28th Indian Institute of Geomorphologists (IGI) Conference

and

National Seminar

on

HUMAN IMPACT ON LANDSCAPES

(29 - 31ST October, 2015)

Souvenir & Abstract Volume

organized by

Department of Geography
North-Eastern Hill University
Shillong 793022, Meghalaya, India

In collaboration with
Indian Council of Social Science Research, NE Region;
Ministry of Earth Sciences, Govt. of India
North-Eastern Hill University, Shillong

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PREFACE

The role of human beings acting as geomorphological agents is indicated by the fact that at least one third of the Earth's continental surface of 149 million km^2 is a scene of direct or indirect anthropo-geomorphological activity. At the turn of the millennium arable land and plantations covered an area of 15 million km^2, grazing lands 35 million km^2 and built-up areas 2 million km^2. In addition to this, a considerable portion of forests covering 38 million km^2 were also under intensive human impact. The areal extension of human activities, however, cannot be adopted as quantitative or qualitative indicators of anthropo-geomorphological impact on the Earth's surface, because the influence of economic activities related to land-use types may substantially differ from one another. The determination of this value, however, is not easy. On one hand, certain human activities (forest clearing, ploughing, grazing, etc.) characteristically modify landforms in an indirect way, e.g. by altering natural erosion processes, on the other hand, there are no precise statistical data concerning the amount of the earth moved by direct anthropo-geomorphological activities. Materials moved by other geomorphic processes are considerably lower. Due to technological progress and increasing demand, humans are irreversibly changing the micro- and meso-scale topography of the Earth.

To discuss on various issues related to that aspect by different academicians and scientists from different field, the Department of Geography, North-Eastern Hill University is hosting this particular Seminar on "Human Impact on Landscapes", on the occasion of 28th Annual Conference of the Indian Institute Geomorphologists (IGI) during 29- 31st October, 2015. We, on behalf of the Organizing Committee, thank all the Members of the Executive Committee of the Indian Institute of Geomoprhologists to give us the chance to hold this Conference.

The volume has been designed with great care by arranging the abstracts according to the relevant subthemes so that the participants can easily go through the pages of their interest. 171 abstracts have been included in 7 subthemes. Some of the abstracts are so generalized that their subthemes could not be determined properly for which they have been placed close to their subthemes. Some of the abstracts crossed the limit of 300 words for which they have been edited in order to bring them within the word limit. Abstracts for plenary and lead lectures have not been changed. A separate section has been made for the abstracts of the Young Geomorphologists competition which, we believe, is going to be a special attraction of the Conference.

This Souvenir and Abstract volume is the outcome of sincere efforts of all our colleagues, scholars and students. No word is enough to thank them all. We are also thankful to Beta Analytic Inc.,USA who have accorded their kind help in bringing out this volume.

We gratefully acknowledge the financial support rendered by ICSSR (North Eastern Region), Ministry of Earth Sciences, New Delhi to organize this Conference and National Seminar.

Prof. H. J. Syiemlieh
Head & Convener
28th IGI Conference and National Seminar

Prof. Sunil Kumar De
Organizing Secretary
28th IGI Conference and National Seminar

12.10.2015

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LIST OF ABSTRACTS

APPLICATION OF MODERN TOOLS AND TECHNIQUES IN GEOMORPHOLOGY

THE UNIVERSITY

The North- Eastern Hill University (NEHU) Shillong, Meghalaya (India) was set up by an Act of Parliament and notified on 19th July 1973. The objective of the University, as laid down in the act, are "to disseminate and advance knowledge by providing instructional and research facilities in such brances of learning as it may deem fit; to pay special attention to the improvement of the social and economic conditions and welfare of the people of the hill areas of the North-Eastern region, and in particular, the intellectual, academic and cultural advancement". NEHU is performing well and it has been re-accredited by the National Assessment and Accreditation Council (NAAC) as an 'A' grade University in 2009. NEHU has also been adjudged as a 'University with Potential for Excellence' in 2006 by the University Grants Commission making it one of the top few Universities in India. According to India Today Nielson Survey NEHU ranks 16 (against 22 in 2011 and 25 in 2010) among the top 50 Universities in India.

DEPARTMENT OF GEOGRAPHY - AT A GLANCE

1 General Background:

The Department of Geography, under School of Environmental Sciences (now, Human & Env. Sc) was established in June 1976 with the appointment of Prof. R. C. Sharma as the Head of the Department and the Dean of the School. Under his able leadership, the Department offered M.A./M.Sc. and M.Phil./Ph.D.

The present (2012) composition of the faculty members includes five Professors, three Associate Professors and threeAssistant Professors. In light of the great diversity of specialisations that Geography has branched into many fields and sub-fields. Current approved strength of the Department is 13 positions, 11 filled-up, and two positions of Professors (non-plan residual vacancies) remain to be filled-up.

2. Equipment and Facilities

The department, however, has a number of (reasonably) well-equipped laboratories to assist the students, research scholars and teachers in teaching and research.

a).The map laboratory has a large collection of wall maps, topographic sheets on different scales and atlases, aerial photos and satellite imageries. Topographic sheets for many areas of the country are available in the Department.

b).The photo-reprographic lab is well equipped with facilities like photo printing; slide making etc. and digital video equipments are also available in the department. The Statistical/Computer lab has number of computers, as well as A4 scanner, A4 digitizer, A0 for students use. Two Weather stations (under SAP), and other peripherals. All the teachers have been provided with PCs and are linked to the department's server through a LAN with Internet facility.

c).GIS Lab: There are also licensed version GIS software, AutoCAD-Map, Idrisi, ArcGIS Master Lab Kit, ERDAS Imagine (under SAP and FIST), which is available for teaching and research.

d).The Cartographic lab has minimum necessary equipments for cartographic needs, which includes Digital area Curvimeter, a computerised scriber and other surveying instruments. Besides, the department has a number of teaching aids like LCD projector, Laptop, slide projector, overhead projector, film projector etc.

e).The Aerial Photogrammetry Lab has a number of mirror stereoscopes, aerial photographs and other equipment. The department has got IRS and LANDSAT imageries of different bands and for different time period for almost whole North-Eastern India. Recently, a soil laboratory has been added to the existing four laboratories. The department has also received grants from DST under FIST programme. In this programme, the department has already equipped with High Resolution A0 colour Plotter, ERDAS Imagine 8.3 DIP Software (5 liceses), ArcGIS Master Lab Kit 8.4 software (3 licenses), High Resolution Digital Camera,

High Resolution IRS 1D, IKONOS Digital Imageries, High-end Leica GPS and Two Hand held GPS. Internet facility for students and faculty is available.

3. Academic Programmes:

The academic programmes of the department can be broadly classified into three major streams. These are (i) MA/ M.Sc. programme, (ii) M.Phil. (iii) Ph.D. (iv) PG Diploma in Geoinformatics Programme, which involve teaching, and research, and (iii) Programme of research activities undertaken by the members of the faculty, which mainly includes research projects/consultancy assignments and collaborative programmes with National and International Agencies.

The emphasis in on all the streams: (i) understanding of the problems at both theoretical and empirical level having universal significance; (ii) applying the knowledge acquired to the issues concerning the nation and in the specific context of the region, particularly the problems associated with the processes of development of the North Eastern region; and (iii) constant skill up-gradation in teaching and research programmes, through extensive use of IT and IT Enabled skills applied to practical development issues.

(a) The Masters' Programme

This programme is based on one-year two-semesters of core courses, followed by two semesters of specialisation, including a project paper in two broad areas of the subject, (a) Physical/ Environmental aspects and (b) Human geography. The overall load in the department for Masters Students has been 1800 marks under CBCS system.

The University academic programme is strictly calendar based and evaluation of the master's students is carried out at two levels: (a) sessional evaluation (25%) that consists of tests, writing of term papers and long essays and seminar presentation during the semester and (b) a written examination conducted at the end of the semester (75%). (Printed Copies of MA/MSc (2009) syllabus is enclosed.

(b)M.Phil. Programme

The department admits 15 students for M.Phil. programme every year. The programme is based on at least one semester of course work to orient the students into research aptitude, followed by dissertation writing. In the last 31 years as many as 115 students have been awarded M.Phil. Degree on theses pertaining to diverse fields in geography. Notable among these are Geomorphology, Agriculture, Political, and Urban Geography, studies on Land use, Social problems such as slums, land ownership and patterns of land holding, environment etc.

(c)Ph.D. Programme

The Ph.D. Programme in the department effectively started from the year 1978. Since then 82 scholars have been awarded Ph.D. degree till date (of which 20 have been awarded between 2007-2012, and more than 55 scholars are currently working towards their Ph.D. degree (The current rate of turnover/ year is 5 Ph.D./ year. See, the latest list enclosed.)

The focus of the research activities in the department is in the field ofGeomorphology, Environment, Urban Geography, Rural Planning, Regional Development &Planning, Agricultural Geography, Social and Urban Geography and more recently on Remote Sensing and GIS with greater emphasis on studies on problems related to the North-East region of India.

4. Academic Information on Programmes and Research Achievements

(i) MA/M.Sc. programme:

Students' intake: 38 in the 1st semester.

(ii)M.Phil /Ph.D Programme:

Ph. D degree awarded: 97, Currently registered: 55
M. Phil degree awarded: 120

(iii)Research publications: (Last 5 years)

Research papers: 83(+ 235 prior to approx.)
Books& Monographs: 15 (+ 44 earlier)

(iv) UGC Special Assistance Programme:

The Department has been identified by the UGC for Special Assistance Programme for a period of 5 years w.e.f. 2002. (DRS: Induction)

(v) DST FIST Programme: w.e.f. 2003-04 (Rs.32 lacs support)

(vi) Research Projects completed:

Number: 28

(vii) On Going Research Projects:

Number: 04

Many individual and joint Research Projects are in progress under UGC Special Assistance Programmes.

(viii) International Collaboration:

- Assessment of Run-off and Soil Loss in Cherrapunjee, under Indo-Polish Collaboration, PI: Prof. S. Singh.
- Crisis of governance under London School of Economics and Political Science, NEHU, Adviser: Prof. D.K.Nayak.
- UNICEF 1991-1995: Urban Poverty Alleviation Programme (GOI): Prof.A.C. Mohapatra
- AusAID (Adelaide) 2004: Research Collaboration on Env. Sanitation in Shillong: Prof.A.C. Mohapatra
- Tokyo University Tokyo, Japan, collaborator Dr. H.J. Syiemlieh
- Fredrich-Schillar University, Jena, Germany, collaborator Prof. B.S.Mipun

(ix) Distinction/ Award received by the Faculty:

Prof. A.C.Mohapatra awarded Prof. R.N.Dubey Memorial Award by Earth Sciences Development Foundation, New Delhi -2001.
Prof. Surendra Singh awarded Young Scientist UGC Career Award

(x) Seminars, Summer Schools, Workshops Organised: (1976-2012)

Seminar/Conference:	38nos.
Summer School:	02 nos.
Workshop:	03 nos.
UGC Refresher Course:	18nos.

(viii) Equipments and Facilities Currently Available in the Dept:

Topographic sheets &wall Maps
Computers: PCs 40 Laptops: 2

A4 scanner, A4 digitizer.
SWs: ArcGIS Master Lab Kit Ver. 8.4 (3 licenses) (under FIST)
SWs: ERDAS Imagine ver. 8.3 (5 licenses) (under FIST)
A0 Colour Plotter DJ800PS (under FIST)
Cameras: Several Still and Digital Movie cameras
Leica GPS GS5+(under FIST)
A0 Colour Scanner (under SAP).
Autocad-Map, Idrisi and ArcView 3.1 (all single licenses).
Four Weather stations (under SAP).
Carl Zeiss surveying instruments
Hand held GPS: 12
Digital Area Curvimeter (Planimeter).
Mirror Stereoscopes: KZ &Topcon(4 sets) + Others
Digital Compass
Digital Altimeter
Satellite Imagery of IKONOS, IRS and LANDSAT & Aerial photos, Cartosat.
LCD Projector: 4
OHPs: 3
Film Projectors: !6mm:1
Flame Photometer
pH meters: Two
Misc Soil samplers & analysis kits
Ovens: 2
Misc Drawing equipments for students Cartographic Laboratory

PRESIDENTIAL ADDRESS

28th Indian Institute of Geomorphologists (IGI)Conference
&
National Seminar on Human Impact on Landscapes
North-Eastern Hill University, Shillong 793022
29.10.2015

S. N. KARLEKAR
Dean, Faculty of Earth Sciences
Tilak Maharashtra Vidyapeeth, Pune
and
President (2014-2015)
Indian Institute of Geomorphologists (IGI)

It gives me a great pleasure to thank all the members of the executive council of IGI to have recommended my name for the post of president of IGI for the year 2015 and all the members of the institute who have elected me to the post. It is indeed a matter of great honor and privilege to get this opportunity to address the gathering of stalwarts, scientists, researchers and research students in the field of geomorphology.

