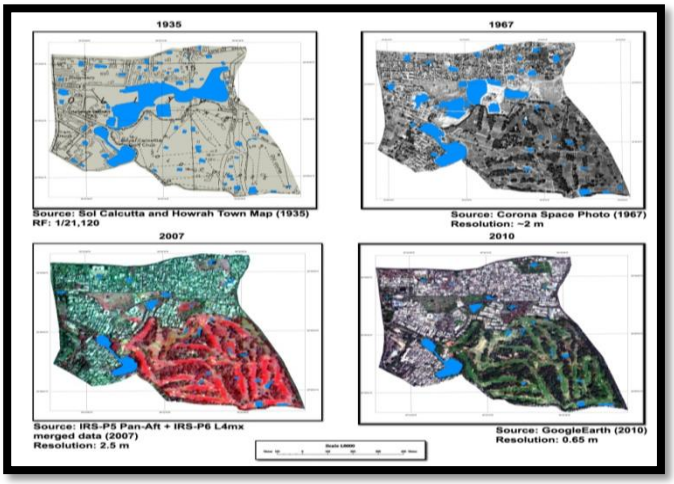


Fig 2: Change in water body areas: 1935-2010

Table 2: *Change in area and number of water bodies (1935-2010)*

YEAR	AREA (in hectares)	NUMBER OF WATER BODY	AREA OF WATER BODY (in hectares)	% OF WATER BODY AREA TO AREA OF THE WARD
1935	139.12	56	24.11	17.33
1967		28	14.49	10.42
2007		11	4.16	2.99
2010		8	3.93	2.83

As this area is fast getting urbanised, the number of water bodies are decreasing at a faster rate. In 1935, a large number of water bodies, having a total area of 24.11 hectares were found which covered 17.33% of the total ward area. There was a huge deterioration both in number and area of water bodies within 32 years. The number reduced to 28 and area coverage to 10.42 hectares, showing a reduction of 40% in respect to 1935. In 2007 and 2010 water body area decreased 71% and 6% respectively. The advent of urban structure and high rise buildings in the area has resulted into such decrease of water bodies, having an area of 4.16 hectares and 3.93 hectares respectively in 2007 and 2010. The water bodies covered only 2.83% of the wards total area in 2010. Thus, there is a reduction of total 81% of the water body areas in the span of 1935-2010 (75 years) as shown in Fig. 3.

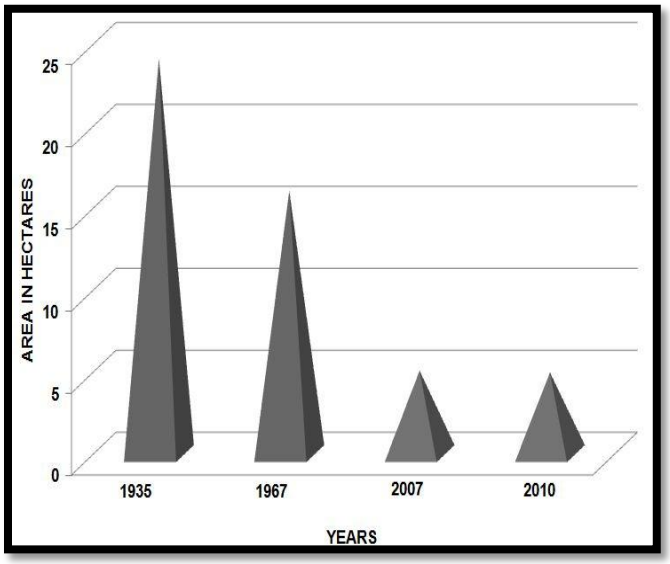


Fig 3: Changes in areas of water body: 1935-2010

Profile characteristics

A number of cross profiles are also drawn on roads as well as remnants of old water bodies to get knowledge about the change in the relative height of the study area. The profiles indicate that average height of the paved surfaces and the floor of the existing water bodies vary around 8.1 m and 2.9 m respectively. As a major part of the area, previously under large water body has now being reclaimed to construct buildings and therefore elevated using various land fill materials.

The calculation made with the difference in the area of the water body present in the past and the ones present today and the difference in elevation, the total volume of material used for landfill can be calculated. As there is no evidence of any new depression zone, it can be assumed that these water bodies are filled up by non-indigenous materials.A thorough survey of the area reveals any new water body is not excavated(Fig. 4).

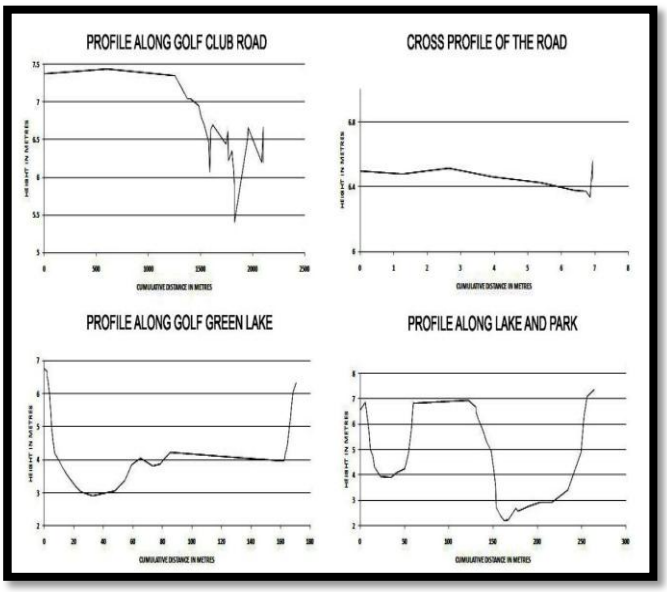


Fig 4: Profiles drawn in the study area

Discussion

The study shows a drastic shrinking in number as well as areal extent in water bodies in the study area within a period of 77 years (1935-2012). In earlier times, water bodies were primarily associated with rural settlement. With the growth of rural settlement, water bodies, mainly ponds, were excavated as it was much easier as well as less risky than excavating wells. In low-lying flood-prone areas, water bodies are often excavated and these excavated materials are used to rise up residential lands. Often these water bodies are used by the locals as a community asset. Water bodies can also be used for pisciculture, which again offers an alternative employment for the villagers. They also provide food for the people.

Primarily, Tollygunj area was a rural- semi urban place with a large number of water bodies till 1967. But due to augmented urban development and constructional activities the water bodies shrunk in area and number. With the increase in population and need for high rises, the decrease in water body areas becomes a widespread feature of the area. A large number of high- rise buildings were being constructed since 1970. Due to lack of proper urban development planning, these buildings were constructed by filling of the water bodies of the area and this has led to problems like loss of water sink aiding water logging situation in some parts of the ward in monsoon season.

Problems and its Management

The present study area is very much prone to water logging in monsoon season *(*Fig. 5*).* The problem is more acute in recent years. The main reason is human intervention and recent urban renewal. As the population of the study area started growing uncontrollably between 1967 and 2007, the land use pattern changed drastically. More area got impervious due to construction of paved roads and filling up of water bodies. This resulted into a gradual obliteration of water sink and change in urban hydrology from gradual rising discharge to quicker and higher peak flow. The problem is aggravated by the age old drainage system which can in no way support the increased pressure of recent urbanisation and associated activities.The existing drainage systems are not maintained properly due to financial constraints. Drainage system gets blocked due to silting, dumping of waste material at the inlets of drains, encroachment over natural drainages, water bodies and so on, which often cause water logging in the concerned area. The sharp peak discharge of flood hydrograph due to intense rainfall many a time crosses the drainage capacity of the system resulting in stagnation of water on roads and open areas resulting in urban water logging.

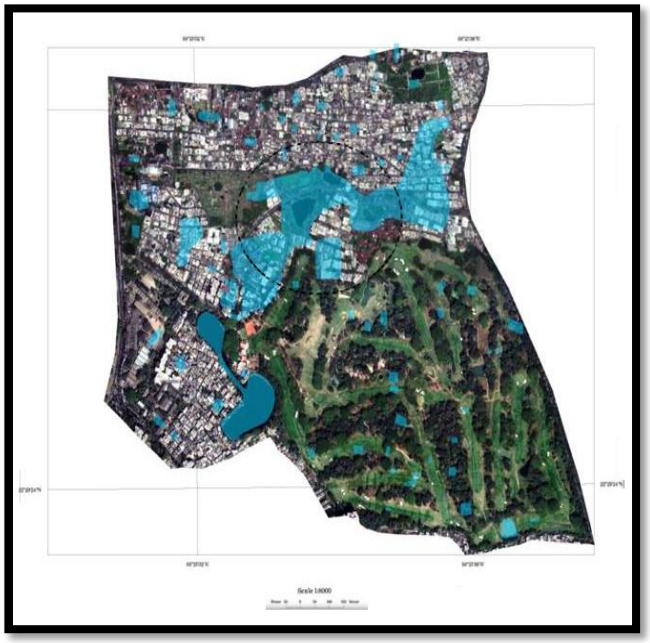


Fig 5: Water logged areas of the study area

Regular maintenance and clearance of the water bodies as well as drainage system, both manmade and natural are therefore needed to lessen the water logging problem. Proper waste disposal and practice of rain water harvesting are useful to combat the problem of water logging. Last but not the least, human consciousness about the serious consequences of filling up of water bodies and blocking the drainage system is very important to resolve this problem.

Conclusion

Tollygunj area has experienced a change in urban landscape since early 1970's and this has led to the waning of a huge number of water bodies, which seemed to be the most vulnerable parts of the ward. The shrinkage in water body areas has resulted in water logging problem in some parts of the area in monsoon season. Thus the problem can be avoided with proper urban management plans to rejuvenate the natural drainage system of the area and the conscious participation of the local people.

References

1. Ghosh, A. K., 1991: Ecology and Environment of Calcutta, *Calcutta's Urban Future,* Government of West Bengal.
2. Ray, M., 2010: *Old Mirrors: Traditional Ponds of Kolkata,* Kolkata Municipal Corporation, Kolkata.

Sprawl of Indore City and Deviation from its Development Plan

Manish Pandey, Dr. Arti Kamediya and Dr. Devendra Kaur
Govt. Art & Commerce College, Indore

Introduction

Indore has an excellent history of planning it was started from the reign of Maharaja Tukoraoji Pawar when the planner Patrick Giddens came to Indore and planned sewage roads and old city according to him- "City Planning is just like curing the disease of living bodies" After this the trend of city planning got popular and was identity of city. The planning city of 2021 is a broad image of planned area of 1975. In year 1982 by coming of CAT the migration towards city was started. Migration process got intense after establishment of IIM, University advance departments, IIT and different kinds of professional centres and employment centres in city, and this process created a pressure on its resource and city, so it is not possible to control the development according to the planning boundaries which is main reason of deviation.

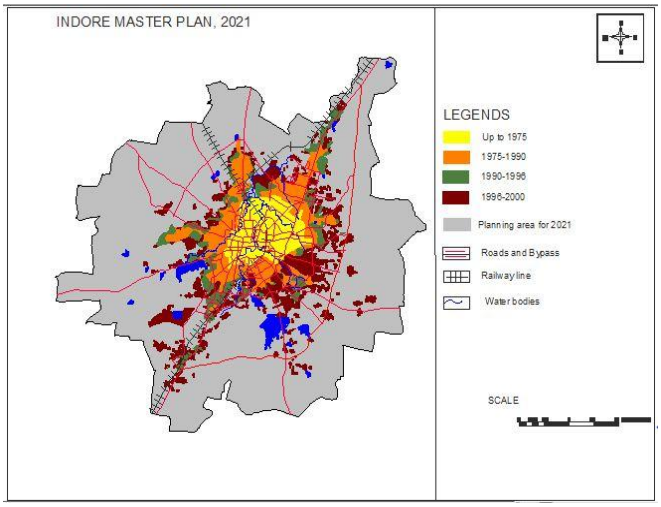
Objectives

- The analysis and measurement of development between two master plans and finding of its present situation.
- To make predictions of planning and possibilities in near future by evaluating present development.
- Making of urban sprawl maps by satellite data.
- According to master plan 2021, identification of "Most developing" and "Non developing" zones.

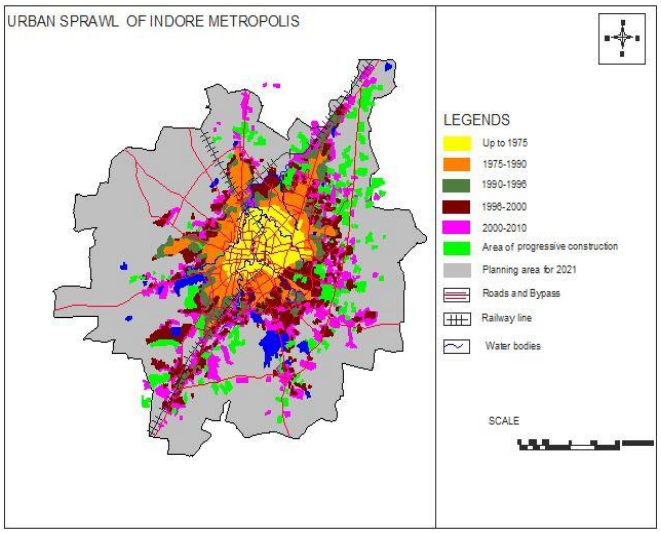
Methodology

Based a GIS Platform, by the help of AutoCAD preparation of maps and after ground verification of these we used it as to collect the information, analyse and make prediction and possibilities of future.

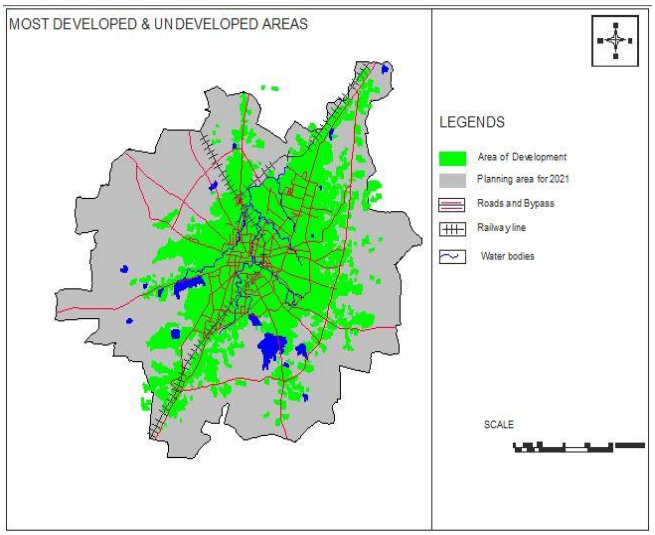
Map-1: Indore master plan 2021



Map-2: Urban sprawl till 2010



Map-3: Developing and undeveloped area



Analysis of Maps

Indore city is growing rapidly which reflects in its development the development growth rate in year 2002-2010 is maximum. The development growth rate in year 2002-2010 is 443.2% comparing to its previous development. Sprawl is getting out of the planning boundaries of 2021 which is through the By Pass and NH3 (AB Road). The direction of development is mainly in North East direction which is 49.1% of total developed Area between 2002 – 2010. Ring Road, By Pass, Ujjain Road are major attraction points of development. By the allocation of land to TCS and HCL, IT Hub Centre will be in super corridor at the same direction of developing areas. It will create one directional growth of city.

Causes of deviations

- Cause of easy accessibility is area of Ring Road By Pass and NH-3 (AB Road) and its connectivity with Pithampur and Dewas industrial Regions, which is part of Delhi-Mumbai industrial corridor.
- The increase in population density in inner part of city, because of it developing regions are attraction points as low populating area, Unavailability of vacant land in CBD and inner part, while developing regions are rich in land and transport facility.
- In developing regions, the townships are in progress some of them are Parshvnath, D.L.F, Omex which are attraction points for population and other commercial centres.
- The development of education and others centres like amusement malls in these areas. In other side the Non-developing part are untouched of infrastructure and service centres as attraction point.

Effects

- The developing trend will laid to a linear form of city development instead of polyhedral as expected in Master plan.
- This development will laid to unsystematic and one directional growth pressure of population will be on specific zone again which is very clear by development growth percent between year Year 2002-2010 as shown in Table1.

Table 1

Direction	The directional Area of development form total developed area (In Sq. Km.)	Percent of directional growth from total developed Area(%)
North-East	54.30	49.1
South-East	25.60	23.1
South-West	29.57	26.1
North-West	1.05	1.1

- It will be load for development of infrastructure and providing the services & Possibility of development of unauthorized colonies.
- North-West region will be emerging as non-developing region.
- The gap between Indore–Rau–Pithampur-Mhow will be end and it will emerge as conurbation.
- The rapid loss of agricultural land in developing direction specially in Northeastern region.

Remedies

- The development of attraction centres in non-developing Areas by-Development of structures milestones like ring road and by pass in this direction. Basic infrastructural development and service centre expansion in this area.
- By allotment some land for small or middle scaled industries.
- The expansion of development plan in growing areas and practicing of micro level planning in this area
- The evaluation of each master plans in certain time period between its tenure.

Conclusion

By evaluation Indore development is getting linear directional and it is deviating from its master plan cause of this type of progress it will lay to in two clear zones of developed and non developing areas. This development trend clarify that the polyhedral planning shape decided in master plan 2012 will difficult to get if not acted in time.

A Case Study for Site Selection of Agroforestry of Umlangia Watershed in GIS Environment

Ratul Arya Baishya[1], Chandra Sharma[2] and Manoj Haloi[3]

[1]*Research Investigator, MAP Cell, National Institute of Rural Development (NIRD), NER Centre, Guwahati-22*

[2]*Lecturer, Deptt. of Environmental Management, Dimoria College, Khetri, Kamrup, Assam*

[3]*Junior Project Scientist, C-GARD, National Institute of Rural Development (NIRD), NER Centre, Guwahati-22*

Abstract

Agroforestry, the combination comprising the integration of trees into crop and livestock operations, has the potential to achieve many of the environmental, economic, and social objectives being demanded from landowners and society. To summarize these goals, a multi-scale planning process must be utilized. This planning process can be expedited using a geographic information system (GIS), a collection of computer hardware and software used to analyze, display and integrate the geographically referenced information. Data layers like soil type, slope, elevation and land cover can be used to identify suitable locations for agroforestry practices. These same data layers can be used to identify promising locations for growing agroforestry products that can be utilized for a variety of uses. By mixing these suitability criteria, locations with multiple objectives can be achieved. A case study from the Umlangia Watershed, West Khasi Hills District, Meghalaya illustrates the role of GIS in helping to address and balance land productivity and environmental protection goals. The implications of the results are discussed in the context of the suitability of the species in this region and their usefulness in agroforestry systems.