On this occasion I would like to thank my teacher and guide Dr.K.R.Dikshit. All my interest, understanding and passion about the subject are only due to his towering efforts in shaping my research career and emphasizing utmost importance of FIELD WORK in my Geomorphologic research. I owe him more than I can probably express.

I would also like to thank Prof. Savindra Singh for recommending my name to this post. I was fortunate enough to get him as an external referee for my first two Ph.D. students in 1993. At that time I really needed a great support and appreciation of my work in Geomorpholgy from someone not belonging to Pune group. Prof. Savindra Singh not only appreciated my research efforts in Coastal geomorphology but also referred it to others interested and working in coastal Geomorphology. My acquaintance with him began from this incidence in 1993.Since then I am his great admirer especially for his enthusiasm and tireless efforts and ability to work as a secretary of IGI which I feel is too difficult a task.

It will not be out of place if I mention some of my friends and renowned personalities in their own field of research, on this occasion. These people have given me a great support and proper direction to my research in Geomorphology, especially Coastal geomorphology when I needed it most. I am sure you all will realize the significance of their role in my research career. For the major part of my academic career I was teaching and engaged in research in a college and not in any university department. My work in coastal geomorphology therefore was noticed after a considerable span of time only when I got appreciation from all these stalwarts. The credit of all this definitely goes to scientists namely Dr. A.R.Gujar from NIO, Dr.G.N.Nayak from Goa university, Dr.N.Chandrashekar from M.S.University, Tirunelvelli, Dr. Sunil Kumar De from NEHU, Shillong, Dr. H.S. Sharma, Dr.V.C. Jha, Dr.S.N. Rajguru, Dr. G. Victor Rajamanickam, Dr.Amal Kar, Dr. A.K.Paul and Dr.Hema Achyuthan.

I will be delighted to share this honour with all my students who were constantly with me in all research endeavors. The credit to rectify, modify and correct many of my ideas, concepts and impressions goes to these students who are like my best friends today. I have always enjoyed inquisitive and cleverly discussions with all of them.

I sincerely feel that the mission of our IGI in future should be to make our students more research oriented, the research that is done faithfully, scientifically and that which is applicable and reaches to world standards. Regional seminars and workshops can be arranged on behalf of IGI to give training in writing a good research paper, not written with the only intention of improving API score. They should be made exposed to research papers published in high standard journals.

Most of the students are the followers of their teachers and research supervisors. This is reflected in the style and substance of their paper writing which in most of the cases needs improvement and proper direction. Same is the case with their paper presentation in seminars and conferences. Here they surely need a good training so that they will prepare themselves before venturing into such a high profile and scientific method of presenting research exercise effectively. The part of the responsibility regarding the selection of such papers for presentation no doubt lies with the organizers of seminars and conferences. IGI certainly has a potential to organize high standard and quality conferences where participants can get exposure to fruitful deliberations.

We at Tilak Maharashtra Vidyapeeth in Pune tried to improve the quality of seminars and conferences under the faculty of Earth sciences by making strict scrutiny of research papers, attempting best time management for presentation sessions and making them fruitful and useful. Theme selection was found to be more crucial in all such conferences. Our experience is that in modern days the interdisciplinary themes get more response from the researchers working in various fields. Seminars and conferences restricted to a narrow and limited scope do not attract participants and therefore do not help in either knowledge building in the discipline or adding to the existing body of research methods.

I also feel that field orientation programmes in Geomorphology, of short duration, say a week or so can be arranged at various colleges and university departments under the banner of IGI. At many occasions it has been seen that our students and even some teachers are at a loss see what is to be done in the field. Ultimately field visits turn out to be pleasure trips. Our students can be trained in scientific techniques of field work through such programs. Such field training weeks can be arranged periodically wherein experts from other disciplines such as Geology, Hydrology, Pedology, Botany and Chemistry can be called.

Geomorphological mapping still plays an important role in understanding the earth surface processes, geochronology, natural resources, natural hazards and landscape evolution. It is a very effective technique which basically tries to partition the terrain into different conceptual spatial entities (Fig 1). Modern survey tools have made this technique more meaningful.

Our student researchers must know how quantitative characterization of landscape morphology is achieved through this technique. Integration of landscape thematic information can be done. Many conceptual, theoretical and information- technology issues are the essence of digital geomorphic mapping (DGM) which could be used to produce good quality information related geomorphic maps.

We have to train our students in multiple geomorphic mapping, carried out for a section, to show outcropping lithologies, processes, morphometric units, morphochronological units, morphogenetic units, for mapping of resources and mapping of hazards. They should also be trained in mapping based on aerial photographs and imageries (Fig 2).

It is high time that we take a serious note of the recent trends in the research in Geomorphology world over. I would like to elaborate on this with special reference to Coastal Geomorphology since it is my main area of interest. You will see that the scenario in other branches of geomorphology is more or less similar to that in coastal geomorphology.

As I pointed out in our conference on estuarine research at TMV in 2013, the coastal studies prior to 1970‘s especially in India were mostly conjectural and subject to varying interpretations. The main reason for this was the non availability of precise analytical tools and techniques. The field equipment that was in use was often primitive and unreliable. The results and interpretations obtained by these earlier studies are now being seriously questioned by modern researchers in coastal geomorphology.

We now have at our disposal many good quality analytical tools and data sources. The most exciting development in coastal studies recently is the availability and use of satellite images. It is giving an entirely new view of our coastlines and allowing the accurate interpretation and quantification of coastal forms and processes, especially the sediment movement. The sediment movement directions along the coast can be now identified using geomorphic indicators by remote sensing techniques. Indicators like stream mouth diversion, spit growth, sediment plumes can be very effectively used to understand the wave and tidal processes.

GPS unit is being used by many researchers to get the exact geolocations on the coast. To fix the position of any observation, measurement or field site on the shore or demarcation of beach dune, mud flat

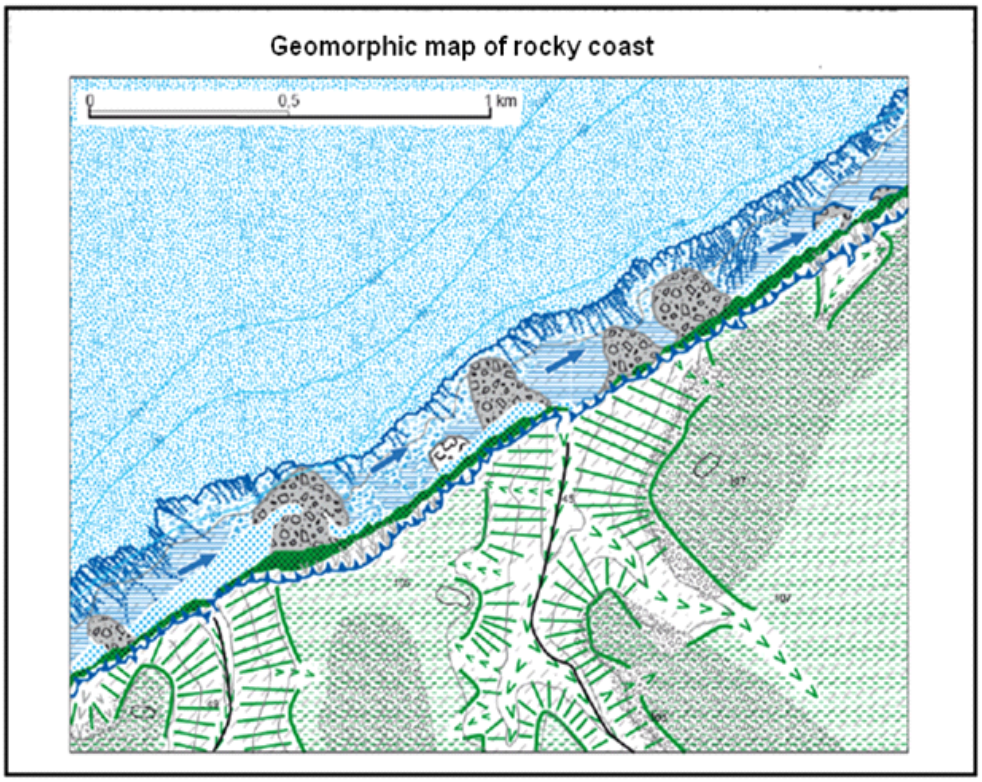


Figure 1

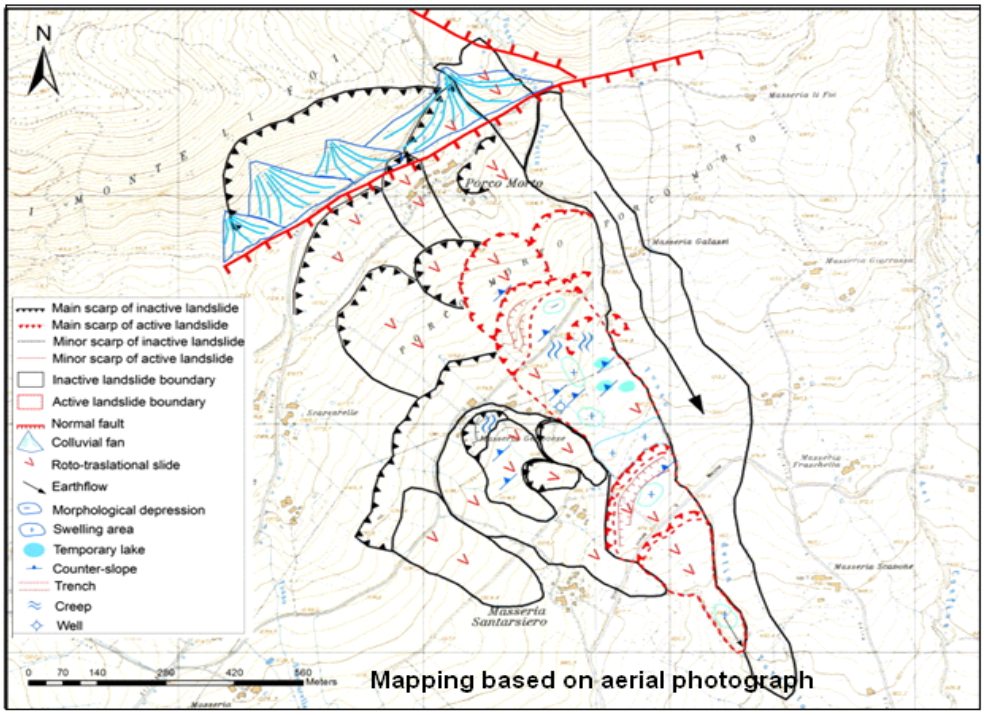
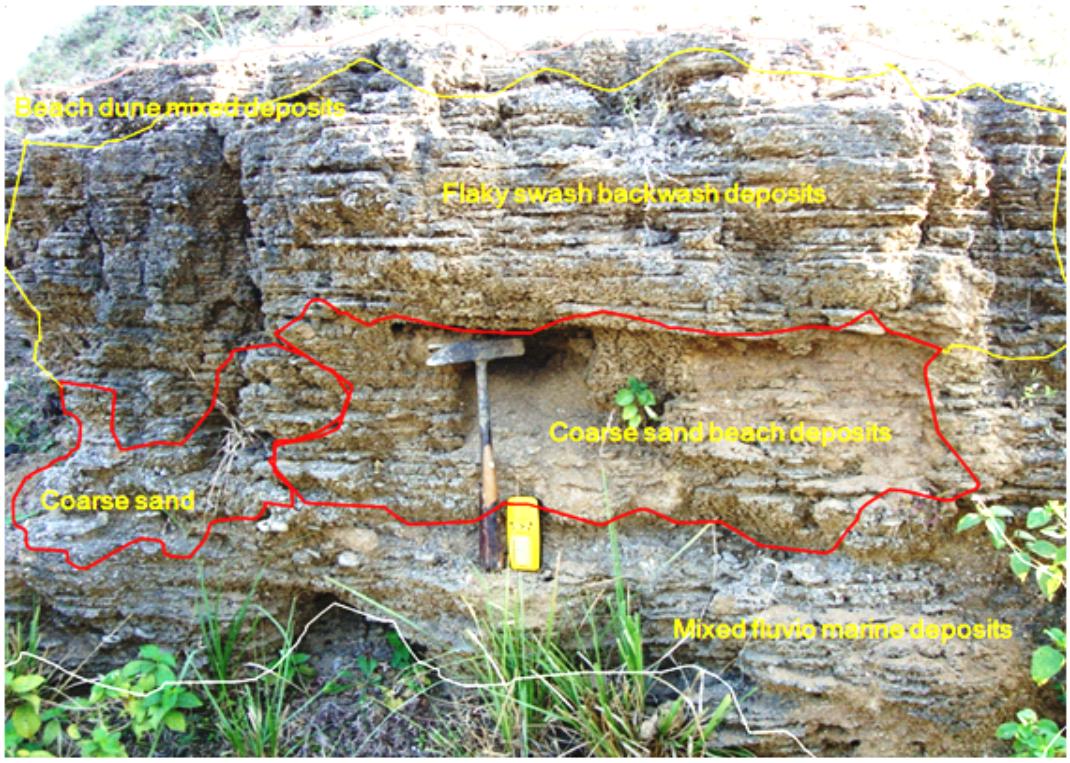
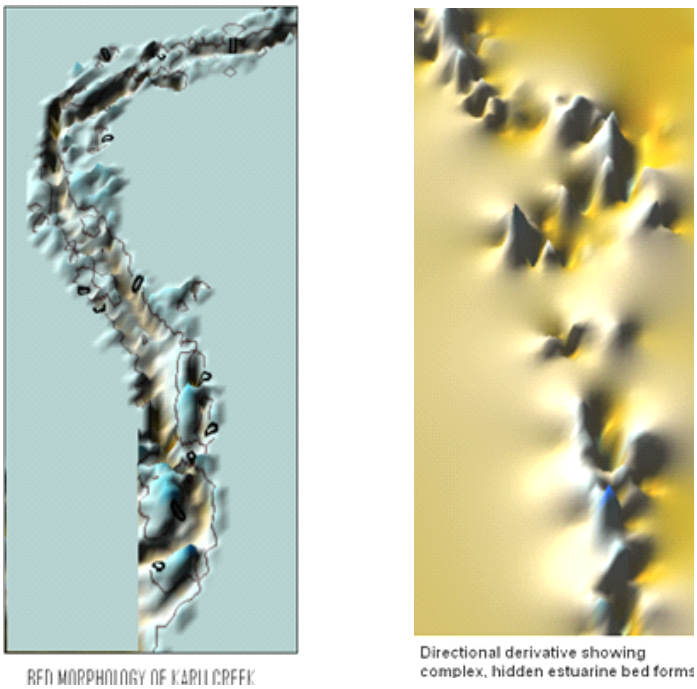


Figure 2



Discriminant analysis providing discrimination between fossil beach dune deposits.

Figure 3



BED MORPHOLOGY OF KARLI CREEK

Directional derivative showing complex, hidden estuarine bed forms

Figure 4

and mangrove swamp boundaries was a very difficult and at times impossible task. Researchers no doubt collected beach dune sediment samples, mud samples and water samples even earlier but the exact location from where these were collected could not be shown precisely on the maps. This can be done easily now a days by using GPS.

The core tubes, current meters, fluorescent and aromatic tracer dyes, wind velocity measurers, salinity meters, turbidity meters, filtration units, sieving apparatus etc are all easily available now to a person working in coastal studies.

Field mapping and surveying has become easy and convenient with the availability of Total Station or at least a Transit Theodolite. Some of the leveling instruments were used earlier but it was not possible to get exact location and alignment of profiles surveyed in the field. With GPS at hand it has become an easy job now.

Since the data collected are more sound, reliable and do not have noise in it the analytical results, mapping and interpretations are now more dependable, useful and applicable.

Coastal studies these days are more focused and therefore level of understanding of coastal forms and processes and their variability has surely improved. It however does not mean that the earlier studies are of no use. They have certainly helped in providing basic framework or broad outlines of forms and processes.

Earlier coastal studies were more of a generalization type. They used to give a broad regional picture of the coasts. The modern day research in coastal geomorphology seems to have concentrated more on site specific local studies. Although such studies are more in number it is also true that there are hardly any efforts to compile, integrate and collate these studies together.

In spite of the availability of precise analytical tools and techniques it is becoming very difficult in these days to study the coastal and other geomorphic landscapes in their natural form. This is because of the fact that quite a substantial area of the earth is under the influence of various anthropo-geomorphological activities. Natural erosional, depositional and even weathering processes are getting altered due to human impact causing significant landscape modifications.

It is the need of the hour to assess the quantum of human impact on landscapes and gather precise quantitative data to understand it. It is heartening to note that the theme of the present seminar is exactly the same. I am sure there would be many fruitful and useful discussions pertaining to this theme in this three day conference.

The human impact today is seen in multitude of micro to meso scale landscape scenarios. The list can be endless but the major ones which can be sited are,

1. Impact of Land-Use and Land-Cover Change on River Systems
2. Flow Regulation by Dams
3. Drastic changes in River Channels / fluvial systems due to Urbanization
4. Impacts of Vegetation Clearance on Channel Change
5. Impact of Anthropogenic activities on Coastal Aquatic Environments
6. Contamination of Sediments in Estuaries and Coastal Systems
7. Removal of Physical Resources from the Systems
8. Recreational, Cultural, and Aesthetic Service effects
9. Restoration of geomorphic systems

The study of such issues essentially requires an interdisciplinary or multidisciplinary approach. If we take a look at the world scenario in geomorphological research, we will see that at the close of 20th

century, well sited geomorphology is highly multidisciplinary and interdisciplinary with the most dominant fields being from biology, civil engineering, earth sciences, geography, geology and soil sciences. Water based research, especially fluvial processes and landforms, riparian and wetland studies, coastal processes and forms dominate the well sited papers.

This however is not the scenario in case of Indian Geomorphology. It appears from the various sited papers in India that we are still lingering only around Geography and in few cases Geology. We are seldom considering other branches of science in our research. It is time we change this situation and reorient our geomorphology research in multidisciplinary and interdisciplinary context making it more scientific and applicable. The technique like discriminant analysis can be effectively used in discriminating and mapping depositional facies (Fig 3) and first and second order directional derivatives to extract hidden complex features like creek bed forms (Fig 4).

Dear friends, I have tried to put before you, my ideas on research and training in Geomorphology. I am sure you have your own ideas and notions on these issues which can also be discussed and implemented.

With these few words, I like to thank you for listening to me patiently. I wish you an excellent seminar and a conference with very rewarding participation. I once again thank the members of the executive council of IGI, Prof. Savindra Singh, secretary of IGI and Dr. Sunil Kumar De, the convener of this meet for giving me this opportunity to share my thoughts and views with you on this occasion.

Thank you.

KEY-NOTE ADDRESS

28th Indian Institute of Geomorphologists (IGI)Conference
&
National Seminar on Human Impact on Landscapes
North-Eastern Hill University, Shillong 793022
29.10.2015

HUMAN IMPACTS ON LANDSCAPES : LESSONS OF CITIES FROM THE PAST

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Abstract

The first cities emerged in the Middle East around the year 3000 BC. Studies in the field of archaeology, geomorphology, geoscience and history allow us to understand which type of hazards were affecting the cities, and how they had an impact on landscapes in the past, in middle East, but also in other parts of the world. There is much to be gained: these studies are fundamental to a better understanding of present-day hazards, to urban development, but also to remembering our heritage. Cities have always been susceptible to nature's risks and natural disasters, but have also- through urban development and through the close proximity of great numbers of human beings-, thrown up their own hazards.

Key Words: City, Hazards, Geo-archaeology, Archaeology, Environment, Urban Development, Heritage

Introduction

If we see the end of the process of neolithisation as being around the year 6000 BC, in the Middle East first of all, then cities begin to appear after a long maturation period around 3000 BC. They sprung up on the banks of big rivers in Mesopotamia, in the areas that are now Iraq, Iran and Syria; and in the valleys of the River Nile, the River Jordan, the River Indus, the River Ganges and the Yellow River. The date of their emergence in Africa, Meso-America and South America is still disputed, but is definitely more recent. What distinguishes cities from villages or clusters of little farming towns is the concentration in a single area of economic, political, social and religious powers, which was reflected in a high relative concentration of non-farming populations and in a monumental administration often enclosed within a surrounding wall.
Geo-archaeology is an interdisciplinary approach that we define as being founded upon the use of methods and techniques drawn from geosciences, archaeology and geography, to recreate- in a multi-scalar, diachronic archaeological perspective-, palaeoenvironments and landscape processes, in connection with human inhabitation (Fouache, 2010). The geo-archaeological approach allows us to comprehend, in an urban studies

context, the evolution of environmental processes over the course of time, and the parallel evolution of the issues, the vagaries and thus the hazards of a city. Large modern-day developments- like the construction of an underground car-park in Lyon (Quai Saint Antoine), or the boring of tunnels in Istanbul (in the Yenikapi neighbourhood), going under the Golden Horn and the Bosphorus to link old Stamboul to the Asian side of the city-, have resulted in a proliferation, where ancient cities once stood, of conservation-oriented archaeological excavations associated with environmental studies; in this instance the identification of the bed of the River Saône in the early Iron Age (http://lugdunumactu), and the excavation of a 10th-11thC AD Byzantine port (Degremont, 2009). This is a major opportunity to bring together urban development, archaeology and history; and to encourage understanding of environmental processes amongst urban populations by integrating the notion of heritage into this understanding. This is of importance to the whole world, and especially to the world's major cities.

Explaining the hazards of ancient cities can also serve as a great warning to the current generation, and promotes prevention policies rooted in a real understanding of the interaction between natural processes and processes brought about by human societies. We mustn't, however, fall into any irrational fear of the risks of our environment. Between the Bronze Age in the Middle East, the Iron Age in Western Europe and the end of the modern era- to stick to a more archaeological than historical approach-, examples of urban civilizations that have been destroyed solely by environmental disasters are rare.

Cities and Cataclysms

The greatest risk for cities of the past was, of course, as today, a cataclysm; be it the direct effects of a natural catastrophe or the effects of society. The most notable kinds of such cataclysms have to be volcanic eruptions, earthquakes and tsunamis (Fouache, 2006). Numerous cities were rubbed off the map in this way: Pompeii, Herculaneum and Stabiae in Campania when Mount Vesuvius erupted in AD 79; Akrotiri in Santorini between 1635 and 1628 BC; and Helike taken by the Corinthian Gulf in 373 BC. The Lisbon earthquake of 1755, followed by a tsunami and the destruction of the city by the ensuing fire, is a good example of how urban development from human beings can heighten the consequences of a catastrophe. The Fukushima catastrophe is another in this long line. However, a city being erased from the map is somewhat exceptional; in the past as in the present, cities normally rise from the ashes in the same place, providing that the political and social systems dispose of sufficient resources to do so, and that the city is needed by the socio-economical, political and religious systems. It is due to these socio-economical, political and/or religious imperatives that the city is rebuilt in the same place, whether because of the site or because of the image of the city. A city's exposure to 'natural' hazards is not, however, limited to cataclysms.