Introduction

Agroforestry is the intentional combination of agriculture and forestry technologies to create integrated, diverse, productive, profitable, and sustainable land-use systems (Rietveld 1995). In general, Agro-forestry can be defined as the agricultural practices along with forestry. Examples of agro forestry practices that are focused on meeting the environmental, social, and economic needs of people on private lands include alley cropping, forest farming, riparian forest product and windbreaks. In agro-forestry systems there are both ecological and economical interactions between the different components'. Environmentally and ecologically, agro forestry practices can reduce erosion, improve water infiltration and quality, moderate microclimates, enhance nutrient cycling, and provide wildlife habitat (Sanchez, 1995). Socially, communities may be revitalized through partnerships that implement publicly owned agro forestry projects like community shelterbelts or ecobelts (Josiah et. al., 1999;Bentrup et. al., 2001). Lal (2000) recently cited agro forestry as one of the future technological innovations that will be needed to meet the food demands for the global increase in population.

Agro forestry practices can minimized the production costs by lowering the need for chemical, water, energy, and/or labor inputs while increasing overall agricultural output in terms of Economy. By appropriate management, agro forestry systems can be made viable and sustainable for production of important edible foods products like berries and nuts, medicinal goods like goldenseal and ginkgo, and horticultural materials like evergreens for floral wreaths. If these agro forestry species or products are properly managed or used, a synergistic system can be made that optimized the benefits of the landholder, while sustaining a unique environmental condition.

Goals with GIS Oriented Planning

With the application of GIS, the goals and objectives of any agro forestry systems can be achieve partially depending on the spatial scale at which the watershed project are planned and formulated. Problems like soil erosion and providing optimal crop production can be overcome by just determining the site conditions within the watershed boundaries. A larger scale perspective often becomes an important requirement for community-oriented goals, like improvement of water quality of their concerned locality and wildlife habitat. For instance, water quality issues need to be studied at the grass-root level and watershed level to examine spatial distribution of pollutant sources, hydrological pathways, and opportunities for the management purposes. To integrate these different concerns and goals within agroforestry systems, a multi-scale planning process needs to be used (Rietveld& Francis, 2000).Using geographic information systems (GIS), geographically related information can be facilitate and processed for the planning process. Spatial data like soil type, slope, and land cover can be used to develop land suitability assessments for identifying the ideal locations for agroforestry practices. A location map of the studied watershed is given below in Figure 1. The advantages of using GIS are the ability

to combine different assessments to determine locations where multiple objectives can be achieved. Some of the first examples of suitability assessments in the United States were prepared by the Natural Resources Conservation Service (previously the Soil Conservation Service), which ranked soil types based on suitability for different engineering and agricultural functions (Soil Survey,1993). Depending upon the scale of analysis, GIS based assessments can serve a variety of uses in the promotion, adoption, planning, and design of agroforestry systems

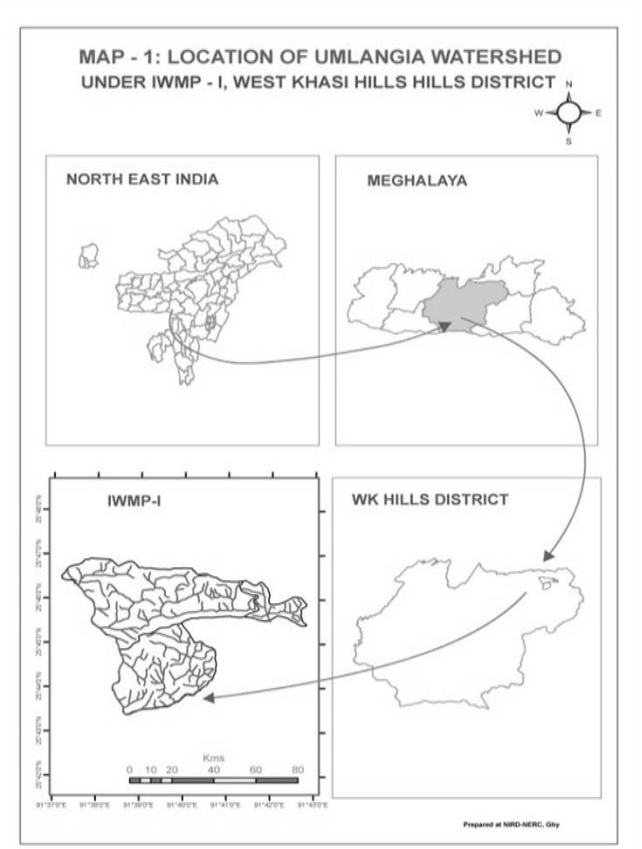


Fig. 1: Location of the Umlangia Watershed

Methods and methodology

SITE:The site taken for the study purpose is theUmlangia Watershed. The area of the Watershed is located in between $91^0\ 37^/\ 0^{//}$ E -$91^0\ 43^/\ 0^{//}$ E and $25^0\ 43^/\ 0^{//}$ N -$25^0\ 47^/\ 0^{//}$ N in the West Khasi Hills District of Meghalaya in India. The total area of the Watershed is 2759.04 Hectare and the area to be treated is approximately 1800 Hectare. The study site considered as a watershed area has logical natural boundary that provide a scientific framework to analyses it in GIS environment. The location map of the study area is given in Fig. 1.

Collection of data

For the study purposes the data are being collected from both the primary and secondary source.

*Primary Source:*Location of proposed Treatment Activities cum Income Generating Activities for household through GPS survey done by the Expert.

*Secondary Data:*Secondary data are being collected from the following sources for the selection of the site for agroforestry.

1. Topological map from Survey of India (SoI) of 1:50000 Scale of the project area.
2. Soil Map from National Bureau of Soil Survey (NBSS) of 1:50000 Scale of the project area
3. Geological Map from Geological Survey of India (GSI) of 1:50000 Scale of the project area.
4. Ground water Maps from Central Ground Water Board (CGWB) of 1:25000 / 1:50000 Scale of the project area.
5. LULC Map, 2006 from North East Space Application Centre (NESAC).
6. Rainfall, Temperature and humidity data (from August 2006 to December 2009) are collectedfrom Automatic Weather Station (AWS), Weiloi, West Khasi Hills, Meghalaya.

Data interpretation in GIS

The maps collected from the aforesaid source were then geo-referenced, digitization for the drainage systems, contours, roads and settlements have been done and respective layers were finally created in the GIS environment. At last the non spatial data were finally interpreted with the layers with the help of GIS tool for the data related output.

Data analysis in GIS

Various spatial data of the study area related with soil, watershed area, location for planned activities, LULC have been analyzed with the help of GIS for the selection procedure of the appropriate site for agro-forestry in that concerned watershed. With the help of all these data finally the proposed land use have been prepared narrating the suitable area for agro-forestry.

Selection of suitable site for agroforestry

The spatial data layers like contour, drainage, slope, elevation, geology, physiography, available water capacity, soil type, wasteland area, location for planned activities and land cover are used in the present case study to develop suitability criteria that can be used to identify the appropriate and optimal locations for agroforestry practices in the concerned watershed to developed and prepare the management plan for the upliftment of the community. A simple overview of the GIS-guided drainage map comprising the settlements is illustrated below in Fig. 2.

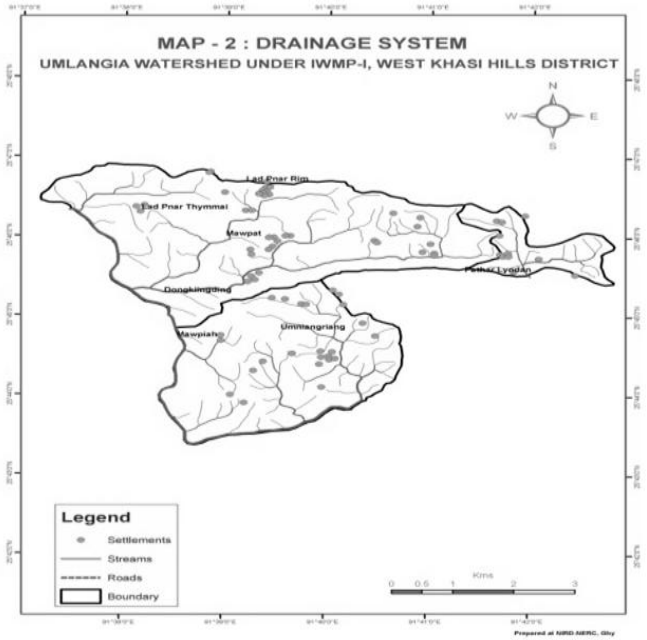


Fig. 2: Drainage System of the Umlangia Watershed.

Result

Slope: The Slope of the studied watershed is classified into seven categories in percent value - <1 %, 1-3 %, 3-5 %, 5-15 %, 15-35 %, 35-50 % and >50 %. The large part of the area (998.60 ha.) in the slope analysis was found to be located in 15-35 % while the smaller part of the area (0.17 ha.) land is located in 3-5 %, slope of the watershed. Landdistributed in <1 %, 1-3%, 5-15%, 35-50% and >50 % are 937.97 ha., 0.37 ha., 131.52 ha., 384.47 ha. and 305.94 ha. respectively. Thearea of land located in different slope category are unevenly distributed in the studied watershed that is illustrated in Fig. 3.

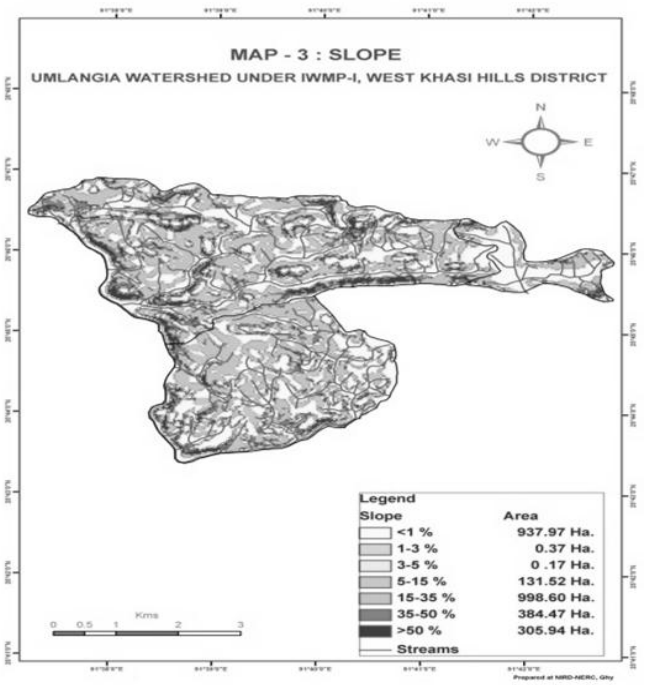


Fig. 3: Slope Map.

*Elevation:*The area of the studied watershed is located at a range of 600 msl to 1000 msl. The contour lines of the watershed is classified into five equal intervals and finally the watershed area have be categorized into five different region that falls in the range of 600-680 msl, 680-760 msl, 760-840 msl, 840-920 msl, and 920-1000 msl. The class wise distribution of the watershed area is shown below in Fig. 4.

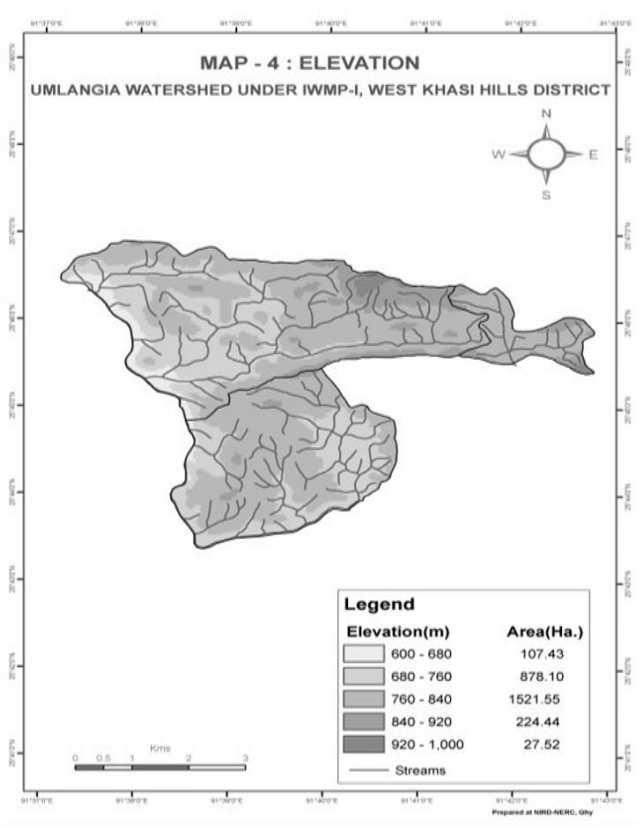


Fig. 4: Elevation Map.

*Geology:*The Geological unit of the entire watershed belongs to Gneiss with old inliers which is a common Sela Group found in another North Eastern state, i.e., Arunachal Pradesh.

*Physiography:*The Umlangia watershed can be divided into two physiographic divisions- Dissected Hilly Terrain and Lower Plateau. The Dissected Hilly Terrain of the watershed comprises an area of 1114.36 ha. of the total 2759.04 ha. area, while the Lower Plateau of the region comprises an area of 1644.68 ha. From the Physiographic divisions of the watershed, it was found that both the area comprises more or less equal area.

*Available water capacity:*The Available water capacity of the studied watershed can be divided into two order- Medium and Medium - Very Low. The Medium part of the watershed comprises the maximum area i.e., an area of 2722.78 ha. While the Medium – Very Low part of the watershed comprises only a small portion of the watershed i.e., only 36.26 ha. of the total are of the watershed respectively.

Soil: The soil type of the studied watershed area was found to fall under three categories namely –

A. Typic Kandihumults-Typic Dystrochrepts soil - Deep, excessively drained, fine soils on moderately sloping side slopes (5-15%) of hills having loamy surface, medium textured soil with moderate erosion

B. (10-15 ton/ha/yr) hazard and which have greater than 100 m soil depth. Soil is slightly stoniness which differ it from the following category.

C. Typic Kandihumults-Typic Dystrochrepts soil - Deep, excessively drained, fine soils on moderately sloping side slopes (5-15%) of hills having loamy surface, medium textured and slight stoniness soil with moderate erosion (10-15 ton/ha/yr) hazard and which have greater than 100 m soil depth.

D. Umbric Dystrochrepts- Typic Udorthents soil. - Deep, excessively drained, fine loamy soils on moderately (5-15%) sloping slight – slopes of hills having loamy surface with moderate erosion hazards, (10-15 ton/ha/yr).

The Soil Types Map of the watershed is shown below in Fig. 5.

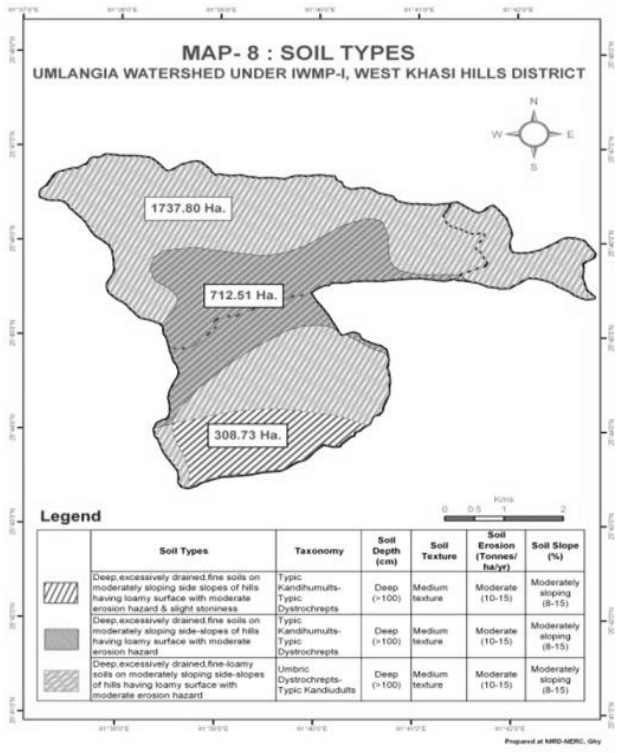


Fig. 5: Soil Types Map.

*Wastelands:*In the studied watershed the wastelands have been categorized into five types namely, land with Scrub, land without scrub, Miscellaneous, river and settlement. Land with scrub comprises 12.72 %, land without scrub comprises 14.02 % of the area. Settlement occupies 0.06 %, miscellaneous type contains 72.6 % and river runs in around 0.59 % area of the total watershed. The large part of the watershed comprising an area of 72.6 % of the total watershed area can be categorized properly so it is indicated as Miscellaneous in the map. The wastelands map is given below in Fig.6.

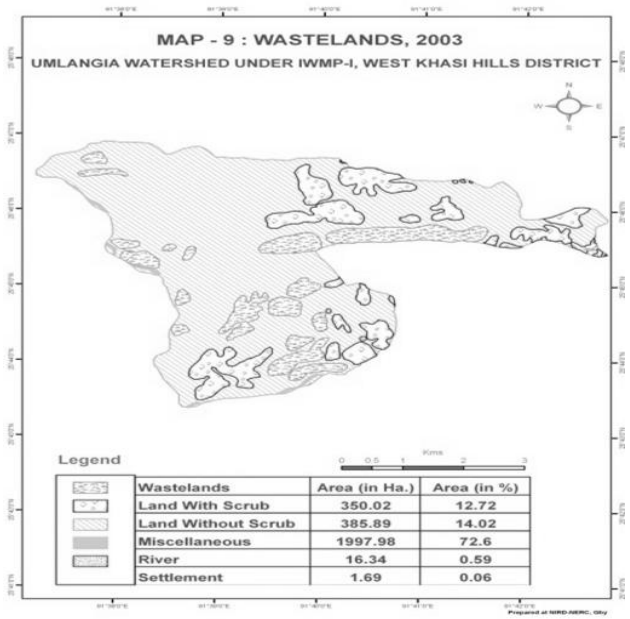


Fig. 6: Wasteland Map.

*Location of planned activity:*The spatial data for the planned activities have been analyzed through GIS and being plotted within the watershed boundary. The map for location of planned activities has been given below in Fig. 7.