Non-cataclysmic Natural Hazards

The frequent location of cities on the banks of rivers (Bravard and Magny, 2002) or by the sea puts them at the mercy of drastic rises in water levels, floods and changing shorelines (Morhange *et al*, 2007). The original site of the city is often sheltered from these dangers, on a headland or hill; but as soon as the city has been established, a lower city, suburbs and a port, which are exposed, all come into existence; then, very soon after, urban growth spreads into at-risk areas, the original site being too small. An example of this is the town of Sommières in the Gard department (France), built at the foot of the hill on which the castle stands, right on the River Vidourle flood plain despite the high frequency of floods originating in the Cevennes rains. The adoption of collective risk-management measures can be a factor in social acceptance of the hazard. Thus the Ancient Egyptians viewed the floods of the Nile as a nourishment of the land, and the Venetians very quickly learnt to live with the phenomenon of Acqua Alta.

Indeed, the site chosen can itself be the cause of a city's wealth. The ancient city of Mari (Margueron, 2004) on the Middle Euphrates in modern-day Syria was closely linked to the river, its irrigated farmland and its waterway. Throughout the third and second centuries BC, these advantages enabled costly development

that the Sumerian civilisation in Uruk had the human and financial resources to support. The surrounding wall of the Mari palace can thus just as easily be viewed as a fortification as it can be a dyke. The same is true for Babylon on the River Tigris: from the late 17th to the 11th century BC, Babylonian kings were incessantly obliged to raise their ramparts, nearly 20m in total, to fight the intense aggradation of the river. In the end it wasn't the river's water levels that did for Babylon, but Median invasion.

What geo-archaeological studies also teach us, as well as the studies of paleo-climatologists, is that at the level of the Holocene (Mayewski *et al.*, 2004) - the last 10,000 years-, environmental processes have varied: the seasonal distribution of weather types, temperatures (by a yearly average of roughly two degrees), rainfall (by irregular amounts) (Birck *et al.*, 2005); the consequences of all of this are heightened all the more in remote areas of the inhabited world. As a result, the morphogenesis and the hydrological rhythms of rivers and thus the hydro-morphological hazards have evolved (Arnaud-Fassetta, 2000, 2008), between calm periods such as the Medieval Warm Period, and other periods witnessing far more exceptional occurrences, such as the Little Ice Age. In the same time period, the changes societies have brought to the exploitation of drainage basins have interacted with these natural processes, sometimes worsening environmental disasters, sometimes balancing them out (Diamond, 2006). This is how- due to erosion linked to the agricultural exploitation of its hinterlands and the progradation of the Küçük Menderes Delta-, the city of Ephesus ended up ceasing to be a port (Kraft *et al.*, 2007).

However, cities do not merely suffer their environment, they affect it themselves.

The Impact of Cities on Their Environment

From the very beginning of its life, a city has a considerable impact on its environment. Huge numbers of inhabitants- Xi'an, for example, in the Chinese province of Shaanxi, is believed to have been the home of over a million people in 1000 BC-, have always been conducive to epidemics (Hays, 2005), pollution (Botsos *et al.*, 2003), and a heightened consumption of energy and natural resources. The supposed plague- more probably a typhus epidemic-, that hit Athens from 430 to 427 BC is still remembered today. Such paleopollution appears in geo-archaeology in the study of intra-site sediments, or that of sedimentary archives in ancient port basins and lake and river sediments found downstream from cities. Thus geo-archaeologists use levels of lead, scoria and heavy metals to trace and mark out the past, whilst the study of skeletons in necropolis offers a glimpse of the health of an ancient population and the impact of chronic illnesses and epidemics. The most finely developed ancient urban societies took measures against some of these risks, as far as the knowledge of their era allowed them to. One needs look no further than supplies of clean drinking water; fountains; urban water tanks; qanat networks (Briant, 2001)- which became commonplace across the Iranian plateau and beyond in the first millennium BC-, or Roman aqueducts (Bonnin, 1985); waste disposal and wastewater disposal; the establishment of cemeteries outside of the city; legislation aiming to curb the risk of fire; paraseismic construction practices; the building of dykes and levees; or the confinement of polluting activities or industries, for example tanneries situated in their own specific neighbourhoods. We must be careful, however, not to apply modern standards of safety and responsibility to ancient urban societies.

The New Responsibility of Contemporary Urban Societies

In an epidemiological as well as an environmental sense, there is most definitely a difference in size between ancient and modern urban societies. Our civilisation- with its knowledge of tectonic plate theory and its vast advances in geosciences and biology-, is the first to have gained a scientific understanding of the genesis of volcanic eruptions, earthquakes, tsunamis and landslides, as well as of the environmental disasters or health crises of the past, and the first to have conceived of forecasting such phenomena. Considering current scientific and technological expertise, preventing major and natural hazards should be a top priority for cities all over the world, based on a five-point plan: studying dangers, knowing what is at stake, defining risks, adopting urban planning regulations, and educating city-dwellers on the states of crisis specific to each urban context. Be it due to a lack of specialists, a lack of resources, an absence of political will, corruption, or misunderstood financial interests, such a plan is still a rare exception in the world today.

What Causes a City to Disappear?

Seeing as cities are each built on areas with their own topography, with site constraints and hazards linked to these dangers, they are in essence social, economical, religious and political products. By way of proof, all cities, throughout history, have been created either by a myth or by a decree. In the Middle East, the first cities to be recognised and partially explored were, obviously, new cities (Margueron, 2004), clearly built by political will. Later on, foundations were in fact often found to be hiding refoundations, and the desire of authority to forever leave its mark on history. The city of Kar-Tukulti-Ninurta (Eickhoff, 2005), is emblematic in this sense: situated on the right bank of the River Tigris, where modern-day Iraq stands, it was founded in such a way by King Tukulti Ninurta I, who ruled from 1244 to 1208 BC. This veritable new city boasted a design based on quadrilaterals, long orchard paths and baked-brick ramparts. The king wanted it to be a new capital, but he died before it was finished, and the city soon crumbled.

What archaeology teaches us is that cities disappear with the civilisations that founded them, for reasons often far more social, political or religious than environmental. The aridification of the global climate (Kuzuçuoglou and Marro, 2007; Fouache *et al*., 2009) that followed the Holocene Climate Optimum is often put forward as the reason behind the great cultural crises that occurred in the Near East, such as the fall of the Akkad Empire (Weiss *et al*., 1993) in the Arabo-Persian Gulf, or the abandonment of Harappan cities in the Indus Valley. This aridification was most probably caused either by thousand- or hundred-year fluctuations, by some sudden turn of events, or by a progressive evolution of the climate towards dryness, connected with the waning of the Indian monsoons (Lézine *et al*., 2007). Pollen and speleothem analyses in the region do show that this waning of the Indian monsoons from 4700 to 4200 BP (Ivory and Lézine), was very real, but an actual link with the collapse of late Bronze Age civilisations is not certain.

When we discuss the collapse of Bronze Age civilisations in the Near and Middle East, we thus must take care to distinguish vast urban centres- economic, political and cultural hubs, very dependant on external flows, and, as we have intimated, very quickly abandoned at the end of the third millennium-, and little urban and rural sites like those, for example, of the Sabzevar region (Fouache *et al*., 2010) in Iran, which have been occupied consistently throughout their existence. One must also consider the duration of aridification, which is by no means a quick and brutal process, but rather a slow evolution over the course of 600 years. To attribute the collapse of these Bronze Age civilisations to the only climactic factor in question seems, in the light of current archaeological knowledge, a gross simplification.

If we move to Central Asia, and protohistoric Central Asia, recent archaeo-environmental research (Cattani, 2005; Francfort, 2005; Francfort, 2009; Francfort and Tremblay, 2010; Luneau, 2010) seems to be showing us that the pinnacle of Oxus civilisation came at the end of this phase of aridification, proven by environmental studies (Cremaschi, 1998), notably the advance of the Kara-Kum dunes and the parallel southerly advance of steppe peoples (Cattani, 2005); its collapse, meanwhile, most likely came with the beginning of a new humid phase.

Conclusion

We are fortunate to be able to use conservation-oriented archaeological digs to carry out, within a dense urban tissue, geo-archaeological studies of environmental processes. This affords us a better understanding of initial site constraints, and allows us to piece together the dynamic evolution of environmental constraints which interacted with processes begotten by human development. This piecing together in turn affords us a better understanding of the perennial or random nature of hazards, lets us know when they will recur, and allows us to form more effective prevention policies. This environmental history can also form part of a city's heritage, a part that can be exhibited for all to see and- by placing a city's current situation in a dual history, that of the environment and that of human societies-, can be used for educational purposes in explaining the nature of hazards and the evolution of issues and risks. We must not, however, focus exclusively on environmental risks to our cities. Preventing major hazards, reducing pollutants and managing waste, optimising the management of water resources, and harnessing the growth of megalopoles are all major issues; but- due to the huge numbers of inhabitants and their increasing concentration-, the greatest dangers to the long lives of our cities are actually, now as they always have been, social and political.

Acknowledgements:

I am most particularly indebted in the preparation of this article to Annie Caubet, the Honorary General Curator of the Louvre Museum, for her remarks and suggestions on Middle Eastern cities and Joe Cunningham for translation.

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PROF. S. R BASU MEMORIAL LECTURE

28th Indian Institute of Geomorphologists (IGI)Conference
&
National Seminar on Human Impact on Landscapes
North-Eastern Hill University, Shillong 793022
29.10.2015

MORPHODYNAMICS OF BEACHES OF THE SOUTH-EASTERN COAST OF TAMILNADU

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It is a great honour and privilege to deliver the Professor S.R. Basu Memorial Lecture at IGI conference, Shillong, Meghalaya. I am extremely grateful to Prof. S.R. Basu family members and IGI for having provided an opportunity to share my experiences on coastal sciences with young geomorphologists. My association with Prof. S.R. Basu was very short, but his constant motivations and support extended to me is unforgettable particularly the experience at coastal field trips in Kanyakumari during IAG Regional Workshop. I have great admiration on his commitment to this society and the discipline of geomorphology more so his humanity with youngsters. Therefore, I have accepted to deliver and share the data on Beach Morphodynamics of Tamil Nadu coast for the benefit of young geomorphologists.

Introduction

Natural beaches, processes and morphology are influenced by waves, tides, and sediment characteristics. Cross-shore morphology of sandy beaches is an important issue for coastal erosion. An ideal beach may be conceived as a smooth expanse of sand stretching indefinitely alongshore. About 50% of the sandy beaches along the SE coast are influenced by placer mining and development pressure along cause severe effect on natural morphodynamic processes and morphological landforms (Chandrasekar 2000). Many beaches topographically exhibit a complex variety of long shore and offshore structures at various scales. Shoreline feature that show a regular longshore periodically drawn the beach as beach cusps, sand waves, rhythmic topography or giant cusps. Cross-shore sediment fluxes are a few orders of magnitude smaller than long shore transport; the cross-shore beach profile has strong influences on long shore velocity profiles. The beach profile is the result of the tradeoff between onshore and offshore fluxes. The direction of the cross-shore fluxes is a key point for predictive tools and is clearly related to the non-linear characteristics of the incoming waves. Beach profiles are generally more complex and the concept of equilibrium beach profile is very useful. Equilibrium of beach profile in the surf zone is controlled by uniform wave energy dissipation per unit of volume. Ever changing wave climate in natural environments, equilibrium profiles could be retrieved as spatial longshore scales or mean international profiles. The objective is to characterize the rates and nature of beach change and to evaluate whether these changes have significant effects on the resulting morphology of the shoreline of Tamil Nadu coast. Further, this shoreline has mixed grain size beach setting due to its

configuration and wave energy. Depending on the deep water wave characteristics and shelf and inshore morphology, breaker wave energy may be high, moderate or low as the accompanying beach surf zone morphodynamic state in fine to medium sandy beaches. The beaches of Tamil Nadu coast are mainly highly mobile beaches with wide range of beach forms. The zones of sediment storage reflect the beach mobility and beach forms in the area.