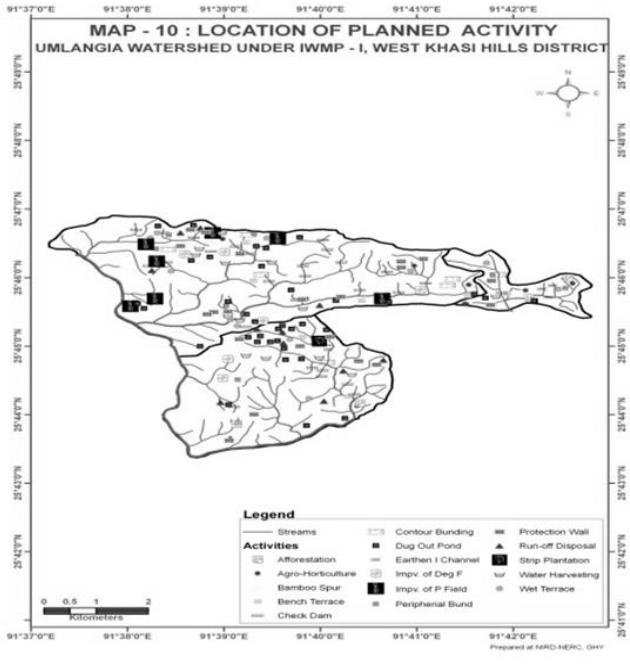


Fig. 7: Map depicting location of planned activity

Present landuse: Seven Land Use Land Cover classes have been found to exist for the concerned studied watershed which are being divided into – agricultural land, build up area, shifting cultivation current, dense scrub, open scrub, tree clad-close, tree-clad-open. Of the total LULC area (2759.04 ha.) of the watershed, 1326.03 ha.falls under tree clad area - open Build up area occupy over an area of 84.76 ha. (3.07 %). The Land Use Land Cover map is given below in Fig. 8.

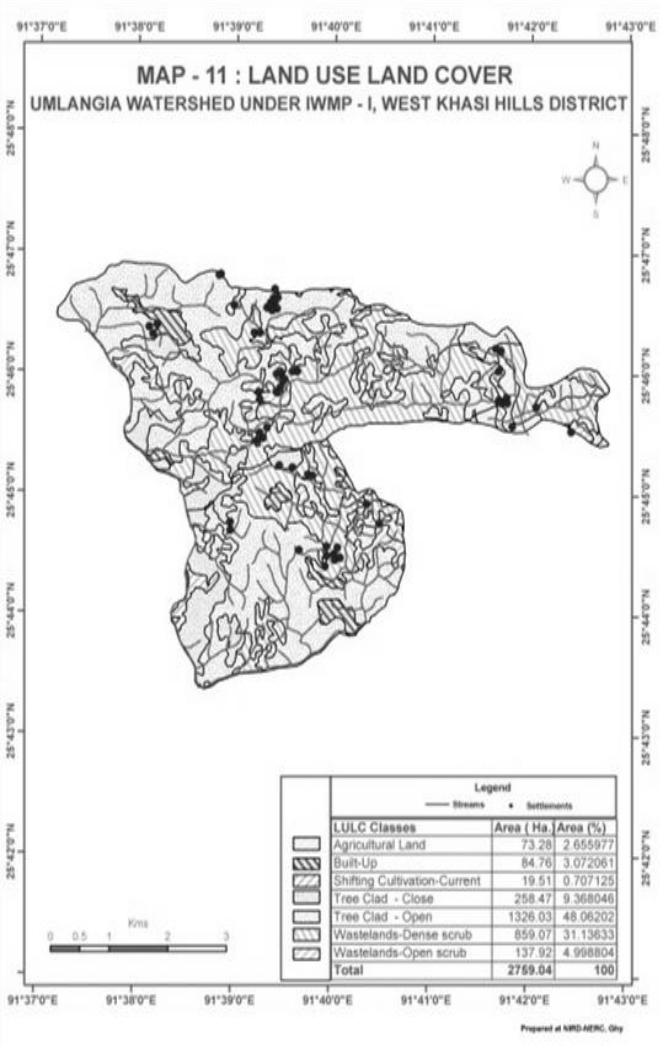


Fig. 8: The Land Use Land Cover Map.

Conclusion

By analyzing all the spatial data and all the layers it was possible to identify the suitable area for Agro-Forestry in the studied watershed, i.e., Umlangia Watershed. The suitable sites for agro-forestry in the Umlangia watershed are distributed randomly. The area for agro-forestry has been estimated to be an area of 470 ha. of the total 1800 ha. which is to be treated under Integrated Watershed Management Plan (IWMP). The sites suitable for agro- forestry of the concerned watershed have been shown in Fig.9.

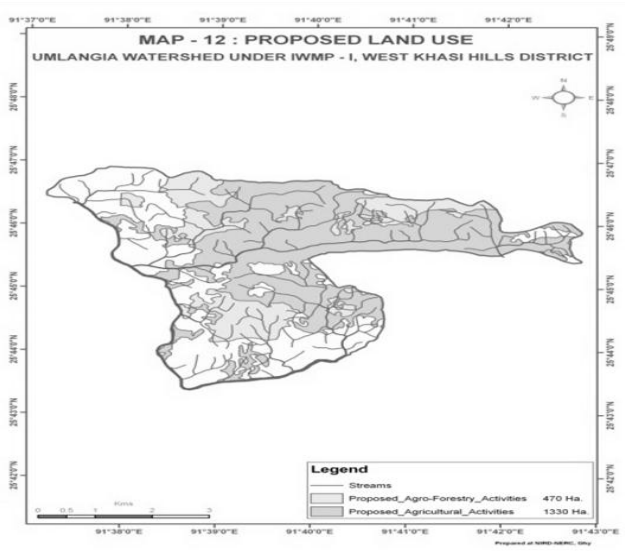


Fig. 9: Proposed Land Use Map.

Acknowledgement

We convey our regards and gratitude to Dr. K. Haloi, Associate Professor, National Institute of Rural Development-NERC, Guwahati for his assistantship and helping guidance. He has helped us to make use of the infrastructure which are available at the premier Institute. We are also thankful to our colleague Project Engineer, Tadrup Mazumdar for his immense helping hand in the preparation of the desired map required to prepare the paper.

We also pay our tribute to the working staff of Soil and Water Conservation Department of the concerned West Khasi Hills District of Meghalaya for providing us the valuable information needed to accomplish our work.

Reference

1. Bentrup, G., Schoeneberger, M.M., Josiah, S. and Francis, C. (2001),*Ecobelts: reconnecting agriculture and communities - case studies*. In: Steward W.C. and Lisec, A. (eds), Proceedings of the Ecospheres Conference. University of Nebraska, Lincoln, NE. June 10-12.
2. Josiah, S.J., Gordon, L.J., Streed, E. and Joannides, J. (1999),*Agroforestry in Minnesota: A Guide to Resources and Demonstration Sites*. University of Minnesota Extension Service, St. Paul, MN.
3. Lal, R. (2000),*A modest proposal for the year 2001: we can control greenhouse gases and feed the world…with proper soil management*. Journal of Soil and Water Conservation 55(4):429-433.
4. Rietveld, W.J. (1995),*Agroforestry: a maverick science and practice*. In: Rietveld, W.J. (ed.)
5. Rietveld, W.J. and Francis, C.A. (2000),*The future of agroforestry in the USA*. In: Garrett, H.E.,

Spatio - Temporal Changes on Demographic Characteristic in2001-2011- A Case Study of Tamil Nadu

S. Ravichandran and Dr. I. K Manonmani
Department of Geography, School of Earth and Atmospheric Sciences, Madurai Kamaraj University, Madurai
E mail: ravi.nithish@gmail.com

Abstract

Population geography as an independent sub-field of human geography is a comparatively recent phenomenon. Demography is the statistical study of population. It is a general science that can be applied to any kind of dynamic population, which is one that changes over the time (or) space. It encompasses the study of the size, structure and distribution of population and spatial, temporal change in them in response to birth, death, migration and ageing. Demography is the study of population characteristics.

- *There are more people living today than any other time in history*
- *There is been a population explosion since world war II.*
- *There is an inverse relationship between population growth and resources that is, there are too many people in places without enough resources to support them and too few people in areas with over abundant resources.*

Geographers study population phenomena in the context of space relationships and aggregate nature of places. The study of population characteristics is essential for any planning purposes. An understanding of the population phenomena over a period of time should be helpful in analyzing the temporal change over an area. Hence in the present investigation it is proposed to undertake a study on population growth and its changes in the Tamil Nadu state for the two census period namely 2001 and 2011. Hence, Tamil Nadu state has more population, it is chosen for the study area.

Introduction

In geography, the study of population distribution has been the focus of traditional human geographers since long. Population geography as an independent sub-field of human geography is a comparatively recent phenomenon. Population geography is the study of spatial variation in distribution, density, composition and growth of human members on earth. It is important because it links all other aspects of the geography together. Population geography deals with the study of population distribution, growth, density, sex ratio, age structure, occupational structure, literacy, migration etc., and other factors related to population in a spatial context.

Choice of present Study

Geographers study population phenomena in the context of space relationships and aggregate nature of places. The study of population characteristics is essential for any planning purposes.
An understanding of the population phenomena over a period of time should be helpful in analyzing the temporal change over an area. Hence in the present investigation it is proposed to undertake a study on population growth and its changes in the Tamil Nadu state for the two census period namely 2001 and 2011.

Aim and Objectives

- To study the spatial pattern of distribution of population in each districts.
- To identify the changes in the population growth in 2001 and 2011 census.
- To analyze the demographic characteristics and its changes due to separation of the districts.

Sources of Data

The present study heavily depends upon the secondary data, which are collected from the sources of census records. The data is collected for two census year namely 2001 and 2011.

Technique used in present study

The decadal growth of population is calculated using computer through Microsoft Excel. The present analysis is made based on the maps and the maps are prepared by using Erdas image 8.1 and Arc view 3.2A software through computer.

Study Area

The state of Tamil Nadu is the southern province of the Indian peninsula. Tamil Nadu lies between 8°5’ and 13°35’ North latitudes and 78°18’ and 80°20’ East longitudes (Fig. 1).

The state of Tamil Nadu is a triangular landmass at the south-eastern end of the main continent. Total area of Tamil Nadu is about 1, 30,058 sq.km, which is 4% of the total land area of India. According to 2011 census the total population of this state is 72138958.

Administratively the state is divided into 32 districts. Each of 32 districts in Tamil Nadu is divided into divisions, which are further divided to Taluks. Each of these Taluks has a list of revenue villages under them.

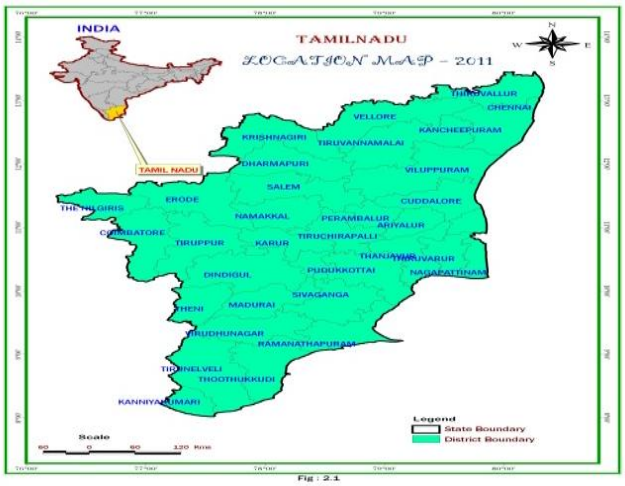


Fig. 1

Demographic characteristics – 2011

Population Distribution

According to 2011 census, the Tamil Nadu state has a total population of 72,138,958. Of all 32 districts, Chennai has the very high concentration of population with 4681087. Next to Chennai, the highest population is concentrated is the districts of Kancheepuram, Vellore, Thiruvallur, Salem, Coimbatore Villupuram, Thirunelveli, and Madurai with more than 30 lakhs of population. The lowest concentration of population is seen in the district of Perambalur with 564511. Next to Perambalur, the lowest population is concentrated in the districts of Nilgiris (735071) and Ariyalur (752481). On the other hand, all the other districts have the moderate population with more than 10 lakhs (Fig. 2).

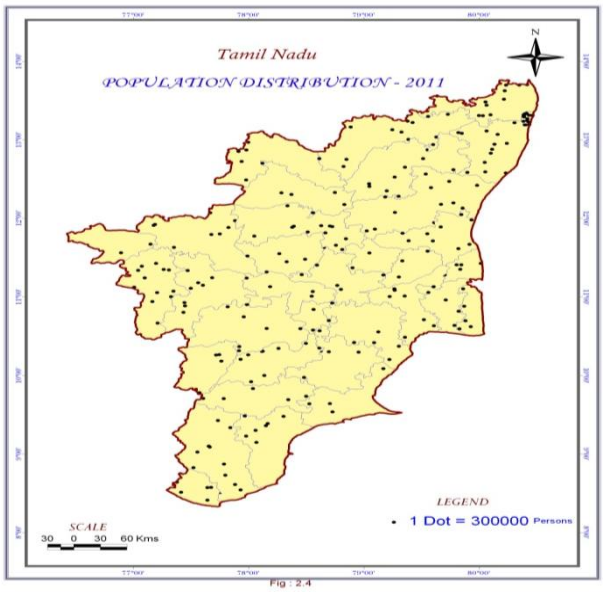


Fig. 2

Population Density

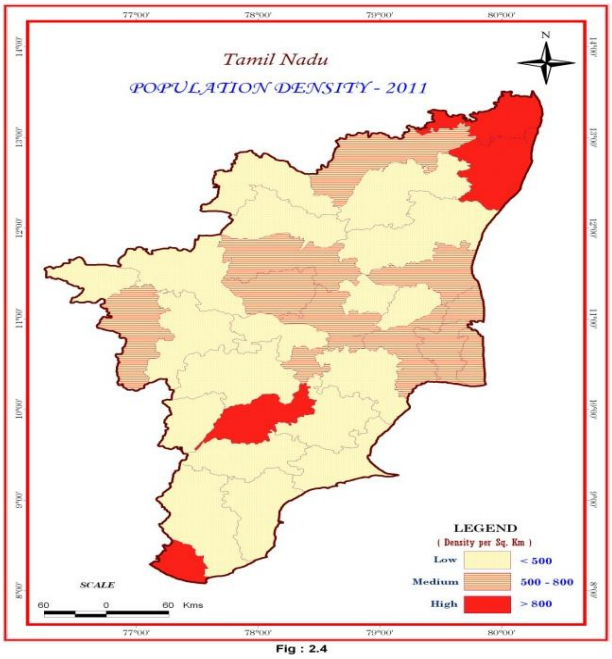


Fig. 3

As per the census of India 2011, Tamil Nadu has a population density of 555 persons per sq.km. Chennai district is the densest district with 26903 persons per sq. km. Kanniyakumari (1106), Thiruvallur (1049), Kancheepuram (927), Madurai (823), Coimbatore (748), Cuddalore (702), Thanjavur (691), Nagapattinam (668), Salem (663), Vellore (646) and Tiruchirappalli (602) are the 11 districts having higher density of more than 600 persons per sq.km. The Nilgiris district has returned the lowest density of 288. The rest of the districts have moderate density of population (Fig. 3).

Sex Ratio

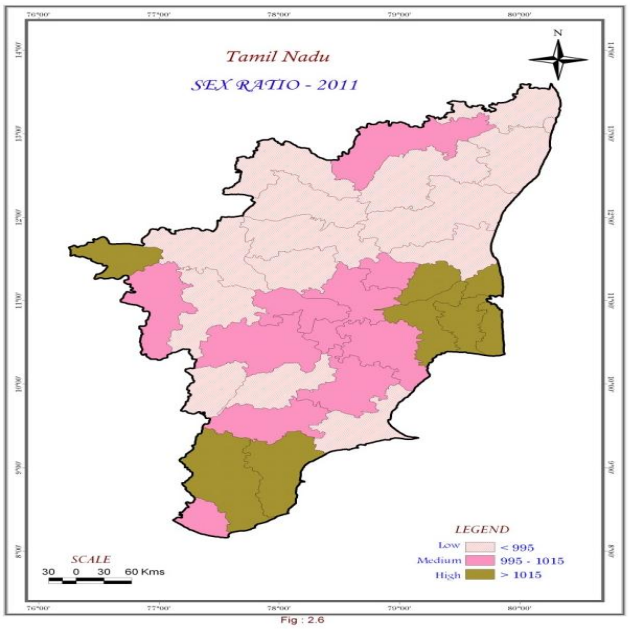


Fig. 4

The sex ratio of Tamil Nadu state in 2011 is 995 females per 1000 males. Of the 32 districts in the state, 15 districts have returned a sex ratio of more than 1000 females per 1000 males. Only one district namely Sivaganga has returned exactly the sex ratio of 1000 (Fig. 4).

Literacy

Among the districts Kanniyakumari has reported the highest literacy rate of 92.14% while Dharampuri district accounts for the lowest rate of 64.71%. The 5 district namely Kanniyakumari (92.14%) Chennai (90.33%), Thoothukkudi (86.52%), The Nilgiris (85.65%) and Kancheepuram (85.29%) have recorded very high literacy rates. As such, 16 districts have registered higher rates than the state average at the same time 16 districts are below the state average (Fig. 5).

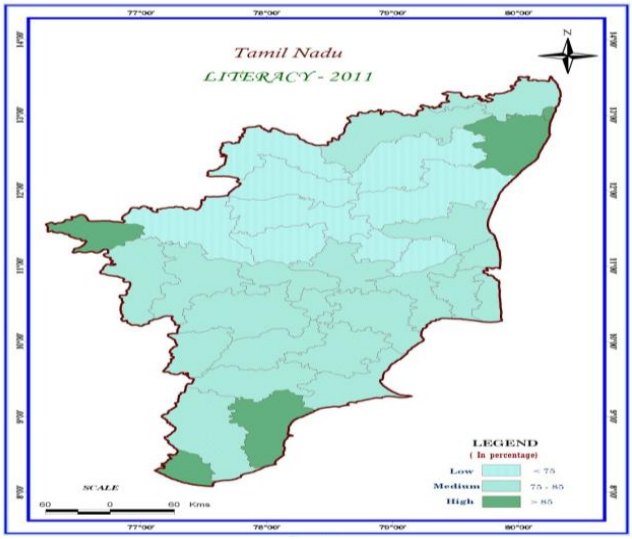


Fig. 5

Demographic characteristics – 2001

Population Distribution

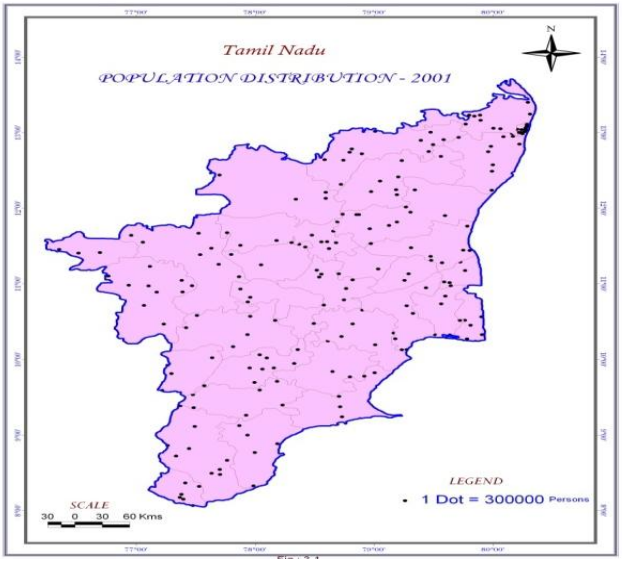


Fig. 6

According to 2001 census, the Tamil Nadu state has a total population of 62405679. Of all 30 disricts, Chennai has the highest population 4343645. Next to Chennai, The highest population is concentrated in the districts of Thiruvallur, Vellore, Kancheepuram, Villupuram, Coimbatore, Salem, Tirunelveli and Madurai. The lowest population concentration is seen in the perambalur district with the population of 493643. Next to perambalur, the lowest population is concentrated in the districts of Ariyalur (695524), Nilgiris (762141) and Karur (935686). On the other hand, the other 17 districts have the moderate population distribution (Fig. 6).

Population Density

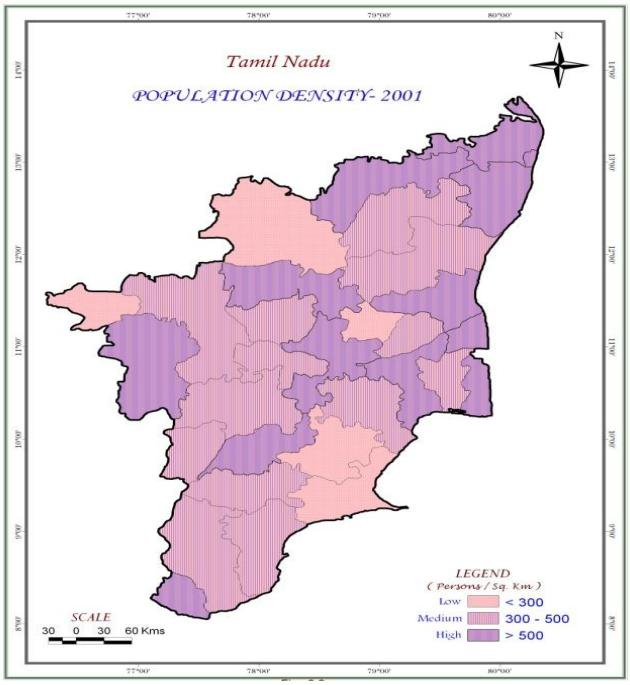


Fig. 7

As per the census of 2001, Tamil Nadu has a population density of 480 persons per sq.km. The highest population density is seen in the district of Chennai with 24963 persons per sq.km, followed by the Kanniyakumari district having 995 persons per sq.km. On the other hand the lowest density of population is seen at Sivaganga district having 279 persons per sq.km, followed by the districts of perambalur (282), Ramanathapuram (284), Dharmapuri (286), and Nilgiris (299).The rest of all the districts having the moderate density of population (Fig. 7).

Sex Ratio

The Sex Ratio of Tamil Nadu is 987 females per 1000 males as per 2001 census. The highest Sex Ratio is seen in the district of Thoothukkudi with 1050 females per 1000 males, it is followed by the districts of Thirunelveli(1042), Sivaganga (1038) and Ramanathapuram (1036). The 11 districts have the sex ratio of more than 1000 females per 1000 males. The

lowest sex ratio is found in the Salem district with 929 females per 1000 males. All the other 14 districts have moderate sex ratio (Fig. 8).

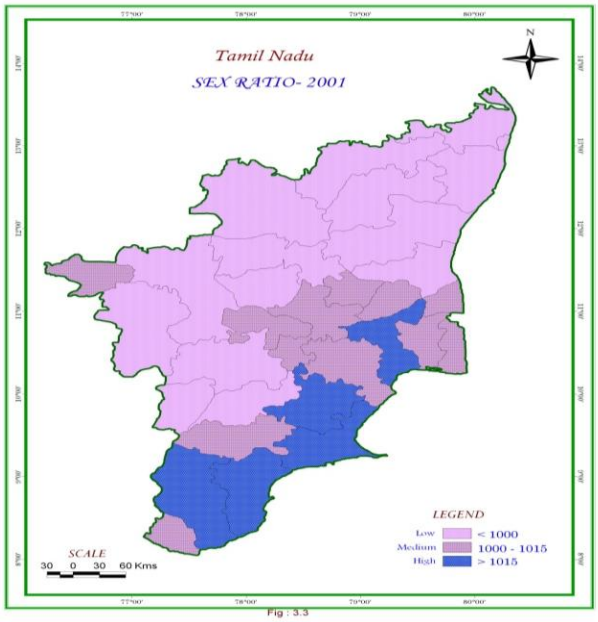


Fig. 8

SC/ST Population

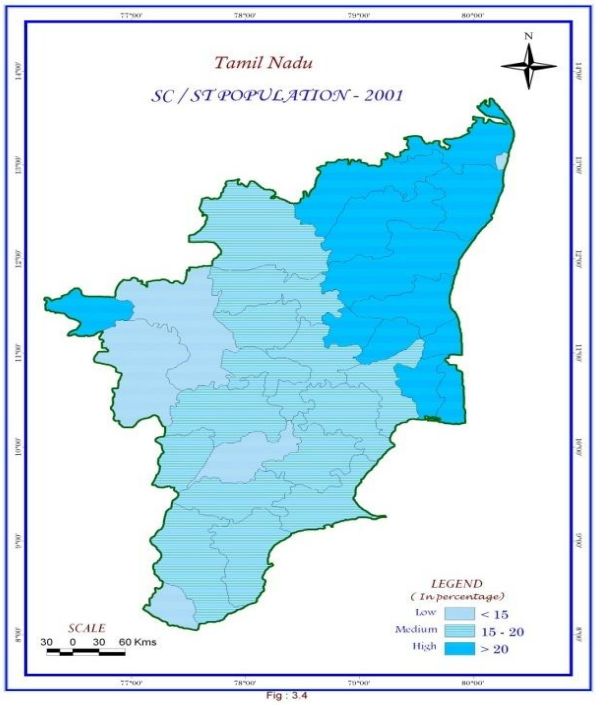


Fig. 9

According to 2001 census, the Tamil Nadu state has 18.35% of SC/ST population. The highest concentration of SC/ST population is found in the district of Thiruvarur with 31.66%, is followed by Nagapattinam (28.73%), Villupuram (29.17), Nilgiris (26.98%), Perambalur (27.84%), and Cuddalore (27.67%). The lowest percentage of SC/ST population is found in the Kanniyakumari district of 2.93%. The rest of 23 districts have the moderate percentage of the SC/ST population (Fig. 9).

Literacy Rate

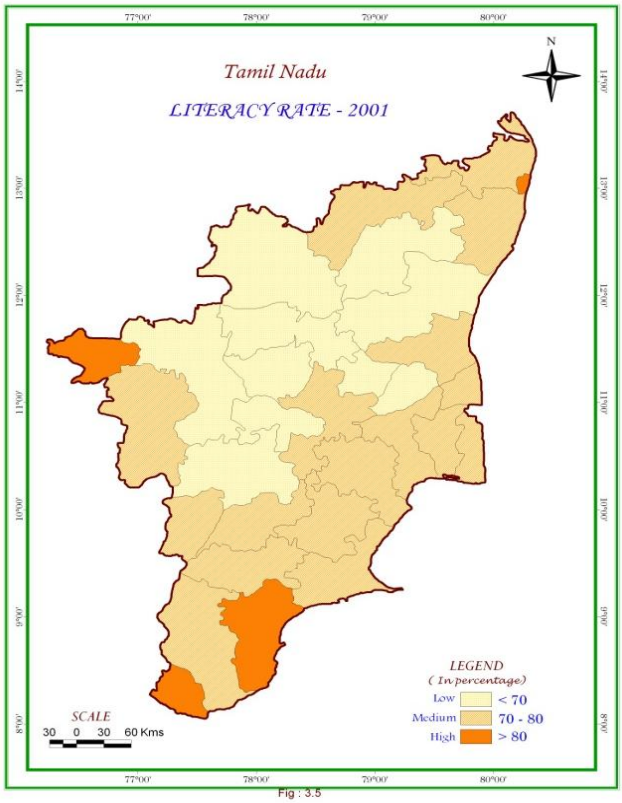


Fig. 10

The average literacy rate of Tamil Nadu is 73.45% as per 2001 census. The highest literacy rate of 87.55% is seen in the Kanniyakumari district and it is followed by the districts of Chennai (85.33%), Thoothukudi (81.52%), and the Nilgiris (80.01%). On the other hand, 25 districts have the moderate literacy rate of more than 65%. The lowest rate of literacy is found in the district of Dharmapuri with 61.39%, followed by the two districts namely Villupuram and Ariyalur (Fig. 10).

Occupational Structure

The occupational structure may be categorized in to three sectors such as Primary, Secondary, and Tertiary. According of 2001 census, the Tamil Nadu state consists of primary workers (49%), the Secondary workers (5%) and Tertiary workers (46%). The participation of primary workers are considerably high in the Tamil Nadu state. Chennai, Nilgiris and Kanniyakumari districts have high concentration of Tertiary workers of more than 70%. In the districts of Thirunelveli (22%), Vellore (12%) and Salem (9%) have the high percentage of Secondary workers. The Primary workers are highly concentrated in the districts of Perambalur (81%), Villupuram (75%) and Ariyalur (74%), with more than 70% of the participation. All

other districts are partially concentrated in the primary, secondary and Tertiary Workers (Fig. 11).

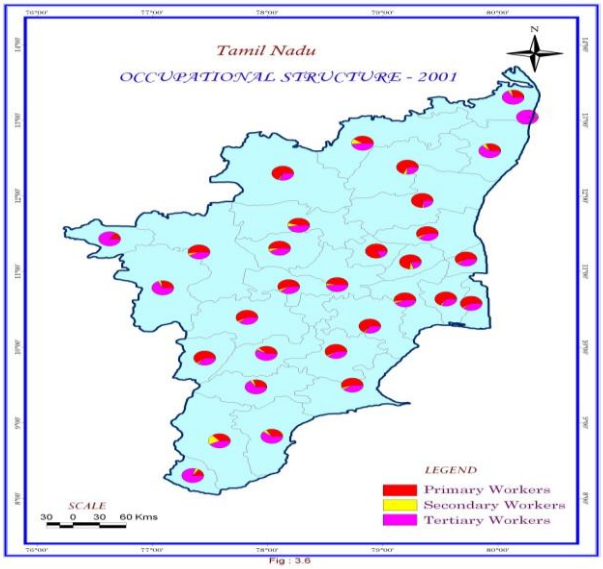


Fig. 11

Spatio – Temporal Changes of Population in 2001 – 2011

Population Distribution

The population distribution of the Tamil Nadu state between 2001 and 2011 year is furnished. According to 2001 census, the Tamil Nadu state has a total population of 62405679 it has increased to 72,138,958 in 2011. Of all the districts, Chennai has the highest population in both the years of 2001 and 2011, where the rate of population is increased from 4343645 to 4681087. The lowest population distribution in 2001 and 2011 years is recorded in the Perambalur district (Fig. 12).

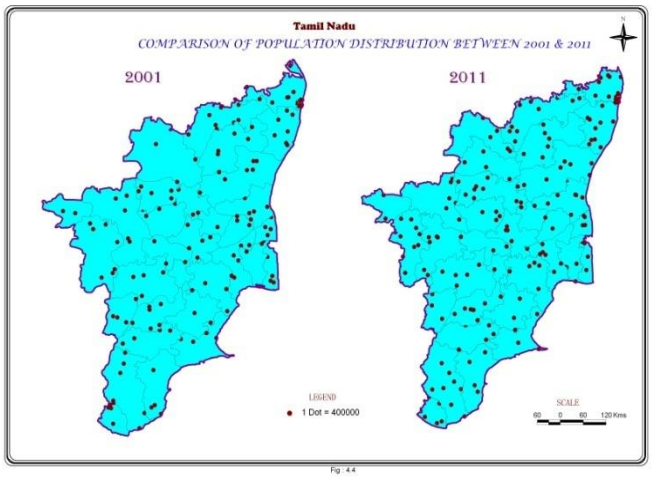


Fig. 12

When compared to 2001 and 2011 census year the population is decreased only in the Nilgiris district from 762141 to 735071. All the other districts in Tamil Nadu have the increased level of population in 2011 when compared with the 2001 census year there are slight variations in the population distributions in the districts between 2001 and 2011.

Population density

The population density of Tamil Nadu state in the year 2001 was 480 persons per sq.km, but when compared to 2011 census the density is increased up to 555 persons per sq.km. The highest population density is seen in the district of Chennai in both the census years 2001 and 2011 which is increased from 24963 to 26903 persons per sq.km. In 2001, the low population density is found in 5 districts namely Nilgiris, Dharmapuri, Perambalur, Sivaganga and Ramanathapuram with less than 300 persons per sq.km. But in 2011, the above mentioned 5 districts except Nilgiris have increased the density above 300 persons per sq.km. Only in the Nilgiris district the population density is comparatively low. The moderate density of population is found in all other districts which have no changes in the years of 2001 and 2011. The high population density in 2001 census is seen in 7 districts of Coimbatore, Madurai, Kanniyakumari, Nagapattinam,Thiruvallur, Kancheepuram (Fig. 13).

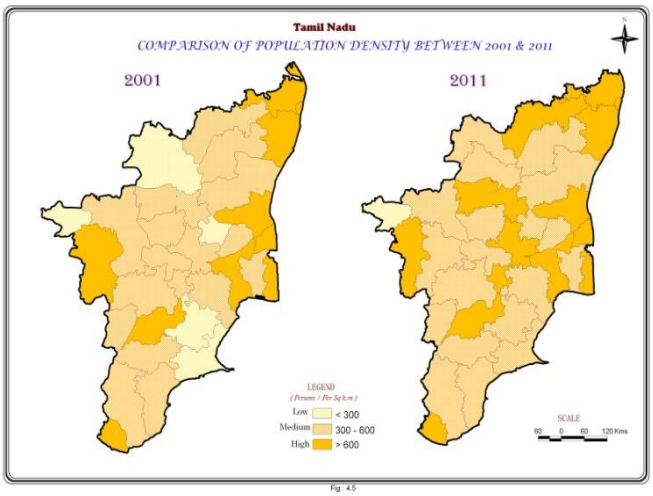


Fig. 13

Sex ratio

As per 2001 census, the sex ratio of Tamil Nadu was of 987 females per 1000 males it has increased to 995 in 2011. By the comparison of 2001 and 2011 census year the sex ratio has the variations which are noted to be very significant. The high sex ratio level in both 2001 and 2011 census year is found with more than 1020 females in the districts of Thanjavur, Tirunelveli, Thoothukudi, etc.., where in 2001 Ramanathapuram district has high sex ratio which is decreased to less than 990 females per 1000 males. At the same time, Sivaganga district has high concentration of sex ratio in 2001 whereas in 2011 it is decreased to 1000 females per 1000 males which is included in moderate population density. In 2001, the Erode district was included in low sex ratio level with less than 990 females per 1000 males, but when compared to 2011 census it is in increased level which is now considered to be moderate rate of sex ratio. All the other districts have moderate sex ratio level in both 2001 and 2011

census year. Chennai district results in low sex ratio in both the census year. It is noted that, there is no changes occurred in any other districts which is present in the low sex ratio level in both census year (Fig. 14).

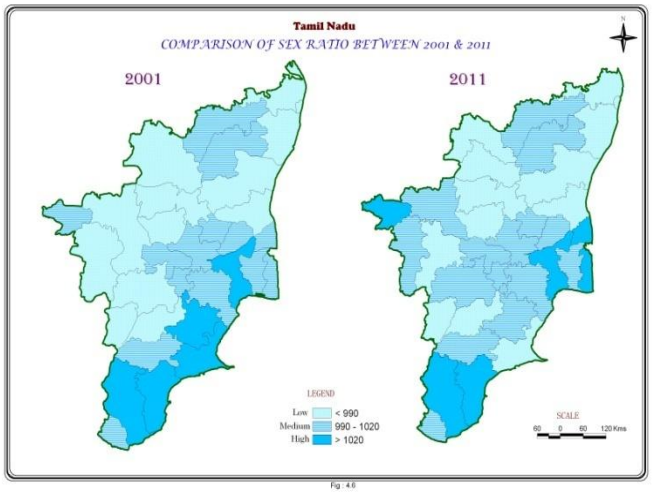


Fig. 14

Literacy rate

The literacy rate for Tamil Nadu in 2011 has increased to 80.33% from 73.45% returned in the 2001 census. Among the males, 86.81% are literates whereas among the females the rate is 73.86% in 2011. The corresponding rates in 2001 were 82.42% for males and 64.43% for females (Fig. 15).

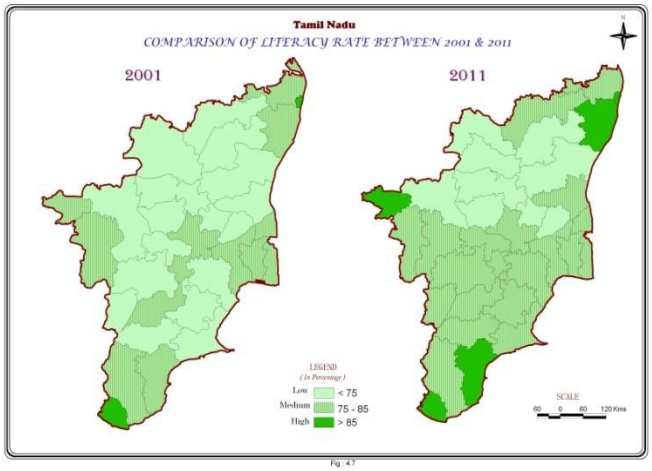


Fig. 15

The literacy rate is high in the district of Kanniyakumari in 2001 and 2011 census year with 87.55% and 92.14% respectively. In 2001, only one district namely Kannniyakumari has higher literacy rate, but in 2011 it is increased upto 3 districts namely Nilgiris, Thoothukudi and Kancheepuram with more than 85%. Chennai district also has the highest literacy rate in both the census years. In 2011, the districts namely Vellore, Cuddalore, Pudukottai, Karur, Dindugul, Theni, Virudhunagar, Ramanathapuram, Sivagangai have the moderate literacy rate ranging from 75%-85%, but in 2001 all these districts are included under the low level of literacy rate with less than 75%. The low literacy level is seen in 17 districts in 2001 census but when compared to 2011, it has decreased to 9 districts with less than 75%.

Summary and Conclusion

In the year 2001, the state has only 30 districts but in 2011 it is bifurcated into another two districts namely Krishnagiri and Tirupur.

The enormous change is observed in the population distribution where the total population was of 62405679 in 2001 and it has increased to 72138958 in 2011 census year.