Geographical location of the study area

The coast between Tuticorin and Kanyakumari of southern coastal Tamil Nadu of India has different morphological features and diverse ecosystem (Fig. 1). The Tamil Nadu coast line extends over a distance of 906 km endowed with a variety of coastal habitats like coral reefs, mangroves, seaweeds, salt marshes, sand dunes, sea grass bed etc. Based on the existing characteristic features, Ahmad (1972) classified the Tamil Nadu coast as a depositional plain type. The lecture is restricted to the area lies between Kanyakumari (From Manakudy Palayar Estuary) and Tuticorin urban coast which extends over a distance of 160 Km and covering the latitudes from 8° to 8.88° N and longitudes from 77.5° to 78.30° E. The major coastal settlements are Tuticorin, Kanyakumari, Tiruchendur, Ovari, Manappad and Kayalpattinam. The area includes headlands along Manappad and Tiruchendur coast. There is a major port in Tuticorin and a fishing harbor near the Kanyakumari coast. The area is highly dynamic with many cyclic and random processes owing to a variety of resources and habitats. The coastal ecosystem is highly disturbed and threatened by industrial like pollution, siltation, erosion, flooding, sea water intrusion, storm surges and ever-expanding human settlements.

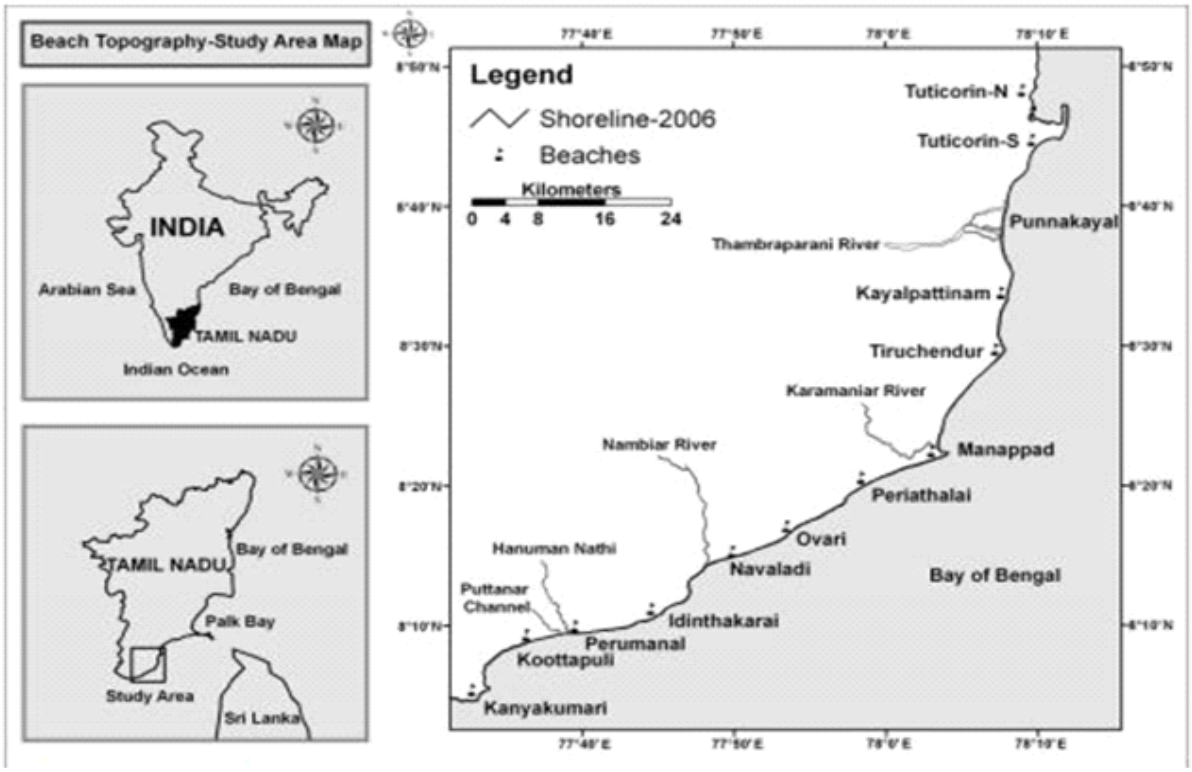


Fig. 1. Geographical extend of the south-east coast of Tamil Nadu

Table 1. Wave Energy conditions prevailing along the SE coast

Station	SE			NW		SSW
	6S	8S	10S	8S	10S	8S
OVR	I	C	C	I	I	I
NAV	I	I	I	I	I	I
KUT	I	C	C	I	I	I
IDI	I	D	D	D	D	D
PERU	I	I	I	I	I	I
KUP	I	I	C	I	I	I
VAT	I	I	I	I	I	I
ARO	D	C	C	I	I	D
CHI	I	C	C	C	D	D
KAN	I	I	I	I	I	I

Comments: I, Inept condition; D, divergence; C, convergence. Here and in Tables 3–5: OVR, Ovari; NAV, Navaladi; KUT, Kuttankuli; IDI, Identhakarai; PERU, Perumanal; KUP, Kuttapuli; VAT, Vattakottai; ARO, Arokiapuram; CHI, Chinnamuttom; KAN, Kanyakumari.

Wave Refraction

Wave refraction diagram has been constructed along the beaches between Ovari and Kanyakumari to investigate the changes that occur in the wave characteristics near the coast as deep-water waves of different periods approach the coast from various directions (Fig.2a - 2e). The wave climate is characterized by the southwest monsoon (June-September), northeast monsoon (October-January), and non-monsoon periods (February-May). The predominant wave directions prevailing in the n region are referred in the wave atlas as SE during SW monsoon and NW during the NE monsoon. As the study area shows a trend of EW-NS orientation, the waves in the coast is predominantly from 45°SE during SW monsoon and 20° NW during NE monsoon. Since the orientation of the shoreline along the study area is, in general, the NS-EW direction, the waves approaching the coast between 110°N and 135°N are of greatest significance in conjunction with littoral processes. Therefore, wave refraction diagrams have been prepared for the wave periods of 8 and 10 sec approaching from 110°N and 135°N by using the Tarangam Program developed by the National Institute of Oceanography (NIO), India, on the basis of finite amplitude wave theory for computing the wave transformation factors. The naval hydrographic chart (1973) was used to assess the water depth at a point for drawing bathymetric contours. The wave refraction pattern for SE for the periods of 6, 8 and 10 sec are shown in Figs. 5a-5e. The wave energy condition prevailing along the area in different wave directions for different periods is given in Table 1. In the pattern of 10 sec, the wave convergence is observed at Thiruchendur, Manappad,Periyathalai, and Vattakottai. An overview of refraction patterns of three wave periods reveals that wave energy is more pronounced and concentrated in the wave period of 10 sec than in other two periods (Table 2). The wave period of 10 sec plays a predominant role in the shaping of various landforms of depositional and erosional nature and in the redistribution of sediments. Chandrasekar et al. (2001) discussed the wave refraction pattern and its role in the redistribution of sediments along the east coast of India. The overall pattern of wave refraction in the area of SE direction displays strong convergence in the number of beaches, and the same may be ascribed to the prevalence of high energy conditions unlike the other two directions. This leads to the inference on sediment transportation and their degree of sorting and are likely to

be more intensive in the southwest monsoon period. The change in wave energy from convergence to divergence in a particular beach with different period was attributed to the change in the quantum of sediment movement from one period to other. The nature of cliffed coastline from Kuttankuli to Vattakottai is with high order of erosion indicating a zone of high energy environment in the strong convergent zones.

Littoral Sediment Transport

The movement of material in this zone mainly depends on three factors: the nature of material available for transport (size and density), orientation and other features of the coast, and an angle of wave approach. Littoral transport plays a major role in the development of certain shoreline features like spits and bars and causes considerable coastal erosion and accretion. The monthly longshore sediment transport rates estimated on the basis of monthly observations on longshore currents and surf zone width are presented in the Table 3 and 4. The monthly volume of longshore sediment transport rates and directions are estimated for the coasts namely Kuttankuli, Vattakottai, Thiruchendur, Alanthalai, Manappad, Periyathalai, Ovari, and Kanyakumari. In general, the sediment transport is northerly during March to October and southerly during November to February. The longshore sediment transport is higher in the northerly direction as compared to southerly direction at all locations except Kanyakumari. This occurs because of the rocky outcrops sheltering the Kanyakumari beach, and manmade features such as a harbor across the surf zone would act as a barrier and sand deposited on the up-drift side of this barrier.

Beach Morphodynamic Classification

The wave refraction analysis has delineated different wave energy conditions prevailing in the area. There are areas of erosion and accretion observed along the coastal stretch, which depends primarily on the direction of wave approach, wave period, and wave refraction pattern. In the nearshore zone of the area, the movement of sand alongshore is due to the action of waves and currents. A complete study of wave dynamics is imperative at this instant, which includes the measurement across the swash and surf zones of local sediment transport, wave height, wave energy conditions, longshore current, etc., to comprehend and describe the swash processes precisely. Also the time scale of each study should be commensurate with that of the duration of the directional wave event that drives the transport. Further, emphasis has to be placed on formulating computer models to conjecture the performance of sediment movement for the development and management of the coastal zone. The direction of littoral drift is from south to north during the period of March to October when the waves are between S and SE, and from north to south during the period of November to February when the wave directions are between E and ENE. The seasonal changes in the direction of littoral drift with SW and NE monsoons cause cyclic variations of the beach morphology along the coast under investigation. The rocky outcrops scattered across the littoral zone causes the reversal of beach cycles at different stations along the coast. For example, at Kanyakumari (October) during SW monsoon, the southerly movement of sediment is observed. The net littoral drift at all stations is generally from south to north with the exception of the Kanyakumari station, where the net drift is southwards. The net erosive nature of the study area (except Kanyakumari) from March to October is due to the prevalence of high waves from S and SE directions. The morphodynamic states of reflective, dissipative, and intermediate beaches of the area (Table 5) are assessed on the basis of energy regimes, gradient of beaches, beach width, backshore width, wave type, coast exposure, and morphological features in the nearshore zone. The morphodynamic status of the beaches along the SE coast of Tamil Nadu is shown in Figure 3.

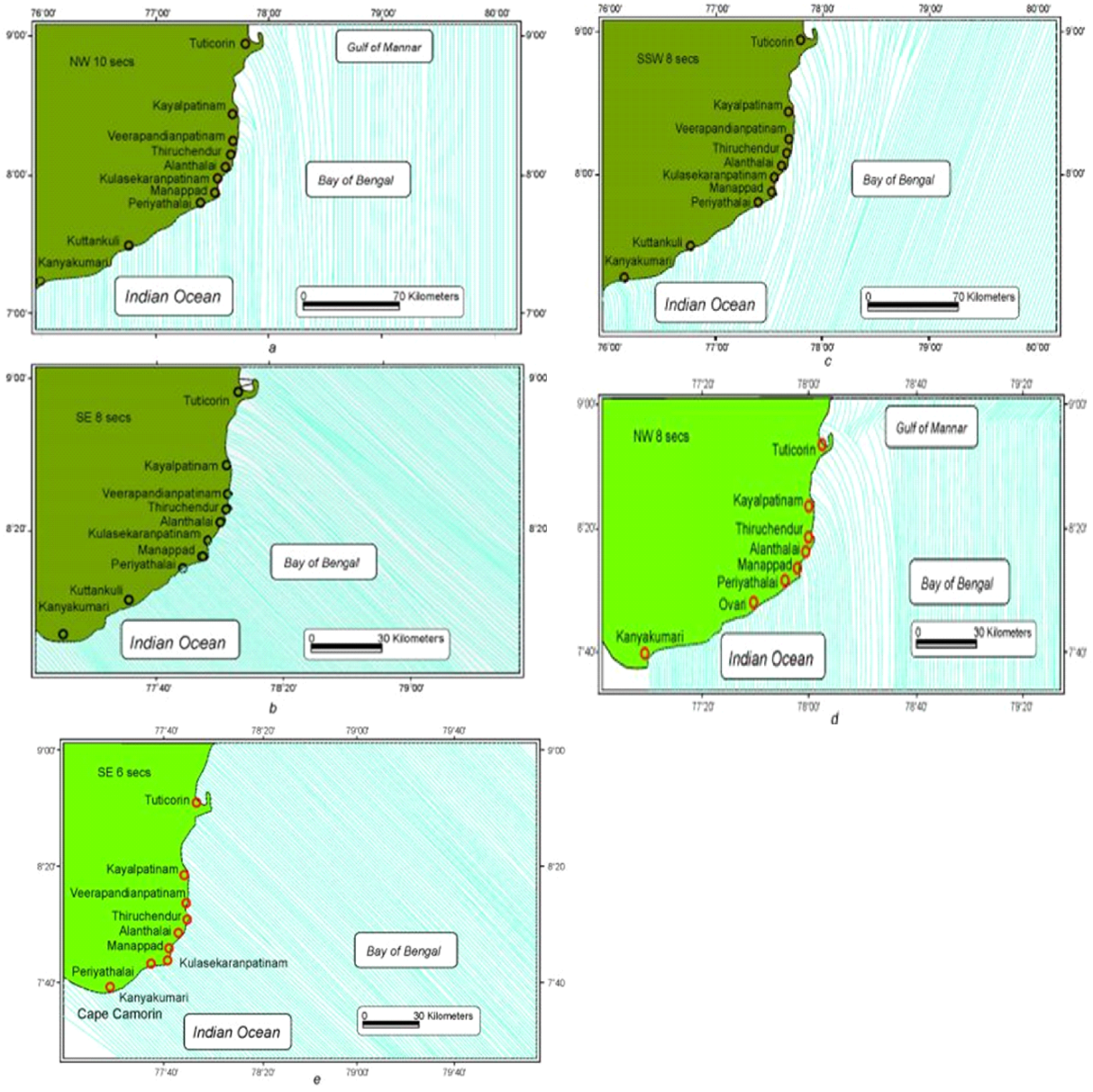


Fig.2. Wave refraction during : (a and b). SW monsoon (c and d). NE monsoon (e) Non monsoon