The population density was 480 persons per sq km in 2001 and it increased to 555 persons per sq km in 2011. When compared to both the census years, only the Nilgiris district has the low population density with less than 300 persons per sq.km.

Sex ratio was recorded as 987 females per 1000 males in 2001 whereas it was about 995 in 2011 census which have resulted in significant change. Here, it is mainly noted that the higher sex ratio is seen in the Nilgiris district with 1041 females per 1000 males. In contrast, the sex ratio is decreased in Sivagangai district from 1038 to 1000.

The literacy rate in the Tamil Nadu state has also increased from 73.45% to 80.33% from 2001 to 2011. Kanniyakumari district is recorded high literacy rate in both the census year.

Fluvio-Geomorphological Characteristics of Sapt Kosi River

RK Mahato and Dr. Jitendra Shukla
Department of Geography, Ranchi University, Ranchi-8, India

Abstract

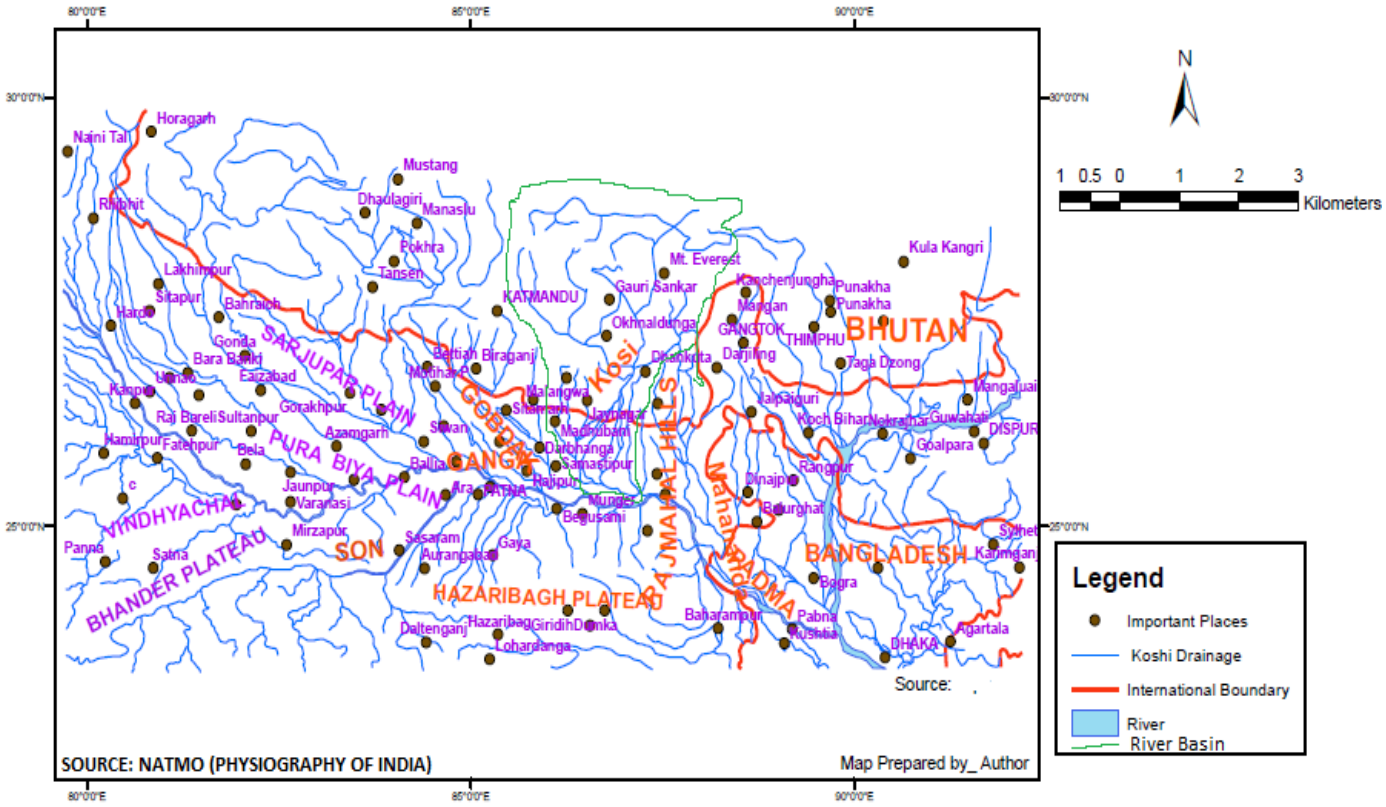
This paper is taken into consideration primarily to study the nature and characteristics of the channel configuration of Sapt Kosi river and its tributaries. This academic attempt has also other consideration like to identify the channel pattern through direct observation of the factors affecting channel configuration to study the nature, characteristics and macro-morphology of the channel pattern with the help of observational techniques and data collected from the field and with the help of morphometric analysis, especially channel morphometric analysis.

Introduction

The network of branching stream channels includes only about 1 to 5 percent of the total area (Kirkby, 1993, p.7), but its role in eroding and transporting sediment is critical to the entire basin's behaviour and evolution. The Sapt Kosi river is a transboundary river among India, Nepal and China and is one of the largest tributary of the river Ganga. The river, along with its tributaries, drains a total area of 69,300 km^2, up to its confluence with the Ganga. In India 29,400 km^2, in China 30700 km^2 and in Nepal 9,200 km^2.Over the last 250 years, the Sapt Kosi river has shifted its course over 120 kms from east to west and the unstable nature of the river is attributed to the heavy silt which it carries during the monsoon season.

However, channel configuration is actually the micro-level study of the channel morphology. For instance, channel pattern, its shape-size, direction, gradient and its alignment on the existing topography and lithological structure. The problems of channel configuration have been considered here for Sapt Kosi river originating from glaciated northern side of Great Himalayan ranges in Southern Tibet plateau (China), turns southward in Nepal and spread in multi branch over northern Bihar (India). The importance of channel configuration of this historical river such as its tributaries and distributaries is much intensity to notable for their different aspect of geomorphological study. The geohydrological characteristics of this river distinguish it from other large river of the world.

Drainage Networks of Kosi River and its Adjoining Areas



Location of the study area

The study area is located in the glaciated northern side of GreatHimalayaRanges in southern Tibetan plateau (China), eastern Nepal and extended in multibranch over northern Bihar (India). Problem selected i.e. the status of valley and channel with special reference to channel configuration – a macro-level study of the river Sapt Kosi.

Methodology

The subject of investigation for the study is to determine the channel configuration through subsequent observation and analysis. Estimated indies and observed features attempts are taken to ascertain the geomorphoic status of the river basin. Image interpretation comprises data derivation form map analysis, map work, computation from topographical map; and satellite imageries pertaining to different components of fluvio-geomorphology. The flow pattern, erosion and transportation characteristics of the existing channel, physical nature of the valley, nature of channel layout on existing topography, are duly considered for the study of the present problem. However, in relation to the whole aspect the area offered a specific geohydrological and fluvial states.

Physical Background

Geology plays dominant role in Sapt Kosi river basin to finalizing the river characteristics. Rock type control the type of river valley, also sediment load and river gradient (Chandra Kumar Sharma, 1983, River system of Nepal).The whole geology is mostly characterized by the quaternary and tertiary formation. In tertiary period Great Himalaya ranges born under Eocene, Oligocene and Middle Miocene to lower Pleistocene mostly upper and lower basin created in the quaternary and lower Pleistocene period lower fluvial come shaped basin created. Tamur Basin is basically characterized by limestone deposition which shows Eocene system. North of higher Himalayan zone belonging from Cambrian to Cretaceous. These rocks escaped metamorphism due to the horst faulty. The peaks of Mt.Everest and Annapurna are supposed to be covered with dolomite and quartzite. Shivalik in the south most are characterized by sandstones, grits, conglomerates, clays and silts. Thick fluvio-glacial material is largely found in the piedmont region of Terai. Bhangar, Bhabhar and Khadar are belonging from Pleistocene and recent. Great fan of Sapt Kosi is also the result of depositional work. Permafrost region extends over southern Tibetan plateau or north of Mt.Everest. The humid Tropical of hot summer and humid rainy season with high rainfall and dry cool winter are significant controlling factor of flow pattern of the river Sapt Kosi. Due to high quantity of glacier deposits on high peaks of Great Himalaya and amount and intensity of rainfall the volume of water is significantly increased and bankful discharge is recorded during rainy season.

The area is characterized by the layer of thick soil cover over the upper Sapt Kosi river basin due to high degree of slope but in near piedmont and lower Sapt Kosi basin has high depth deposition of transported debris and soil. Almost every year flood brings new thick layer of soil cover. In the Terai region due to turbulent nature of flow the loose and friable bank materials are attacked by turbulent action with coarse and sharp grains of rocks.

The coniferous vegetation i.e. Pine, Spruce etc. are frequently founds over the approximately height of 5000 m and in middle basin are characterized with tropical deciduous vegetations i.e. Sal (Sorearubasta), Chirassi, Panisaj, Bamboo etc. are frequent.

Fluvio-Geomorphological characteristics of Sapt Kosi river:

Despite its diversity, the Sapt Kosi basin is a highly effective producer of water and sediments which to formation of world's largest river mad inland delta (Fluvial fan).

Attributes	Sapt Kosi	Sun Kosi	Arun	Tamur	Total
Area (km^2) Proportion of total	58,900 1.00	18,800 0.32	34,300 0.58	5,800 0.10	1,17,800 2
Average Annual Flow ($x10^9m^3$) Proportion of total	51 1.00	22 0.44	18 0.36	10 0.20	101 2
Average Sediment Load ($x10^6m^3$) Proportion of total	18 1.00	54 0.45	35 0.30	30 0.25	137 2
Flood-5 year RI ($x10^3m^3s^{-1}$)	20	8	8	4	40

Hydrologic characteristics of the Sapt Kosi and their tributaries

The study across-valley profiles of the Sapt Kosi river are also shows some important facts for the determination of configuration status of the river. From north to south a number of cross profile are drawn to determine the valley as well as channel configuration. From these profiles erosional, transportational and depositional status of the channel are clearly displayed, and Scarp, Gorge, Canyon, Braided, Shifting meander about all types of geometrical pattern can be easily seen.

Hydrology:

The dynamic and statistical features of the rivers are reflected in the river hydrology. Flow in the river, size of channel, gradient and sediment load are governed by intensity of rainfall, topography and types of rocks.

- Streams originated from high mountain peaks

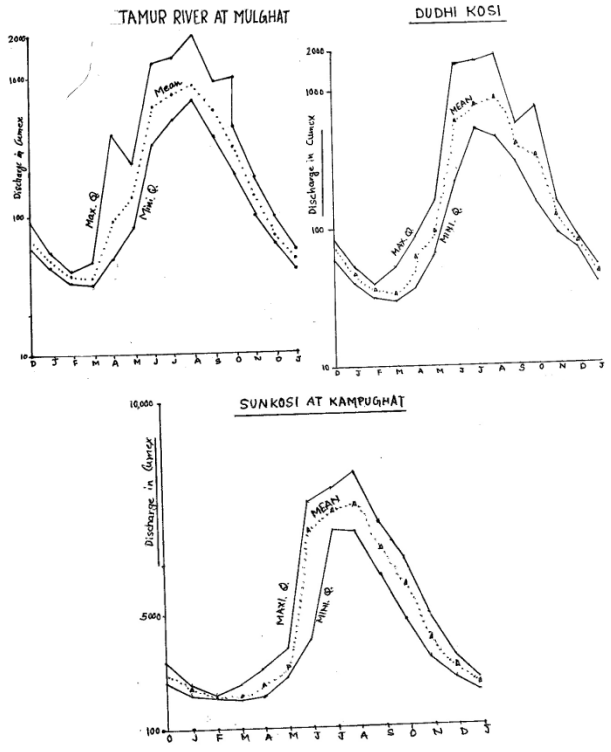
Snow fed rivers are mostly permial, most of rainfall and snowfall occurs in the basin from June to September and hence discharge rises fast during this period, in the winter only the bank storage; snow melting and ground water meets the need of the low flow.Snow covered catchment area of Arun is 4475 sq.km.

- Groundwater

Groundwater helps in the low flow of the river, from October to June the groundwater is contributing and rocks of all area with few exceptions are metamorphic.

- Hydrograph

Most of the tributaries of the basin have a sharp discharge hydrograph during monsoon season (July-September) and comes rapidly down to November and finally becomes low In February. The mean discharge of Dhudhi Kosi becomes low in March and snow melt starts from April to June. The rate of decrease from October to January is 2.8 cumec per day. Sun kosi becomes low in March and gradually rise in May by snow melt and leads peak in July and slowly comes down. The role of decrese 5.1 cumec per day from October to January. The rate of Tamur is 4 cumec/day.



Due to sudden decrease of velocity and seasonal variation of discharge the river Sapt Kosi has its pattern purely different from high attitude course.Due to high gradient in slope all downstream comes down with high velocity. In the scarped valley number of landslide, debris slide or Earth slide can be seen, small scale waterfall are frequently large amount of glacier melted water flows in the main stream in monsoonseason it brings maximum fluvial impact over the basin, due to this in the lower Sapt Kosi basin characterized with over discharged, resultant as flood.Due to wide valley profile, low velocity and less discharge the huge amount of load with big size boulders, pebbles and rock fragments can be seen in Terai region. In the upper river basin Sapt Kosi's tributaries have significantly characteristics, we found their gradient in many places described as follows:

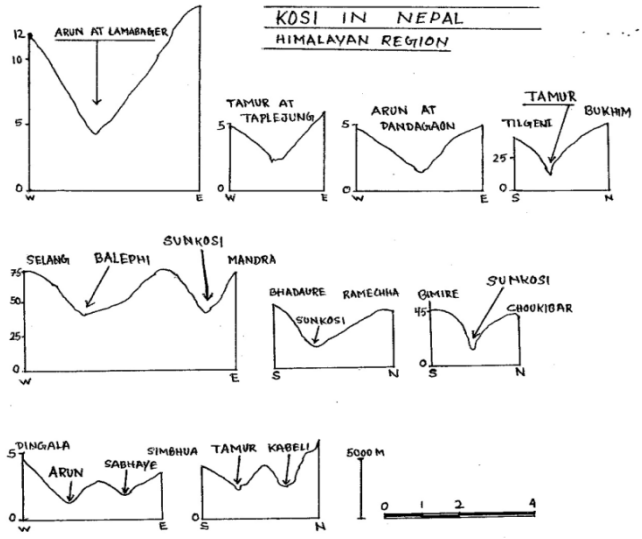
River	From	To	Distance	Gradient (In feet/mile
Arun	Tibet (10000')	Naktang (7610')	6 mile	398
	Naktang	Sedua (4080')	36	98 (deep gorge)
	Sedua	Meleng (2500')	7	225
	Maleng	Rameche (2000')	14	35 (wide valley with sandbars)
	Ramche	Mughaghat (1500')	30	16
Tamur	Sakathum (5000')	Khokling (2500')	16	156
	Khokling	Angbung (2000'/0	12	41
	Angbung	Mahasar (1500')	14	35
Sun Kosi	Kodari (5000')	Chakhukhola (4500')	4.8	104
	Chakhakhola	Ghumtang (4000')	.6	83
	Gurdum	Tokarbu (3000')	.6	83 (Rapids)
	Tokrbu	Chuka (2500')	11.2	45 (Sandbars)
Dudhi Kosi	Jubling (5000')	Chijankhughat (2500')	24	104
	Chisanku	Kharpa (2000')	.4	125
	Kharpa (1550')	Kudule	18	25

It indicates that the average gradient is 226 feet in Khimtikhola and main channel of Sunkosi is 35 feet per mile.

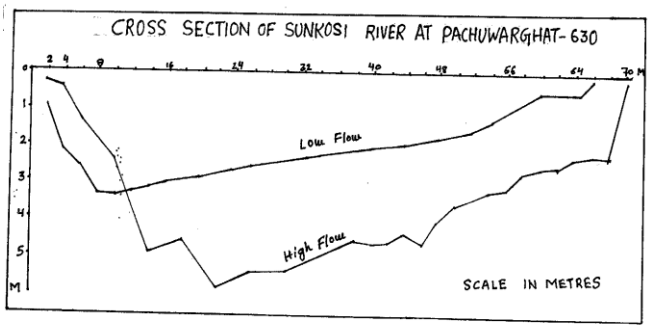
The shape and size of channel is important and this gives some idea about the cross section and the velocity. In the high flow the channel which is 120 m and max depth is 7.3 meters covering a cross sectional area 2171 sq.mile with discharge of 1860 cumec and velocity was 3.95 m/sec. whereas, the same river at low flow has channel 0.83 m wide and the maximum depth is 1.8 meter. Velocity is 0.64 m/sec and Discharge 54.5 cumec. SunKosi at Pachuwarghat has 70 meter wide river channel, being rocky the channel is not wide and hence the main variation is the scaring depth. In high flow V= 3.06 m/sec had discharge 6.73 cumec whereas, in the low flow 72.9 cumec with velocity 0.65/m/sec and depth was 6 meter.

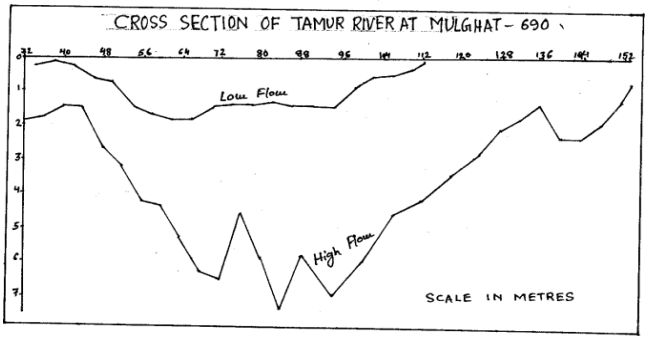
Later on the same place the channel is deepened to 10 meters and velocity increased 4.8-8 m /sec to cause the flow 2000 cumec and cross sectional area 498.40 sq.m and low flow the cross section area of channel was 101.67 sq.m and velocity 0.43 m/sec and

discharge was 43.68 cumec. This indicates that each time nearly 6 meters column of bed load is removed at the onset of flood to accommodate the flow and deposited the same slowly in the 10 m flow.



Channel altitude (Thalweg) has been recorded their gradient and channel relief has been determined registered by a number of different landforms such as glaciers, hanging valley, rapids, waterfall, potholes, in the upper catchments and pool and the depression landforms in the lower catchment area. Loose sediments and rock fragments in different segments in the channel bed are supported by annual renewal of sediment load especially during maximum fluvial season; which is significantly affecting the overall channel configuration of the river Sapt Kosi. Longitudinal profile noticed a considerable number of falls from upper to lower reaches indicating the changing pattern of channel morphology.





Sedimetation:

Sediment in the rivers are two types that is suspended sediment and bed load. Suspended sediments are fine and mixed with water which are cause of silting and bed load are reason for channel shifting. Mass of sediment increases with landslide, mass movement, deforestation, rainfall etc. Tributary Tamur is the major source of sediments in Sapt Kosi river valley. These can be clear from the following data:

S.N.	Rivers	Catchment area	Sediments	Sediment load m^3 per sq. km.
1.	Sunkosi	19230 sq.km.	$54.2x10^6m^3$	2818
2.	Arun	36533 sq.km.	$34.6x10^6m^3$	947
3.	Tamur	5900 sq.km	$29.6x10^6m^3$	5016
Total		61663 sq.km.	$116.4x10^6m^3$	

Channel Direction:

Tamur, Sunkosi and Arun join at Tribeni and come out as Sapta Kosi from the gorge of Chatra. The Sapt Kosi river is a ideal river in view of fluvial landscape development. Approximately all type of channel morphology are founds which are significantly checkup through channel direction.

The following table displays the magnitude variation of channel direction.

1.	SunKosi Upper Middle Lower Lowest	S30^{0}W S30^{0}E (Tectonic) S40^{0}E S70^{0}E	9.	Arun	S55^{0}E
2.	Indrawati	S50^{0}E	10.	Tamur Upper Middle Lower At Dhankuta	S5^{0}W S45^{0}W S45^{0}E (Tectonic) S45^{0}W S75^{0}W
3.	Balephi	N-S	11.	Kosi in Gorge Kosi in Terai	S5^{0}W S45^{0}W
4.	Rosi	S60^{0}E	12.	Kamala	N-S
5.	Tamakosi	S30^{0}E	13.	Bagmati	S12^{0}W (Topographic)
6.	Likhu	S35^{0}W	14.	SaptKosi Near Kosi Barrage	N-S
7.	Dudhkosi Upper Lower	N-S S65^{0}W	15.	SaptKosi Near Kursela	W-E
8.	Arun Uppper Middle Lower	S15^{0}W S45^{0}W S20^{0}E (Tectonic) S40^{0}E	16.	SaptKosi Near Kundah	N-S

Density of drainage:

Density of drainage reflects topography, rainfall and

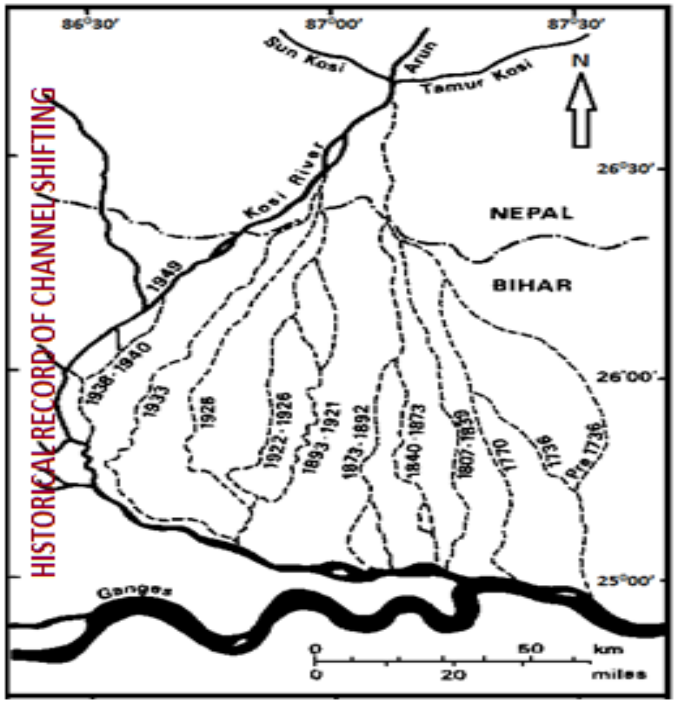
type of rocks. In the Terai and CHuria hill the drainage is dendritic. The total length of first second and third orders river channels versus total area they drain is given below:

1.	Indrawati – Sunkosi (hill)	0.78
2.	Kamla	0.44
3.	Arun river northern part	0.80
4.	Loer Arun valley	0.58

Drainage density based 1"= 4 mile map

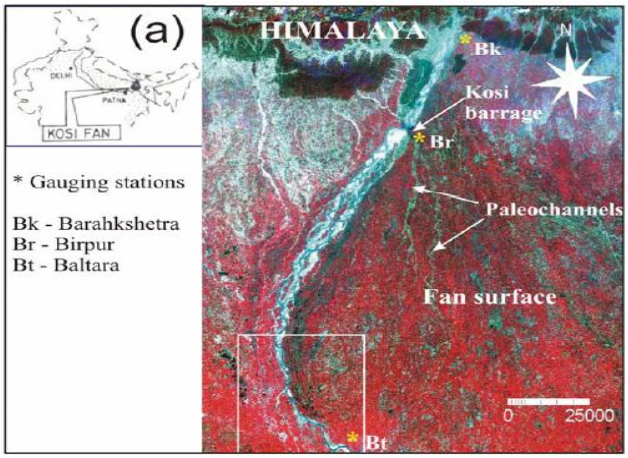
According to above drainage density id reduced in Terai area (0.4) linear mile to per sq.mile, compared to mountains which range 0.52 to 0.8.

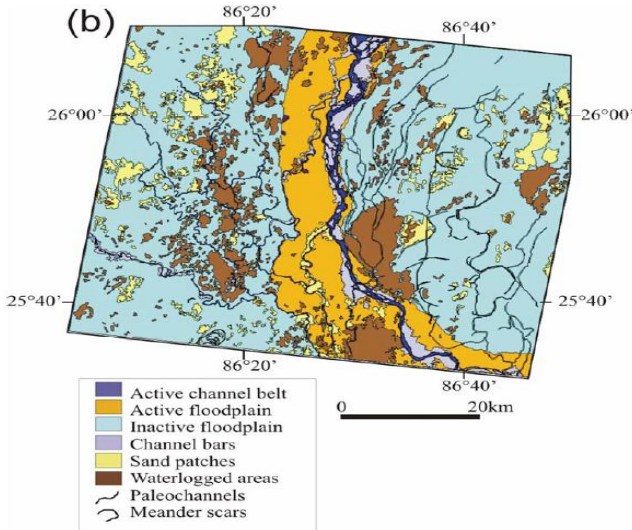
1. Number of 'V' shaped depression valley can be seen which denoting the vertical erosion downward.
2. Shivalik rocks (conglomerate, silting, cable) etc. can be easily identify in the Terai region, where Sapt Kosi started to braiding (specially from south of Chatra).
3. A number of high and lows registered by pools and riffles are recovered in the channel denoting the channel depth variation.
4. Channel highs are denoting sedimentation or siltation in the channel carried by the river during the rainy season.
5. Channel high are registered as different depositional features in the lower Sapt Kosi fan, such as mid channel bar, channel bar, point bar, ox-bow Lake in side of channel etc. of different sizes and shapes.



In this study, seen that in the upper catchment are described by high degree of gradient, resultant speed and velocity leads to high discharge, capable to carry big size boulders, cobles and pebbles toward downward direction; and comparatively shallow part of the channel comprised of fine sand and marshes. Fine sand, clay, silt constitutes to upper ridges of Sapt Kosi fan which leads to channel shifting again and again. Channel deposition constitutes the depositional features of the channel. Sapt Kosi fan submerges during the rainy season and because the active sector of the channel configuration system.

In the Terai region characterized by coarse sand, fine sand, silt, medium size rock fragments, small pebbles etc. in Bihar region, Sapt Kosi river embarkmented by man and natural system of channel morphology got affected. During maximum fluvial season maximum discharge of water leads to configure the channel morphology. The main importance in geometrical point of view is channel shifting.During the last two centuries, for whichrecords are available, the river has changed its course in a westerly direction and it haslaterally moved nearly 150 kilometers (Gole and Chitale, 1966).

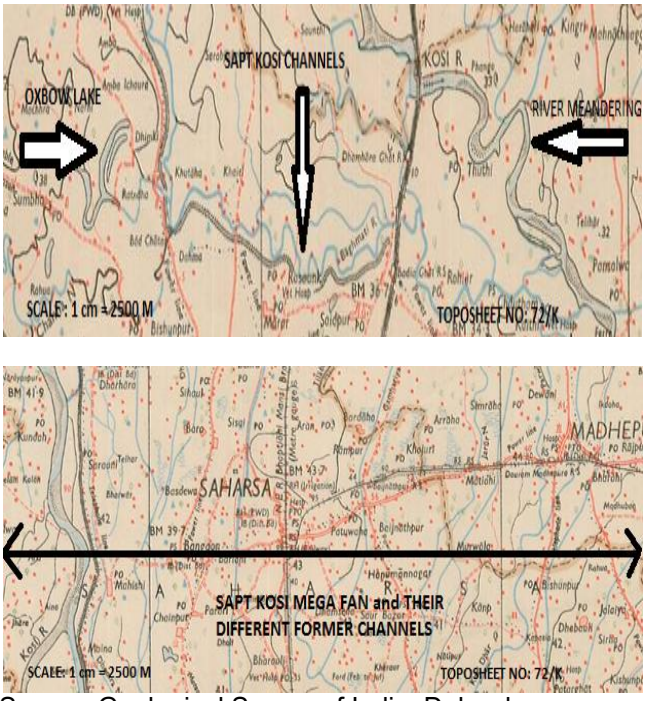




A number of paleochannels on the satellite image of the Sapt Kosi basin testify the migratorybehaviour of the river (above figure). The river is typically braided in nature and has formed a very large alluvial fan due to a large sediment supply from the Himalaya and a generally aggradational regime. Further complications

arise due to (a) very high rainfall in thecatchment (1200-2000 mm in most parts),

Meandering:
Most of the rivers meanders when they reach midland or in plain region. In case of the Arun river even though the main course is north – south it meanders within limit of the valley because valley becomes wide. Similarly the Kosi river starts meandering after the Dolaghat where the river is flowing near one bank and deflected to other bank in the next few km. But when Sapt Kosi river goes down in fan region of Biharriver creates great meandering with slow flow. It can be more clear through the beside and following toposheet figure.



Source: Geological Survey of India, Dehradun

Conclusion

The study of channel configuration of the river Sapt Kosi displays some intensity facts and observations. The whole basin is no doubt a significant field of geomorphology and some geomorphic issue as well as some environmental problems are to be noted in relation to the channel configuration issue in fluvial geomorphology.
The studied span of river Sapt Kosi is flowing along a significant zone of Greater, Middle and lower Himalaya, Tibet plateau and Bihar Plain. Fluvial dynamics in upper catchment area are significantly influence on the lower Sapt Kosi fan system; through the historic time to till now and it will probably continue in the coming future also.

Reference

1. Arogyaswamy, R.N.P., 1971. Some geological factors influencing the behaviour of the Kosi. Records of Geological Survey of India, 92 (2), 42-52.
2. Gole, C. V. and Chitale, S. V., 1996. Inland delta building activity of Kosiriver. Journal of the Hydraulics Division, American Society of Civil Engineers, 92, 111-126.

POSTER PRESENTATION IN THEMATIC CARTOGRAPHY

Prof. Premlata Singhi
Ashmita Rumde, Vinod Kanojia**,** F.Y. B.Com Students
Mittal college, Mumbai.

Map is the representation of the earth or parts of the earth on the plain surface drawn to specific scale. Geographer is interested in studying statistical figures of the production, distribution and consumption of various commodities in the world. When this statistical data is represented with the help of cartographic techniques then it becomes easy to understand. Cartography is the discipline dealing with maps and mapping .Literally meaning the science or practice of map drawing .The field of cartography can be divided in two general categories. General cartography and Thematic cartography. General cartography shows a variety of features for general audience. Thematic cartography involves maps of specific geographic themes oriented towards specific audience for example dot map, choropleth map etc.

As the volume of geographic data has exploded over last century, Thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data. Now these maps are the visual representation of data. These maps prepared by using cartographic techniques to represent the statistical data are equivalent to reading many pages and pictures. Such maps are also helpful in making comparative study of the production in different countries, areas or regions.Topographical maps show natural as well as man-made features of an area and draw on large scales but Thematic maps are maps for special purpose. Such maps are prepares as per the users requirements.An interesting cartography of map will no doubt engage the reader. Information richness shows relationship with in the map. Showing several variables allows comparison which adds to the meaningfulness of the map .This also generates hypothesis and stimulates ideas and perhaps further research.

Depending on the nature of the phenomena, one dimensional, two dimensional, or three dimensional diagrams are used:

a) One dimensional: such as simple bar diagram

b) Two Dimensional: Use rectangles, circles, and squares.

c) Three Dimensional: Cubes and Spheres.

These graphical techniques when used to represent information in maps are called as cartographic techniques. The commerce student uses following techniques to represent information in the maps. An attempt is made by the commerce students to design posters in a manner which will aid the reader in the over all understanding of its purpose.

Bar Graphs: The simple vertical bars are drawn to show the total quality of a phenomenon. Sometimes two aspects of a phenomenon can be shown by divising the bar proportionately, like rural and urban literacy. Such bar is called compound bar or component bars. Alternatively, separate bars showing rural and urban literacy can be shown side by side. This technique is called a multiple bar diagram. So there are in all:

a. Simple Bars

b. Comparative Bars (Multiple)

c. Component Bars (Percentage)

Dot Maps: When the occurrence and location of phenomena is fixed, point symbol can be used to represent the data, popularly known as dot technique. On this technique, a dot representing a unit quantity is distributes over the area in accordance with the approximate location while putting the dots on the map. The physiography of the region must be taken into consideration as the distribution of the elements is governed by the physical features like mountains, rivers, forests etc.

Proportionate Circle: when the quantities of phenomena vary over a great range, the common method of representation is to use proportionate symbols showing the quantitative differences. The are os a circle is made proportionate to the quantity ot represents.

Pie Diagram: It is also known as divided circle. It is drawn to compare two or more components of phenomena. Here the totals are shown by the circles of same size and the component parts are shown by the proportionate sectors of the circles. Pie Diagrams are used to compare the rural-urban population, the proportions of land area under different crops or landuse patterns in different countries etc. the square root of total is taken, and scale is decided for the radius of the circle. Once the circle is drawn which represents 360, other angles are calculated. Mark the angle in the circle, further shaping and colour can be used in that circle.

Chloropleth: These maps are also called as density maps, as the quantity of the data relates to the area. This technique is used when the data given is administrative boundary wise at any level. The given data is divided into five or six classes and values are assigned to each class. The front shades are used to bringing out the sufficient differences in the distribution

of the p[phenomenon. Following points should be considered while preparing chloropleth:

1. Average density figures per unit area and outline map of that area are essential.
2. After understanding the maximum and minimum values, suitable intervals should be then decided.
3. To decide shaping scheme, basic principle used is to have dark shading for highest value and gradually shading decreases with decreasing value. This ensures that the lowest shading is shown by white or the lightest colour of the shade.
4. A key for the shading scheme with interval figure should be given on the right side of the map.

Merits of this method:

1. The distribution of the element in different political units is shown clearly due to the use of shading scheme.
2. It is very useful to make comparative study of sub-regions.

Demerits of this method:

1. The map gives vague idea about the distribution of element in a given area. The internal variation in the area cannot be studied by this method.
2. While using this method, the physical features such as lakes, mountains, and desserts are not considered.

The chloropleth technique can be used to show the density of population and growth rate of population in the world.

Pictorial Diagram: In pictorial Diagrams, pictorial symbols are used to represent statistical data. Generally, an outline map with political boundaries is used and pictorial symbols are drawn in political areas.

Merits:

1. Pictorial diagrams are very easy to understand.
2. They give general idea about production in different areas.
3. It is easier method to represent the statistical data and to read it.

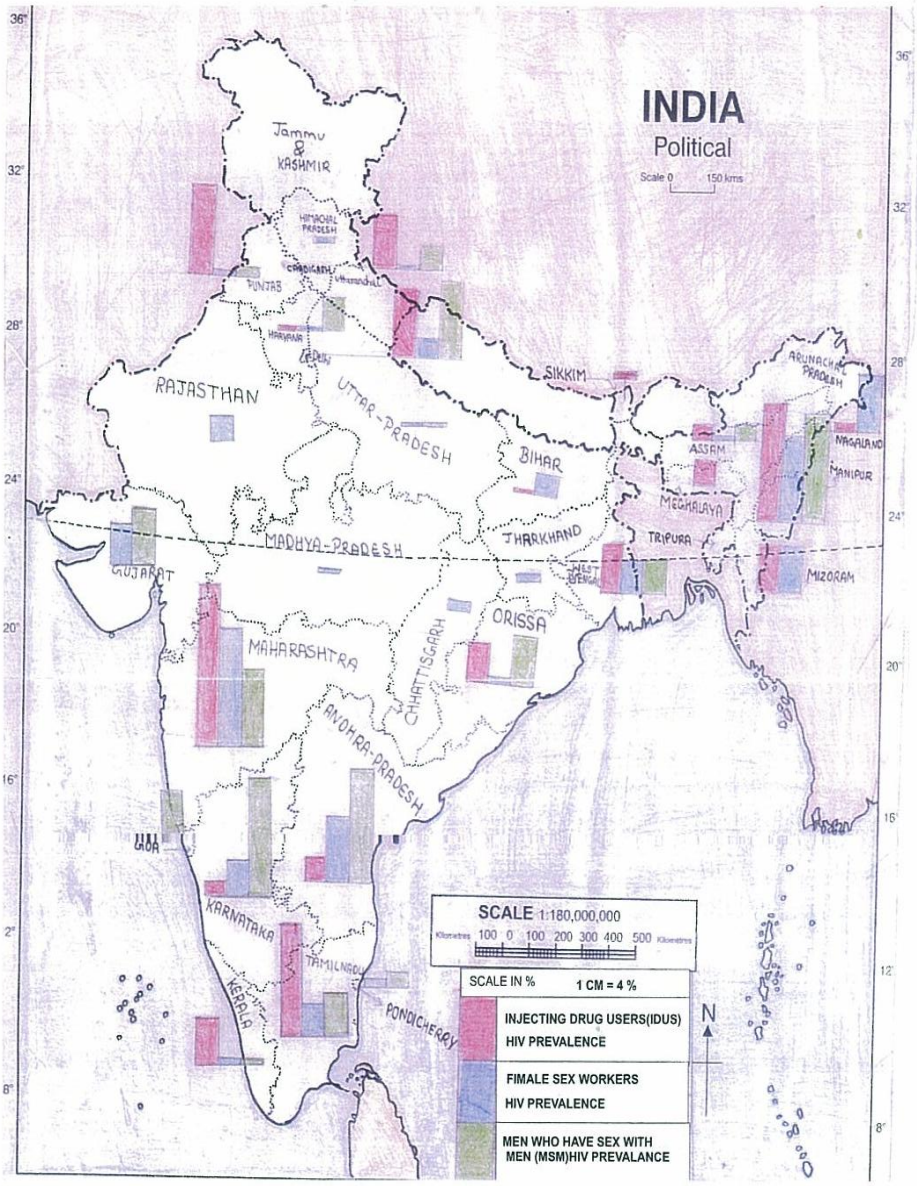
Demerits:

1. The main drawback is that it gives approximate rather than accurate information.
2. Many times the political area of the state in the maps are not enough to draw required number of pictures.