Table 2. Monthly data of Breaking Wave Height along the SE coast

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	0.50	0.20	0.20	0.50	0.30	0.45	0.70	0.45	0.60	0.45	0.50	0.50
NAV	0.40	0.45	0.30	0.15	0.40	0.30	0.55	0.40	0.35	0.45	0.445	0.60
KUT	0.50	0.50	0.25	0.20	0.20	0.15	0.50	0.20	0.25	0.40	0.55	0.55
IDI	0.40	0.45	0.40	0.25	0.30	0.70	0.30	0.60	0.80	0.30	0.45	0.30
PERU	0.50	0.35	0.15	0.20	0.30	0.20	0.45	0.20	0.55	0.45	0.35	0.45
KUP	0.30	0.40	0.20	0.15	0.25	0.10	0.60	0.30	0.45	0.25	0.40	0.40
VAT	0.25	0.15	0.05	0.25	0.10	0.25	0.20	0.20	0.20	0.05	0.15	0.20
ARO	0.30	0.40	0.25	0.25	0.35	0.60	0.20	0.45	0.60	0.25	0.35	0.20
CHI	0.40	0.20	0.25	0.20	0.25	0.35	0.85	0.50	0.55	0.35	0.55	0.50
KAN	0.20	0.20	0.25	0.20	0.15	0.30	0.35	0.35	0.15	0.25	0.20	0.20

Table 3. Monthly data of longshore currents along the SE coast

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	0.48	0.01	–0.16	–0.01	–0.18	–0.06	–0.36	–0.39	–0.43	–0.09	0.14	0.29
NAV	0.44	0.13	–0.20	–0.32	–0.22	–0.22	–0.30	–0.22	–0.32	–0.16	0.11	0.20
KUT	0.40	0.14	–0.21	–0.33	–0.24	–0.24	–0.30	–0.33	–0.33	–0.10	0.12	0.18
IDI	0.31	–0.10	–0.09	–0.07	–0.21	–0.08	–0.07	–0.01	0.03	–0.11	0.04	0.04
PERU	0.42	0.04	–0.20	–0.13	–0.26	–0.10	–0.29	–0.14	–0.34	–0.06	0.12	0.18
KUP	0.38	0.02	–0.23	–0.20	–0.23	–0.31	–0.26	–0.16	–0.32	–0.04	0.16	0.16
VAT	0.50	0.03	–0.05	–0.10	–0.01	–0.21	–0.31	–0.16	–0.30	–0.08	0.10	0.16
ARO	0.30	0.12	–0.10	–0.06	–0.28	–0.09	–0.07	–0.04	0.06	–0.13	0.06	0.08
CHI	0.39	0.02	–0.07	–0.04	–0.1	–0.07	–0.3	–0.4	0.05	–0.07	0.01	0.16
KAN	0.34	0.14	–0.04	–0.20	–0.07	–0.20	–0.30	–0.15	–0.30	–0.17	0.10	0.16

Comment: (–) Northerly direction, (+) Southerly direction.

Table 4. Monthly data of Surf zone width along the SE coast

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	18	20	20	22	15	19	18	17	20	18	20	20
NAV	19	20	16	18	17	20	16	16	20	20	20	20
KUT	18	16	15	15	20	18	17	15	17	15	20	20
IDI	13	12	12	11	12	14	13	12	14	12	12	14
PERU	17	20	15	15	20	18	17	15	17	15	20	20
KUP	20	18	15	16	17	20	18	17	16	18	19	20
VAT	16	14	18	14	14	17	15	14	17	18	16	16
ARO	20	22	20	17	19	20	17	16	18	19	22	22
CHI	17	17	16	18	17	19	20	17	20	18	20	20
KAN	16	14	13	16	15	12	14	15	14	17	18	16

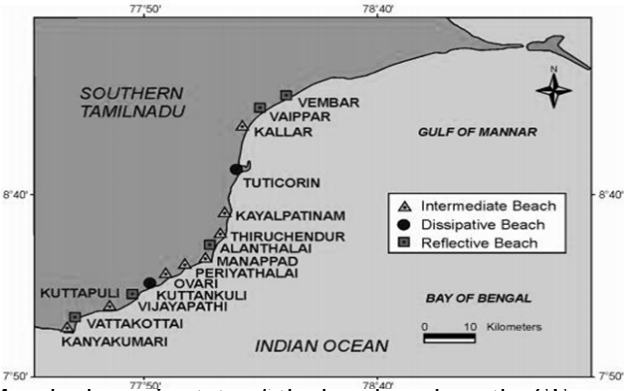
Table 5. Beach morphodynamic classification along the SE coast

I. Breaker type (Battjes, 1974)	Spilling $\xi b < 0.4$	Plunging $0.4 < \xi b < 2.0$	Surging $\xi b > 2$
Locations	Kuttapuli, Vijayapathi, Arokiapuram and Vattakottai	Kuttankuli, Chinnamuttom and Kanyakumari	Ovari and Perumanal
II. Beach type (Wright & Short, 1984)	Reflective $\Omega < 1$	Intermediate $1 < \Omega < 6$	Dissipative $\Omega > 6$
Locations	Kuttapuli, Vijayapathi, Arokiapuram and Vattakottai	Kuttankuli, Chinnamuttom and Kanyakumari	Ovari and Perumanal

(i) Dissipative Beaches: The high wave energy condition with low gradient beach slope has a surf scaling parameter. They have higher rate of dune and backshore recession. Dissipative beaches in the study area are composed of fine to medium sand, and, hence, the mobility of the beaches is more enhanced than the higher energy conditions of the reflective beaches. Due to repeated oscillations of high wave energy condition in the dissipative beaches, scarping of the beach profiles occur. Beaches falling under this category are Ovari and Perumanal.

(ii) Reflective Beaches: Low modal wave heights and steep gradients of the beach have resulted in a low surf scaling parameter. However, if the wave height increases seasonally, the beaches in these environments would be severely affected by erosional processes. The same is attested in the region during the northeast monsoon, and the erosion-sensitive concave beach profiles dominate over convex profiles. The mobility of the beaches is hindered by the coarseness of the sediments,low energy condition, and steep beach gradients. Beaches like Kuttapuli, Vijayapathi, Arokiapuram, and Vattakottai fall under this category.

(iii) Intermediate Beaches: Intermediate domains exhibit the characters of both reflective and dissipative beaches. Moderate gradient and abundant supply of sediments are seen more with dominant alongshore movement than with onshore-offshore movement. Broad backshore width is observed in the intermediate state of beaches in Perumanal and Vijayapathi coast. Flat and moderate beach gradients with strong rip current and well developed cusps that disappear as the reflective shoreline conditions dominate over the intermediate state are perceptible in the zeta form bay between Kuttapuli and Arokiapuram. The gradients of the beaches that are gentle with low energy conditions are seen in Ovari coast. Along with other modes of beach cuttings, rip currents developed in this coast caused the continual erosion. Along the area, such beaches as Kuttankuli, Chinnamuttom, and Kanyakumari are to this category.



Fig,3. Morphodynamic state of the beaches along the SE coast of Tamil Nadu

Beach Topographical Analysis

The profiles of beaches, cliffs and other coastal landforms are often studied and analyzed in the coastal areas. These cross sections through coastlines can give a good idea on the changes that can occur over time at one point on the coast, either in the shape of a beach or cliff, or in its size and volume. Beach topography is a result of complex interactions between natural coastal processes and anthropogenic activities. The most common method for measuring beach topographic change is the beach profile. Coastal morphology is the result of combined action of hydrodynamic, geologic and climatologic processes. The beach morphology of coast undergoes perpetual and rapid changes. Generally, the influencing natural forces can be subdivided into long-term processes, which shape the coastal morphology on large spatial scales in the order of kilometers or more and short-term processes. More recently, anthropogenic effects may also influence substantially the shape of the coastline. Consequently, the beach morphology can be regarded as a sensitive indicator for the ongoing coastal dynamic processes of a particular coastline. By monitoring the spatial and morphological changes of a beach over time, a good estimate of the rate and direction of coastal changes can be obtained. The beach profiles obtained from the level surveys are processed by using sophisticated software tools like 'THE BEACH' and 'BMAP'. The temporal and spatial representations of beach profiles have been delivered. The morphological parameters such as beach width and slope have been analyzed. The volumetric change of beach sediments and their annual and seasonal variations have been evaluated. The morphodynamics of beaches can be investigated by performing the EOF analysis of profiles. The shoreline change, erosion and accretion made along the beaches have been predicted.

(i). Spatial and Temporal Representation of Profiles

Beach topographic analysis with short-term and long-term change in different spatial and temporal scales in the coastal dynamic environment is crucial for sustainable coastal management. A study of number of profiles from different points can produce information about the transportation of sediment along a coast, or how one area differs from another. The numerical profile data can be analyzed statistically or it can be plotted as a graph to give a physical representation of the shape of a coastline. The beach profiles have been observed to change over a range of spatial and temporal scales; however techniques for quantifying this variability have not been fully established. Beach erosion may be a short-term (order of hours to seasons) process that reflects adjustment to wave energy changes, or a longer-term (order of years) one that reflects an increasingly deficient beach sediment budget and shoreline changes. Also, the seasonal changes in beach profiles constitute an important aspect of the variability of the coastal environment. The topographical and morphological changes of beach profiles are mainly oriented with coastal geology, shore configuration and seasonal oscillation prevailing along the study area. The topographical representation of different beaches reveals that the profiles are higher during March-2006 and the profile rises further during from March to May. During April or May, the profile of almost all beaches attains maximum level. The low energy littoral currents and waves prevailing along the area during the summer deposit sediment on the beach berms and dune, thereby raising the beach profile. From the month of June, the profiles start to lower due to the increase in wave energy due to the south-west monsoon. The lowering of profiles still continues up to the month of September (north-east monsoon period, winter). The seasonal migration of the sand exists, with sediment transport towards the beach in the summer, resulting steep beach face and high berms at the end of the summer. On sandy beaches, short-term changes involving erosion are commonly part of a so-called morphodynamic cycle of adjustment of the beach profile to seasonal or non-seasonal changes in wave energy. The short-term seasonal changes commonly correspond to the classic winter profile flattened by storms and the summer profile that accretes under fair weather conditions. The profile of beaches during the different periods such as Pre-Monsoon, Monsoon (SW & NE) and the Post-Monsoon are shown in Figure 4. The profiles during March, April and May (pre-monsoon and summer) implies that the beaches have experienced accretion. The shift in profile level is more along the backshore due to more deposition of sediments. During this period, well

developed berms have been observed in the high-tide region of beaches. Accretion is noticed along the foreshore of Navaladi, Ovari and Periathalai beaches, which indicates the landward movement of sediments.