References

1. Alan G. Hodgkiss. (2007) Discovering ANTIQUE MAPS,Shire Publication Ltd.UK,5-7.
2. Aslam Mahmood.(1977) Stastical Methods in Geographical Studies,Rajesh Publications,New Delhi.
3. Dr. Shrikant Karlekar, Dr. Mohan Kale,(2006) Stastical Analysis of Geographical Data,Diamond Publication,Pune,
4. Zamir Alvi. (2005) Stastical Geography Methods and Applications, Jaipure .
5. D. N. Sarkar, V. Kumar, (2009) Environmental Studies, Himalaya Publishing House, Mumbai, 187-198.
6. Shailaja Sangle (2009) Environmental Studies, Reliable Publications, 52,129.

HEALTH STATISTIC IN INDIA 2007



state	Injekting drug user (IDU)-HIV prevelance % of 2007	1cm=4%
Arunanchal preadesh	0	0
tripuri	0	0
Sikkim	0.47	0.11
Bihar	0.6	0.15
Haryana	0.8	0.2
Nagaland	1.91	0.48
Karnatka	2	0.5
Assam	2.49	0.62
Andhra pradesh	3.7	0.92
Meghalaya	4.12	1.03
Orrissa	7.33	1.53
Mizoram	7.53	1.88
West Bengal	7.76	1.94
Kerla	7.85	1.96
Chandigarh	8.64	2.16
Delhi	10.1	2.52
Punjab	13.79	3.4
Tamilnadu	16.8	4.2
Manipur	17.9	4.4
Maharashtra	24.4	6.1

State	female sex prevelance % of 2007	1cm=4%
Sikkim	0	0
Chandigarh	0.4	0.1
Assam	0.44	0.11
Punjab	0.65	0.13
Madhya pradesh	0.67	0.16
Utter pradesh	0.78	0.19
Orrissa	0.8	0.2
Himanchal pradesh	0.87	0.21
Kerla	0.87	0.21
Haryana	0.91	0.22
Jharkhand	1.09	0.27
Pondicheray	1.3	0.32
Chhatishgarh	1.43	0.35
Delhi	1.15	0.29
Bihar	3.4	0.85
Rajasthan	4.16	1.04
Tamilnadu	4.68	1.17
Karnatka	5.3	1.32
West Bengal	5.92	1.48
Gujrat	6.53	1.63
Mizoram	7.2	1.8
Nagaland	8.91	2.22
Andhra pradesh	9.74	2.43
Manipur	13.07	3.26
Maharashtra	17.91	4.477

state	Men who have sex with men (MSM)HIV prevelance 2007(%)	1 cm=4%
Bihar	0	0
Himanchal pradesh	0	0
Utter pradesh	0.4	0.1
Kerla	0.96	0.24
Punjab	1.22	0.3
Pondicheray	2	0.5
Assam	2.78	0.69
Chandigarh	3.6	0.9
Haryana	5.39	1.34
West Bengal	5.61	1.4
Tamilnadu	6.6	1.65
Orrissa	7.37	1.84
Goa	7.93	1.98
Gujrat	8.4	2.1
Delhi	11.73	2.93
Maharashtra	11.8	2.95
Manipur	16.4	4.1
Andhra pradesh	17.04	4.26
Karnatka	17.6	4.45

Sub Theme- Cartography for Urban and Regional Mapping – October 11-13, 2012, Dehradun

POSTER PRESENTATION IN THEMATIC CARTOGRAPHY

Prof.PremlataSinghi,AshmitaRumde,VinodKanojia, F.Y. B.Com Students,Mittal college, Mumbai.

Map is the representation of the earth or parts of the earth on the plain surface drawn to specific scale. Geographer is interested in studyingstatistical figures of the production, distribution and consumption of various commodities in the world. When this statistical data is represented with the help of cartographic techniques then it becomes easy to understand. Cartography is the discipline dealing with maps and mapping .Literally meaning the science or practice of map drawing .The field of cartography can be divided in two general categories. General cartography and Thematic cartography. General cartography shows a variety of features for general audience. Thematic cartography involves maps of specific geographic themes oriented towards specific audience for example dot map, choropleth map etc.

As the volume of geographic data has exploded over last century, Thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data. Now these maps are the visual representation of data. These maps prepared by using cartographic techniques to represent the statistical data are equivalent to reading many pages and

REFERENCES:

Alan G.Hodgkiss. (2007) Discovering ANTIQUE MAPS,Shire Publication Ltd.UK,5-7.

AslamMahmood.(1977)Stastical Methods in Geographical Studies,RajeshPublications,New Delhi.

Dr.ShrikantKarlekar, Dr. Mohan Kale,(2006)Stastical Analysis of Geographical Data,DiamondPublication,Pune,

ZamirAlvi.(2005)Stastical Geography Methods and Applications,Jaipure .

D.N.Sarkar,V.Kumar,(2009)Environmental Studies,Himalaya Publishing House,Mumbai, 187-198.

ShailajaSangle(2009)Environmental Studies,Reliable Publications,52,129.

Prof.Premlata Singhi, Mittal College Mumbai
Student F.Y.B.Com

Cartographic technique: Bar Graphs

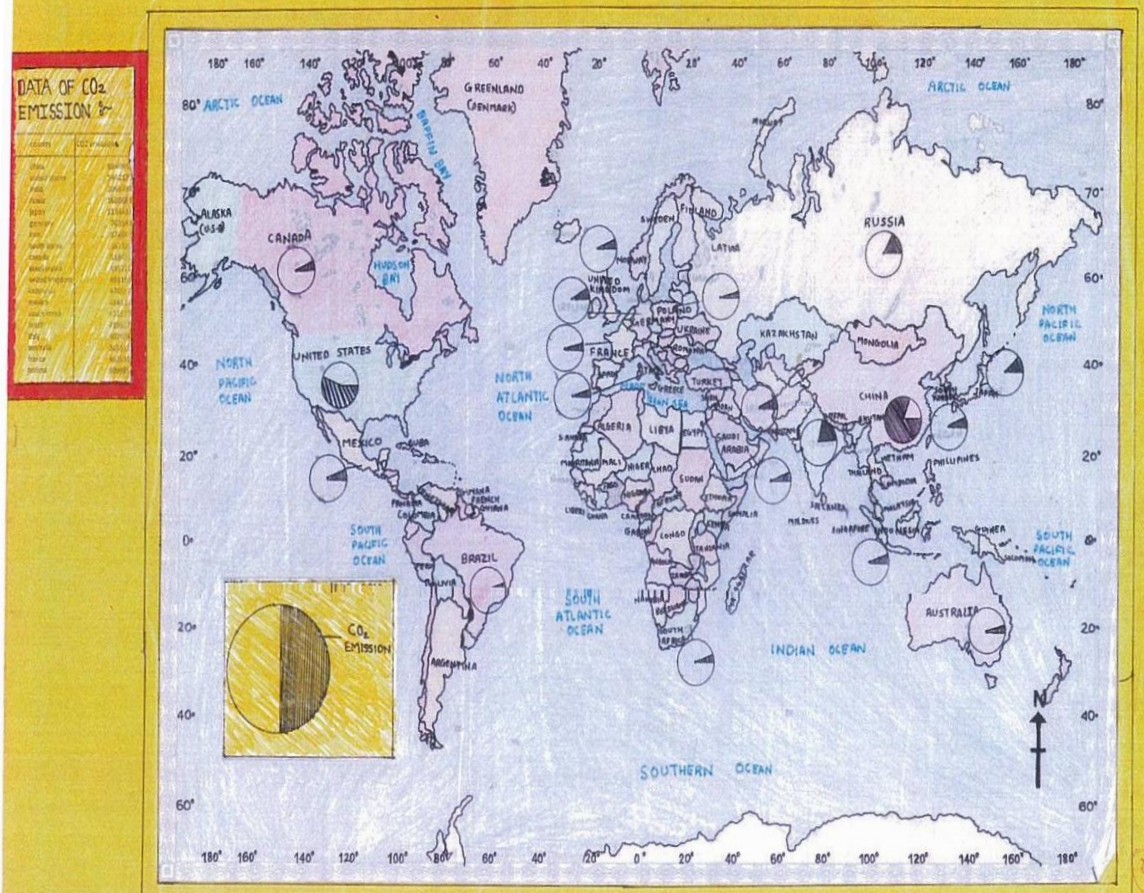
The simple vertical bars are drawn to show the total quality of a phenomenon. Sometimes two aspects of a phenomenon can be shown by devising the bar proportionately, like rural and urban literacy. Such bar is called compound bar or component bars. Alternatively, separate bars showing rural and urban literacy can be shown side by side. This technique is called a multiple bar diagram. So there are in all:

a. Simple Bars
b. Comparative Bars (Multiple)
c. Component Bars (Percentage)

Health Statistics in India through cartography

- States of Maharashtra and Manipur have all the three HIV cases highest in India
- Karnataka and Andhra Pradesh are the two states that have very high HIV cases by men who have sex with men
- Goa has only one type of HIV case – of men who have sex with men
- Punjab, Tamil Nadu, Delhi, Uttaranchal, West Bengal and Kerala are the cases of HIV by Injecting Drug User
- Nagaland and A.P has high HIV by female sex workers
- Rajasthan, Bihar, Jharkand, Chattisgarh , M.P, Himachal have HIV only by female sex worker

WORLD DISTRIBUTION OF CO_2 EMISSION-12



Sub Theme- Cartography for Urban and Regional Mapping - October 11-13, 2012, Dehradun

POSTER PRESENTATION IN THEMATIC CARTOGRAPHY

Prof.PremlataSinghi,AshmitaRumde,VinodKanojia, F.Y. B.Com Students,Mittal college, Mumbai.

Map is the representation of the earth or parts of the earth on the plain surface drawn to specific scale. Geographer is interested in studyingstatistical figures of the production, distribution and consumption of various commodities in the world. When this statistical data is represented with the help of cartographic techniques then it becomes easy to understand. Cartography is the discipline dealing with maps and mapping .Literally meaning the science or practice of map drawing .The field of cartography can be divided in two general categories. General cartography and Thematic cartography. General cartography shows a variety of features for general audience. Thematic cartography involves maps of specific geographic themes oriented towards specific audience for example dot map, choropleth map etc.

As the volume of geographic data has exploded over last century, Thematic cartography has become increasingly useful and necessary to interpret spatial, cultural and social data. Now these maps are the visual representation of data. These maps prepared by using cartographic techniques to represent the statistical data are equivalent to reading many pages and

REFERENCES:

Alan G.Hodgkiss. (2007) Discovering ANTIQUE MAPS,Shire Publication Ltd.UK,5-7.

AslamMahmood.(1977)Stastical Methods in Geographical Studies,RajeshPublications,New Delhi.

Dr.ShrikantKarlekar, Dr. Mohan Kale,(2006)Stastical Analysis of Geographical Data,DiamondPublication,Pune,

ZamirAlvi.(2005)Stastical Geography Methods and Applications,Jaipure .

D.N.Sarkar,V.Kumar,(2009)Environmental Studies,Himalaya Publishing House,Mumbai, 187-198.

ShailajaSangle(2009)Environmental Studies,Reliable Publications,52,129.

Prof.Premlata Singhi, Mittal College,Mumbai

F.Y. B.Com Students

Cartographic technique: Pie Diagram

It is also known as divided circle. It is drawn to compare two or more components of phenomena. Here the totals are shown by the circles of same size and the component parts are shown by the proportionate sectors of the circles. Pie Diagrams are used to compare the rural-urban population, the proportions of land area under different crops or land use patterns in different countries etc. the square root of total is taken, and scale is decided for the radius of the circle. Once the circle is drawn which represents 360, other angles are calculated. Mark the angle in the circle, further shaping and colour can be used in that circle.

World Distribution of CO2 Emission 2012

- CO2 is the chief active gas causing earth's nature Green House effect.
- Its increase in the atmosphere has consequently led to increase in world temperature due to its property of absorbing heat.
- There is a need to mitigate CO2 emission.
- The initiative to reduce is provided by Kyoto Protocol which provides certain market based flexibility mechanisms.
- CO2, a polluting gas has become a commodity of exchange.
- The year 2008 marked the beginning of the commitment period which ends in 2012. So the seriousness to buy carbon credit will increase among developed countries in order to fulfill the Kyoto Protocol emission limit.
- The world must restrict its carbon emissions to 190 gigatonnes by 2050 if it is to have a chance of escaping the catastrophic consequences of global warming.
- The world must cut emission faster and deeper. The carbon budget is like a cake much of which has been eaten by the developed. For the

धार जिले (म.प्र.) की संसाधन क्षमताओं के विकास में आउटसोर्सिंग की भूमिका
Role of Outsourcing in Development of Resource Potential of Dhar District (M.P.)]

डॉ. आरती कमेड़िया
शा. क. वा. महा.
इन्दौर (म.प्र.)

मनीश पाण्डेयडॉ.
शोध विधार्थी
शा.क.वा.महा. इन्दौर (म.प्र.)

देवेन्दर कौर
प्राध्यापक,शा.क.वा.महा.
इन्दौर(म.प्र.)

सारांश :–
प्रस्तुत अध्ययन में म.प्र. के धार जिले में आउटसोर्सिंग की भूमिका का अध्ययन किया गया जिससे हमें ज्ञात हुआ कि धार जिला जनजातिय बाहुल्य क्षेत्र होने की वजह से आउटसोर्सिंग की प्रक्रिया अपनी प्रारम्भिक अवस्था में हैं। धार जिले में आउटसोर्सिंग एवं इनसोर्सिंग का अध्ययन सेवाओं के वितरण के आधार पर किया गया है । अतः धार जिले में आउटसोर्सिंग नवीन क्रिया होने की वजह से संसाधन क्षमताओं के विकास में इसका नियोजित रुप से क्रियान्वयन विकास हेतु आवश्यक है ।

(1) प्रस्तावना :–
उदारीकरण की नीति एवं मुक्त बाजार व्यवस्था के तहत शहरी क्षेत्रों के साथ – साथ ग्रामीण क्षेत्रों में भी कई परिवर्तन हुए है तथा विभिन्न नवीन क्रियाएँ प्रारंभ हुई है। इन्हीं नवीन क्रियाओं से जुड़ी है आउटसोर्सिंग की क्रिया ।

आउटसोर्सिंग एक ऐसी व्यवस्था होती है जिसमें एक कंपनी दूसरी कम्पनी को सेवाएँ देती है । आउटसोर्सिंग जहाँ उत्पादक, उपभोक्ता और किसी कंपनी के लिए फायदेमंद है वहीं किसी क्षेत्र विशेष की उन्नति में भी सहायक है, इसलिये यह अध्ययन किया गया कि आउटसोर्सिंग ने जनजातिय बाहुल्य धार जिले के ग्रामीण – नगरीय क्षेत्रों को कितना प्रभावित किया है तथा आउटसोर्सिंग से विकास की क्यॉ–क्यॉ सम्भावनाएँ है।

(2) उपकल्पनाएँ :–
प्रस्तुत शोध–पत्र में निम्नलिखित उपकल्पनाएँ अभिकल्पित की गई है–

(i) बदले संदर्भ में मुक्त बाजार की नीति के तहत धार जिले में आउटसोर्सिंग की विकास–पूर्ण शुरुआत हुई है।

(ii) उचित नियोजन के माध्यम से आउटसोर्सिंग को धार जिले में बढ़ाया जा सकता हैं।

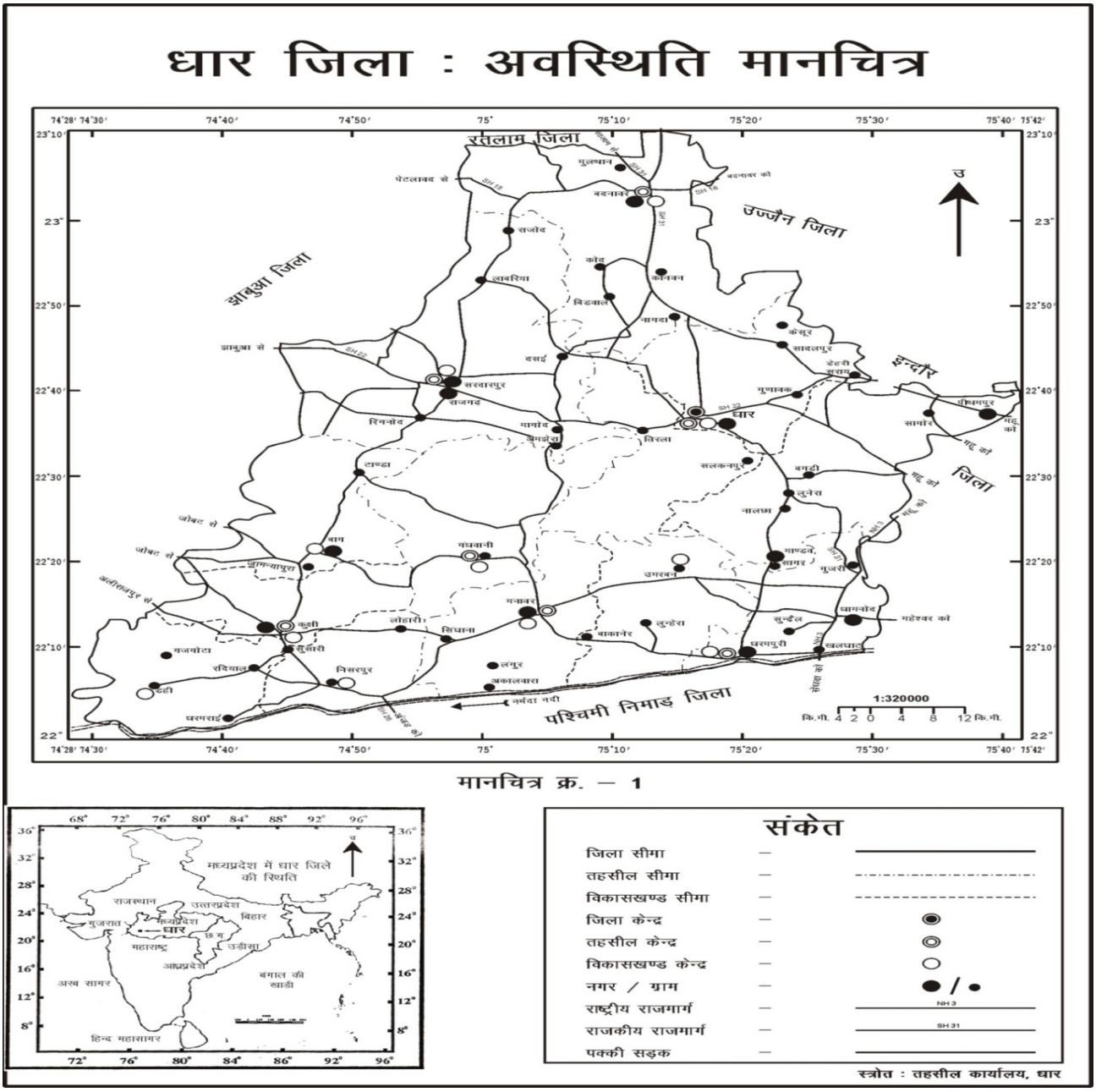
(3) उद्देश्य :–
शोध–पत्र के निम्नलिखित उद्देश्य है –