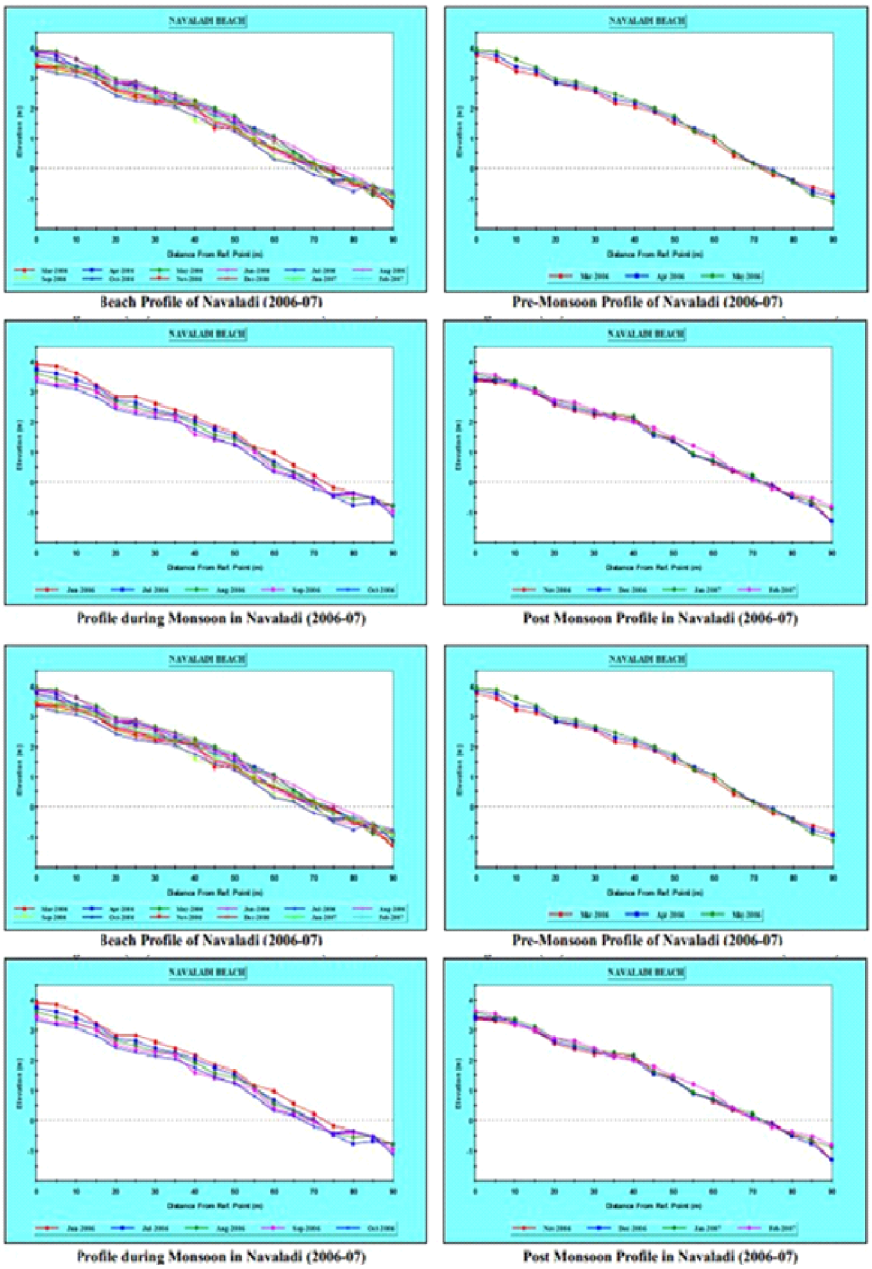


Fig.4. Spatial and Temporal variations of the beach profile along the SE coast during various monsoon periods

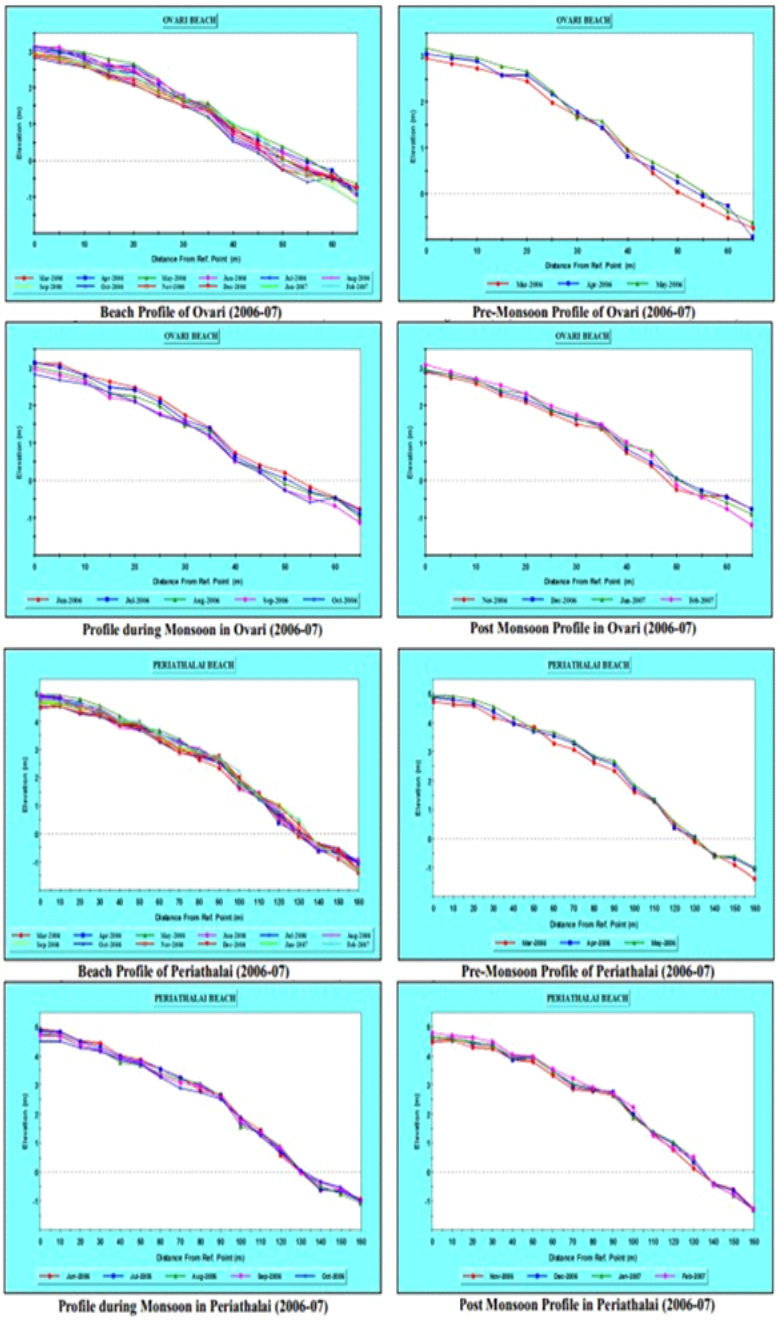


Fig.4. Spatial and Temporal variations of the beach profile along the SE coast during various monsoon periods (continued)

Beach Morphodynamics

The beach width is defined as the horizontal dimension of beach measured at right angles to the shoreline from the line of extreme low water inland to the landward limit of a beach. It is also defined as the distance between dune crest and shoreline position at high tide. It is an important parameter measuring the 'health' of

a beach. Understanding how beach width changes over varying timescales is vital for future shoreline management planning, for example, planning of beach nourishment or seawall construction, defining hazard setbacks, identifying 'hot spots' (locations of enhanced erosion) and the threat to human structures and/or recreational activities. The width of different beaches along the study area undergoes dynamic changes in both spatial and temporal scales (Tables 6 - 8) which have been controlled by both natural and human induced activities particularly beach sand mining. The Profiles are characterized by a large seasonal and annual variation in the incident wave height and beaches exhibit a distinct change in beach morphology. However the morphological changes are better explained by seasonal reversals in the littoral drift direction and by the variations in the incident wave energy conditions. The seasonal change in beach morphology is traditionally ascribed to a variation in the incident wave energy level with calm conditions in summer resulting wide beaches with pronounced sub-aerial berms and energetic conditions in winter causing narrow beaches with near-shore bar morphology. The seasonal and annual variations of beach width have been represented in Figure 5 and 6. It is observed that the beaches of Kanyakumari, Koottapuli, Idinthakarai, Navaladi and Ovari have experienced a reduction of beach width during the study period while the other beaches have experienced an increase in beach width. This indicates the spatial variation of erosion and accretion along the different beaches of the study area. During the period of March to May, the widths of beaches are in increasing trend, and it reaches a maximum value in April to May. The berms area is also more during these months. After this period, the increase in wave climate due to south-west monsoon lowers the profile and reduces the beach width considerably. In most of the beaches the beach width attains minimum values during August or September. From September onwards, the beach width slightly increases from its minimum level. It is due to comparatively low wave energy and reversal trend in the direction of sediment transport prevailing during NE monsoon. The littoral currents were moderate to strong during the SW monsoon, variable during the NE monsoon, and weak during non-monsoon period. The direction of these currents also varies during the SW and NE monsoons. Beach eroded during SW monsoon, but despite the prevalent moderate-high wave regime, and moderate-strong littoral currents, the beach profiles of the NE monsoon had accretion over the profiles of the SW monsoon. The beach profiles of the NE monsoon had accretion over the profiles of the SW monsoon. During NE monsoon, the influence of littoral currents and waves is comparatively lower than that of SW monsoon and the widths of most beaches are in increasing trend. But severe storms may also attack the shoreline during this period and the storm-generated waves that cut away the berm cause an offshore sediment motion and bar formation. During December to March, the beach profiles are gradually raises and attain maximum level during April or May. The annual changes in beach widths (Table 7) indicate that the beaches of Kanyakumari, Koottapuli, Idinthakarai, Navaladi and Ovari are eroding considerably and the beaches of Periathalai, Manappad, Kayalpattinam, Tiruchendur and Tuticorin south have been present in accretion trend. It has been noted that the width of beaches along the intensive mining sites have been considerably decreased which leads to more erosion along the coast. Here, the beach slope has been measured from the beach profile data. The size of the beach slope or degree of beach slopes by more or less, fixing the width of the beaches covered by tidal water. During non-monsoon, the slopes are more almost in all beaches due to the accumulation of sediment along the berm and high-tide zones (Figures 6). The reduction of beach slope during monsoon indicates the removal of sediment from the berm and dune to the off-shore. After the monsoon the beach slope again increases. There is no significant annual changes in beach slopes have been noticed.

Morphodynamics and Volumetric Analysis

The morphodynamics of beach refers to the interaction and adjustment of seafloor topography and fluid hydrodynamic processes. The hydrodynamic processes include those of waves, tides and wind-induced currents respond instantaneously and lead to the morphological change and redistribution of sediment. The seafloor morphologies and sequences of change dynamics involves in cross-shore and longshore sediment

transport. As sediment takes a finite time to move, there is a lag in the morphological response to hydrodynamic forcing. Sediment can therefore be considered to be a time dependent coupling mechanism. Since the boundary conditions of hydrodynamic forcing change regularly, this may mean that the beach never attains equilibrium. The beach profiles vary with time, both seasonally as the wave climate changes and over the long-term, in response to the pressures of erosion or accretion. Beach profiles measured at the same location over time can provide details about the behavior of the beach. The behavior of the entire beach can be examined in terms of shoreline recession and volumetric sand loss by the continuous profile measurements along the beach; moreover, an overall sand budget (sources and sinks of sand) can also be determined. Interpretation of beach response to coastal processes can be done with geometric and volumetric comparison of beach profiles sets. The convenient use of beach profiles is the determination of volumetric change of a beach, ?Vs. The volumetric calculation of profiles provide a time history of the volume of beach, and by determining the volume differences between surveys the erosion or accretion of the beach can be assessed as a function of time. There are no common standards for quantifying rates of beach change and for determining high-tide shoreline position. Beach erosion is generally quantified through some statistical treatment of retreat rates and volumetric losses. The variations on beach sediment volume have been widely used to quantify the changes and to understand the beach response to coastal processes. For any geometric and volumetric calculations an arbitrary vertical datum is needed. Here, the Mean Sea Level (MSL) has been considered as the reference vertical datum for performing geometric and volumetric analysis of beach profiles. Based on that, beach volume variability is higher for levels across the MSL, which provides higher with the morphological features of the profile. For each profile at a given time, the area of sand above the arbitrary datum, from the baseline to the offshore limit of the profile, is determined. For all profiles of the survey, the volume of sand in the beach above the arbitrary datum is obtained by the areas of the profiles along the beach which provides the beach sediment volume per unit length of beach.