(i) धार जिले की वर्तमान स्थिति एवं पदानुक्रमण के आधार पर सेवा केंद्रों का निर्धारण ।

(ii) धार जिले के सेवा केंद्रों में निम्न कोटिक्रम, मध्यम कोटिकम एवं उच्च कोटिक्रम की सेवाओं की आउटसोर्सिंग का विश्लेषण ।

(iii) धार जिले में आउटसोर्सिंग में आ रही बाधाएँ तथा संसाधन क्षमताओं के विकास में आउटसोर्सिंग की भूमिका का अध्ययन ।

(4) अध्ययन क्षेत्र :–
अध्ययन क्षेत्र धार जिला 22°0′ उत्तरी अक्षांश से 23°10′ उत्तरी अक्षांश एवं 74°28′ पूर्वी देशांतर से 75°42′ पूर्वी देशांतर के मध्य फैला हुआ है। यह जिला मध्यप्रदेश के पश्चिमी भाग में स्थित है। जिले का क्षेत्रफल 8153 वर्ग कि.मी. एवं वर्ष 2011 के अनुसार जनसंख्या 21,84,672 है। जिले में 7 तहसीले एवं 13 विकासखण्ड है। धार जिले का जनसंख्या घनत्व 268 व्यक्ति प्रति वर्ग कि.मी. है। धार जिले में रेल सुविधा नहीं है। यहाँ सबसे नजदीकी हवाई पट्टी इन्दौर में है।



(5) विधि तंत्र :–

प्रस्तुत शोध अध्ययन में धार जिले के 68 हाट बाजार अध्ययन का समग्र है । इन 68 हाट बाजारों का स्केलोग्राम बनाकर उनके केन्द्रियता मान के आधार Q_3, मीडियन तथा Q_1 की गणना करके मीडियन मान से अधिक 34 हाट बाजारों का चयन किया गया । ये ही सर्वेक्षण की न्यूनतम इकाई हैं । इन 34 हाट बाजारों का पुनः स्केलोग्राम निर्मित कर सेवाओं का निम्न,मध्य एवं उच्च कोटिक्रम ज्ञात किया गया ।

अध्ययन में द्वितीयक एवं प्राथमिक दोनों ही स्त्रोतों से आँकड़े एकत्रित किए गए है । सर्वेक्षण हेतु सेवा केंद्रो के कुल परिवारों की संख्या का 5%भाग साक्षात्कार अनुसूची के लिए चुना गया । प्रत्येक केंद्र में अवलोकन तालिका एवं समूह चर्चा द्वारा प्राप्त जानकारी को भी विश्लेषण में सम्मिलित कर अध्ययन किया गया है ।

(6) धार जिले में आउटसोर्सिंग :–

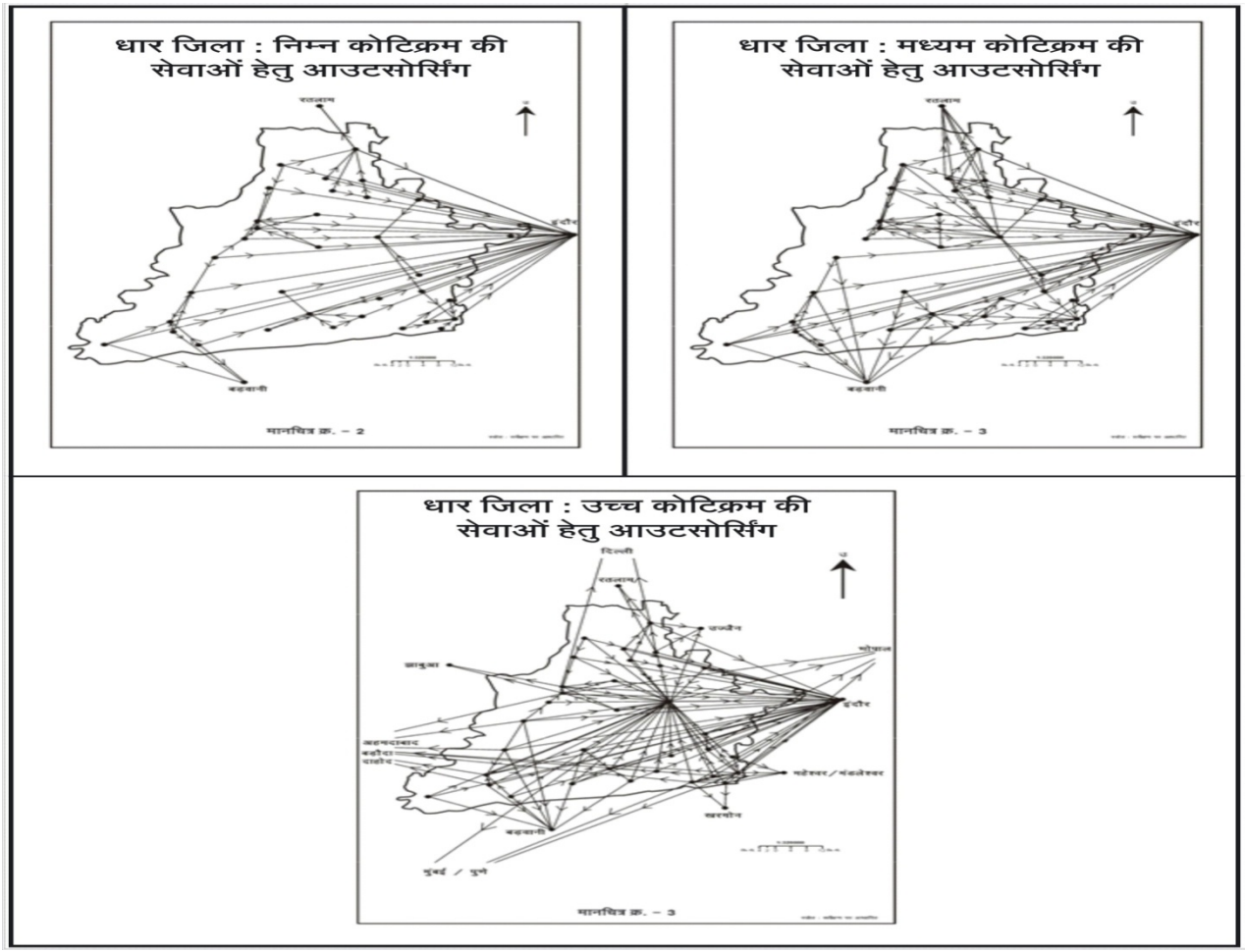
आउटसोर्सिंग को वर्तमान आर्थिक परिदृश्य में एक सक्रिय व्यापार रणनीति के रुप में देखा जा सकता है । आउटसोर्सिंग भविष्य की लहर है जो पैसा बचाती है तथा गुणवत्ता को बढ़ाती है ।

मुक्त बाजार की व्यवस्था ने जहाँ भारत की आर्थिक स्थिति को सुदृढ़ किया है, वहीं धार जिला भी इससे अछूता नहीं है। आउटसोर्सिंग का अर्थ हम जिस बड़े

पैमाने के रूप में लेते है, वह धार जिले में तो दिखलाई नहीं देती है, किन्तु मुक्त बाजार व्यवस्था के कारण भारत में आउटसोर्सिंग के विस्तार से धार जिले के भी आर्थिक परिदृश्य में परिवर्तन दिखाई देता है। चूँकि धार जिले में बड़े स्तर पर आउटसोर्सिंग विद्यमान नहीं है, इसलिए धार जिले में आउटसोर्सिंग से हमारा अभिप्राय है कि धार जिले में एक सेवा क्षेत्र या एक सेवा केन्द्र के द्वारा दूसरे सेवा केन्द्र को दी जाने वाली सेवाएँ अर्थात् एक सेवा केन्द्र अपनी कौन–कौन सी सेवाएँ बाहर या अन्य सेवा केन्द्रों (Outsource) को दे रहा है तथा कौन–कौन सी सेवाएँ बाहरी क्षेत्रों से स्वयं (Insource) ले रहा है।

धार जिले में अध्ययन हेतु कुल 41 सेवाएँ सम्मिलित की गई है। धार जिले में बैंक, टेलीफोन बिल ऑफिस, खाद–बीज वितरण केन्द्र, प्राथमिक स्वास्थ्य केन्द्र, क्लीनिक, विद्यालय, हाट बाजार, अन्य क्रेडिट सोसायटी आदि ऐसी सेवाएँ है जो सभी सेवा केन्द्रों में व्याप्त है तथा इन सेवाओं की आउटसोर्सिंग ये सेवा केन्द्र अपने आसपास के सभी छोटे–छोटे गाँवों को करते है। इसके अतिरिक्त कोर्ट, नगरपंचायत, नगरपालिका, जेल, महाविद्यालय, तहसील कार्यालय, विकासखण्ड कार्यालय, सिनेमा हॉल, नर्सिंग होम, ए.टी.एम., पेट्रोल पम्प, कृषि मण्डी, गोदाम, दो पहिया वाहन शोरूम, लॉज या होटल आदि सेवाएँ धार, पीथमपुर, माण्डव, कुक्षी, बाग, धरमपुरी, धामनोद, खलघाट, बदनावर, कानवन, नागदा, मनावर, सिंघाना, उमरबन, सरदारपुर, राजगढ़, गंधवानी, डही, निसरपुर आदि सेवा केन्द्रों में उपस्थित है जिनकी आउटसोर्सिंग लुन्हेरा, लाबरिया, रिंगनोद, कोद, गुजरी, सुन्द्रैल, केसूर, टाण्डा आदि के साथ–साथ अन्य छोटे–बड़े गाँवों को भी की जाती है। जिला कार्यालय, जिला स्वास्थ्य केन्द्र, चौपाल सागर, विशाल मेगा मार्ट ऐसी सेवाएँ है जो सिर्फ धार नगर में ही है और इन सेवाओं की आउटसोर्सिंग धार, पूरे जिले को करता है।

उच्च शिक्षा सेवा, उच्च स्वास्थ्य सेवा, दो पहिया वाहन शोरूम, चार पहिया वाहन शोरूम, मॉल या बड़े–बड़े शोरूम आदि ऐसी उच्चकोटि की सेवाएँ है जिसके लिये धार जिला इन्दौर, भोपाल, उज्जैन, पूना, सूरत, मुम्बई, दिल्ली, अहमदाबाद, बैंगलोर आदि शहरों से सेवाएँ इनसोर्स करता है।



तलिका क्र.– 1
धार जिले के सेवा केन्द्रों में व्याप्त विभिन्न सेवाएँ

क्र.	सेवा केन्द्र	सेवाएँ
1.	धार	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,32, 33,34,35,36,37,38,39,40,41
2.	मनावर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,32, 33,34,35,36,37
3.	सरदारपुर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31, 32,35,36,38
4.	कुक्षी	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31, 32,33, 34,35,36
5.	बदनावर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31, 32,33, 34,35,36
6.	धरमपुरी	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,30,31,32, 35,36,38
7.	धामनोद	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,26,27,28,29,30,31,32, 34,37
8.	पीथमपुर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,26,27,28,29,30,33,34
9.	राजगढ़	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,23,24,26,27,29,31,33
10.	बाग	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,25,26,27,29,30,31
11.	गंधवानी	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,33,34
12.	माण्डव	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,19,21,22,26,27,29,31,34
13.	खलघाट	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,23,28
14.	कानवन	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,22,23,24
15.	डही	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,20,21,22,25
16.	नालछा	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,22,25
17.	सुसारी	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,23,28
18.	नागदा	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,24
19.	राजोद	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22
20.	उमरबन	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,25
21.	सिंघाना	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,24
22.	दसई	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21
23.	अमझेरा	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,20,21,22

24.	निसरपुर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,20,25
25.	टाण्डा	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,20,22
26.	केसूर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
27.	सुन्द्रैल	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
28.	गुजरी	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
29.	बाकानेर	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
30.	बिड़वाल	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
31.	कोद	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
32.	लाबरिया	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
33.	रिंगनोद	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
34.	लुन्हेरा	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,19,20

संकेत :–

1. प्राथमिक स्कूल
2. माध्यमिक स्कूल
3. हाई स्कूल
4. हायर सेकण्डरी स्कूल
5. प्राथमिक स्वास्थ्य केन्द्र
6. क्लिनिक
7. डाक घर
8. टेलीफोन सुविधा
9. मोबाइल सुविधा
10. पक्की सड़क
11. बस सेवा
12. समाचार – पत्र
13. पत्रिकाएँ
14. टेलीफोन बिल ऑफिस
15. खाद–बीज वितरण केन्द्र
16. को–ऑपरेटिव बैंक
17. अन्य क्रेडिट सोसायटी
18. बिजली बिल ऑफिस
19. वाणिज्य बैंक
20. ग्राम पंचायत
21. लॉज या होटल
22. पुलिस स्टेशन
23. पेट्रोल पम्प
24. दो पहिया वाहन शोरुम
25. विकासखण्ड कार्यालय
26. नर्सिंग होम
27. साइबर कैफे
28. ए.टी.एम.
29. गोदाम
30. गैस बुकिंग कार्यालय
31. नगर पंचायत
32. महाविद्यालय
33. कृषि मण्डी
34. सिनेमा हॉल
35. तहसील कार्यालय
36. कोर्ट
37. नगर पालिका
38. जेल
39. जिला स्वास्थ्य केन्द्र
40. सुपर मार्केट
41. जिला कार्यालय

(7) बाधाएँ :–

धार जिले में आउटसोर्सिंग के द्वारा संसाधन क्षमताओं का विकास करने में निम्नलिखित बाधाएँ आ रहीं है –

(i) आर्थिक क्षमता कमी के कारण खरीदारी की न्यूनक्षमता
(ii) औद्योगीकरण की कमी
(iii) आवागमन के साधनों की कमी
(iv) शिक्षा का अभाव
(v) सूचना प्रौद्योगिकी साधनों की कमी
(vi) जागरुकता का अभाव
(vii) ग्रामीण बाजार का स्वभाव
(viii) अज्ञानता एवं पिछड़ापन
(ix) योजनाओं का सही प्रचार–प्रसार नहीं ।

(8) निष्कर्ष :

आउटसोर्सिंग के माध्यम से धार जिले में संसाधन क्षमताओं के विकास की कई सम्भावनाएँ निहीत है। आउटसोर्सिंग के द्वारा ग्रामीण क्षेत्रों में ग्रामीण बी.पी.ओ. स्थापित किए जा सकते हैं तथा सेवा केन्द्रों में उपस्थित सेवाओं के उचित प्रचार–प्रसार, वितरण एवं नियोजन के द्वारा सेवाओं को नया स्वरुप प्रदान किया जा सकता है। साथ ही निम्नलिखित उपाय करके भी धार जिले में आउटसोर्सिंग को बढ़ाया जा सकता है –

(i) मूलभूत साधनों जैसे – शिक्षा, स्वास्थ्य, बैंक, सूचना प्रौद्योगिकी एवं संचार के साधनों का विकास ।

(ii) गाँवो में नगरो जैसी सुविधा उपलब्ध करवाने हेतु योजनाएँ ताकि जनसंख्या का स्थानान्तरण समीपवर्ती बड़े नगरो में न हो ।

(iii) औद्योगीकरण, निजीकरण, सार्वजनिक–निजी सहयोग (PPP) तथा आउटसोर्सिंग आदि का विकास एवं प्रचार।

(iv) ग्रामीण बाजारों (नियमित एवं साप्ताहिक बाजार) का आधुनिक विस्तार ।

(v) विद्युत, जल, रेलवे लाईन, तकनीकी विकास आदि सुविधाओं हेतु योजनाएँ ।

(vi) सरकारी योजनाओं का उचित प्रबंधन व सही प्रचार–प्रसार ।

References

- Dhar District Gazetteer, 1990
- Bansal, Suresh Chandra (1999) : Urban Geography, Minakshi Publication, Meerath
- Kothari, Rakesh Kumar, Rathod , B. S. and Jain , P.C. (2009) : International Marketing , Ramesh Book Depot Publication
- What are major outsourcing benefits? (2008) \
- www.outsourcewebsite.com

INDIAN NATIONAL CARTOGRAPHIC ASSOCIATION CONGRESSES TO DATE

1990	Bombay (Mumbai)	Advances in Cartography
1991	Hyderabad	Cartography and Geo-Information System for Planning
1992	New Delhi	Mapping of Environment & Sustainable Development
1993	Dehra Dun	Cartography The Technological Transition
1994	Bangalore	Mapping from Space Cartographic Challenges
1995	Indore	Cartography Emerging Technologies and Alliances
1996	New Delhi	Carto-Vision 2001 Earth Resources Management
1997	Chandigarh	Cartography and Administration
1998	Calcutta (Kolkata)	Cartography in Action
1999	Vasco-Da-Gama(Goa)	Modern Cartography for Ocean and Land Management
2000	Dehra Dun	Cartographic Challenges at the Dawn of New Millennium
2001	Hyderabad	Cartography and E-Governance
2002	Ahmedabad	Convergence of Imagery, Information and Maps
2003	Dehradun	Sustainable Development From Village Level Upwards
2004	Kolkata	Cartographic Technologies for Water, Land and Infrastructure Development
2005	Sagar M. P.	Bridging the Digital Divide and taking Cartography at Grass roots Level
2006	New Delhi	Cartography Expanding Horizon
2007	Visakhapatnam	Cartography for Coastal Management
2008	Gandhinagar	Collaborative mapping and space technology
2009	Kolkata	Technological Solutions in Urban & Regional Mapping
2010	Dehradun	Cartography for Sustainable Environment
2011	Chandigarh	Cartography for Disaster management