(i). Seasonal Changes

The computed seasonal beach sediment volume changes from March-2006 to February-2008 of all beaches have been given in Table 8. It implies the sediment volume along the different beaches undergoes typical seasonal changes due to the hydrological conditions. During the period March-May, the volume of sediment in beaches is more almost in all beaches. The low wave energy prevailing along the study area during this summer period enhances the trapping of sediments across the beaches.

From June onwards the sediment volume decreases due to the changes in the wave climate due to the SW monsoon. The sediment from the berms and high-tide zone of the beaches are eroded and transported due to the littoral currents. The change in beach profile shows the movement of sediment from berms to the off-shore and it also indicates the development of small bars along the low tide region and off-shore of the coasts. In addition to the changes in the beach morphology, the sediment volume undergoes rapidly decreases in beaches. The reduction of sediment volume continues up to October. From November onwards the beaches start to regain the sediments. The comparatively low wave climate of north-east monsoon than the southwest monsoon enhanced the slight increase in sediment volume during the period of October and November. After the end of December it has been noticed that the beaches regain more amount of sediment due to the landward movement of off-shore sediment. Well developed berms have been noticed in some beaches due to movement off-shore sand bar towards the berms. There is a spatial and temporal variation of beach sediment volume with respect to the seasonal wave parameters along the beaches. It also indicates the cyclic changes on the beach morphology and morphodynamics. The seasonal changes in beach profiles constitute an important aspect of the variability of the coastal environment. It has been understood since late 1940's that with few exceptions the sand level on the exposed portion of a beach is higher towards the end of the summer than at any other time of the year. The winter storm waves overtop the summer berms and erode the backshore, their action thus reducing the width of the exposed beach. The winter beach is typified by a gently sloping beach face that in places extends shoreward to the toe of the sea cliff. The changes in beaches are signifi-

cantly different with respect to physiography, incident wave energy and direction, available sediment supply, tendency to erode or accrete, and level of development. The cycles of change in beach profile configuration and sediment volume may be associated with changes in the relative energy levels of winter and summer wave climates. The changes during the south-west monsoon are more than the north-east monsoon due to the difference in the wave climate during these monsoons. The beaches are highly responding to the south-west monsoon than thenorth-east monsoon due to the high wave conditions. SW and the NE monsoons and non- monsoon periods, the average wave energy flux (P) is 1.35, 0.66 and 0.4 K watts/m along the east coast of India. During NE monsoon the sediments accumulate and depositional environment prevails on the beaches along central east coast of India. The relatively high wave and current regime during the NE monsoon does not produce any erosions effect on the beach, and the area has accretionary tendency. High input of the fluvial sediments and their deposition on the beach due to fluctuations in the wave energy flux, from the turbid water plumes during this monsoon, appears to be the contributing process.

(ii). Annual Changes

The annual beach sediment volume and changes for all beaches along the study area are shown in Table 8. During the period 2006-07, the beaches of Kanyakumari, Koottapuli, Navaladi, Ovari and Manappad have experienced a reduction of sediment volume while the remaining beaches have gained sediment. The Kanyakumari, Navaladi and Ovari beaches have experienced more loss of sediment (6, 5, 4 cu.m/m respectively). The beaches of Manappad and Koottapuli have very low sediment losses. The Idinthakarai beach has no net loss or gain. The beaches of Periathalai, Tuticorin, Kayalpatinam, Tiruchendur, Perumanal and Tuticorin-south have gained sediments. The beaches of Periathalai, Tuticorin-south and Kayalpattinam have experienced more gain of sediment during this period. The Periathalai beach has gained sediment of volume 29 cu.m/m and the Tuticorin-south has gained 27cu.m/m of sediment. The construction of breakwater (Groin) at the Periathalai has enhances the trapping of sediment along the coast. During monsoon, large amount of sediments from the Thambraparani River are discharged along the Punnakayal coast are transported by littoral currents and waves. The bay nature of Tuticorin-south beach has effectively enhances the trapping of more amount of sediments are depositing along the coast. During the period 2007-08, the same trend is observed almost in all the beaches. But, the beaches of Kanyakumari and Navaladi have experienced more loss of sediment than that of during 2006-07. The Kanyakumari beach has experienced a loss of 12cu.m/m of sand and the Navaladi beach has lost 16cu.m/m of sand. Idinthakarai has experienced a sand loss of 5cu.m/m of sand while it gained sediment during 2006-07. The Koottapuli beach has gained sediment during 2006-07 while it lost sediment during 2006-07. The beaches of Perumanal, Periathalai, Tiruchendur, Kayalpatinam, Tuticorin-south and Tuticorin-north have experienced gain of sediments.

But the amounts of deposition of sediment on these beaches are decreased than that of during the period 2006-07. During 2006-07, the Periathalai beach has gained a sand of volume 29cu.m/m but it is considerably decreased to 12cu.m/m during 2007-08. Similarly the Tuticorin-south beach has gained a sand of volume 27cu.m/m but it is considerably decreased to 24cu.m/m during 2007-08. The gains of sediment of other beaches are also reduced during this period due to the changes in hydrological and littoral sediment transport. The reduction of sediment volume has also indicates the lack of sediment supply along beaches.

Beach Dynamics and Grain size Analysis

The mean size, standard deviation, skewness and kurtosis of beach of sediments from beaches with different morphology have been calculated (Table 9 and 10). The changes in sediment characteristics are associated with corresponding variations in beach profiles, so the variations in grain size could be well explained by the changes in profiles. The dynamics of profiles and morphology of beaches have also been characterized by the seasonal and cyclic changes of beach sediment size. The variations of mean size, standard deviation, skewness and ketosis are represented in Figure 7. The mean sediment size varies from fine to coarser grade

(0.12 mm to 0.72 mm). During the summer, the mean size of sediments undergoes small changes almost in all beaches. From the month of June onwards the sediments are changing from fine to coarser. The increase in the grain size indicates the erosional phase of the beaches. The volumetric analysis of the beach sediments emphasizes that there is a reduction of sand storage along the beaches during the SW monsoon which is due to the high wave energy conditions. The beach grain size analysis reflects the same trend of beach dynamics and morphology. Thus it is evident that the maximum values of sediment size leads to the erosional activity along the beaches. It has been observed that, the standard deviation of samples collected from the estuarine beaches such as Kanyakumari, Manappad and Tuticorin-South have been moderately sorted during the month of June and July. The skewness values of samples collected from beaches attains negative values during the monsoon periods. The negative skewness values represent the erosional phase of beaches. Coarser sediments have been observed in most of beaches during both south-west and north-west monsoon periods. This reveals the erosional activities of sediments along the beaches. But, during the period of North-East monsoon (October and November), the beaches of Perumanal, Tiruchendur and Tuticorin-south have symmetrical skewness values even with the negative skewness. This indicates that these beaches have gain sediment during the post-monsoon periods. The volumetric analysis also emphasizes that the increase of beach sediment volume during October and November. The accumulation of fluvial sediments to the coastal turbid water along these coasts and the small fluctuations in low wave energy also enhances the deposition of sediments. Thus the grain size reveals that the morphological changes of beaches are cyclic and experiences erosion in monsoon and accretion in fair weather conditions.

EOF Analysis of Beach Profiles

The empirical orthogonal function (EOF) method, a widely used statistical tool, can be applied to analyze the beach profiles to determine their variation through time or space. Even though the EOF method is only a descriptive tool and does not yield any information relating to the processes that govern the beach profile, it is a means of examining the variations in the beach profiles and the importance of the variations in a compact statistical fashion. The data required for the EOF analysis consist of multiple beach profiles, either over time at a fixed location or over distance at a fixed time (Spatial and Temporal Empirical Orthogonal Functions). In this present research, the EOF analysis has been performed to cross-shore profiles. The pattern of cross-shore sediment exchange can more be closely investigated by the EOF analysis. The analysis shows that the largest eigen value is much greater than the others. The obtained eigen values and the related variance has been shown in Table 11. It is noted that the first eigen values of both spatial and temporal eigen functions are high and their corresponding percentage of variance are more than 90%. It was also known that for coastal profile data that only the first three largest eigen values are significant. The first three spatial EOF's of profiles of Kanyakumari, Ovari, Tiruchendur and the Tuticorin-south beaches are shown in Figure 8. They represent the beach dynamics, accretion or erosion conditions along the beaches. The first spatial function of EOF'S are plotted against the distance from the reference point of the beach profile, which expresses the average of all profiles. The shape of an equilibrium coastal profile can be identified and calculated by using the first spatially-related eigen function. The equilibrium slope-elevation curves of profiles may have spatial variations, particularly for the upper part of the profiles; this indicates that this part is more sensitive to equilibrium adjustment than the lower part. For all profile stations, the first temporally-related eigen function is almost stationary, indicating that a stable slope-elevation relationship (i.e. equilibrium) exists. The first temporal eigen function also fluctuates significantly during some period, but it recovers rapidly in a very short time. The second spatial eigen functions associated with the second largest eigen value are referred to the seasonal variations of the beach profiles. The eigen values reach a maximum at the location of the summer berm and a minimum in the area of the winter sub-water bar formation. The eigen values of first few spatial points are negative from the reference point of the survey, which indicates the erosion or transport of sediments from the berm or high tide region of beaches. It also represents the loss of sediment during the

Fig. 5. Seasonal and Annual changes of beach width along the SE coast

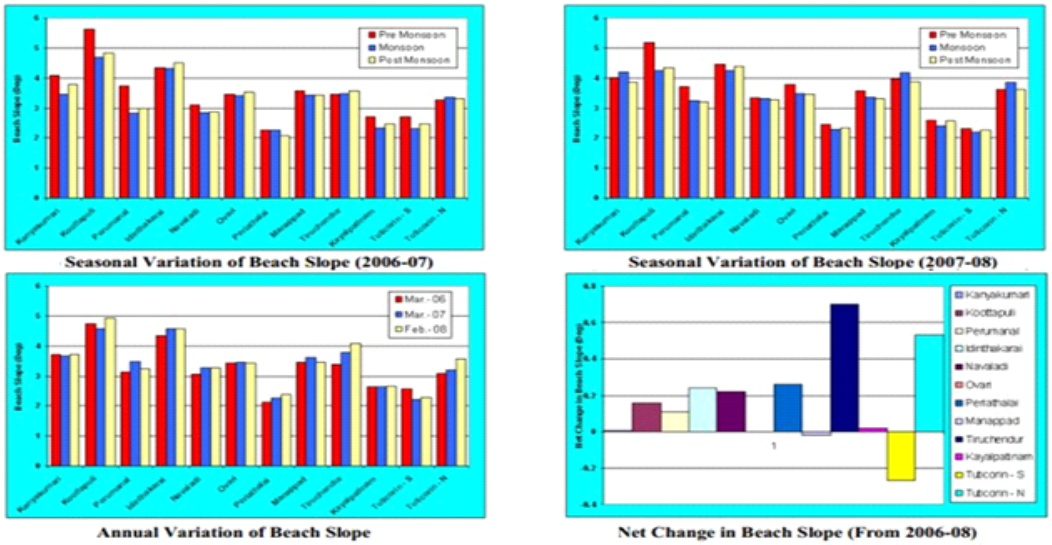


Fig.6. Seasonal and Annual changes of beach slope along the SE coast

monsoon period. The eigen values attain positive values when moves toward the off-shore of the beaches. This indicates that, during the monsoon the off-shore and low-tide zones of beaches gain sediment from the berm and high-tide zones. This variation in the amplitudes of different spatial points of the profile survey indicates the cross-shore sediment transport. It clearly indicates the berm erosion and the formation of sand bars during the monsoon. The trend of the second temporal eigen function reflects the seasonal variations of beach profiles. During summer, the amplitudes attain positive values indicating the accretion and whereas in

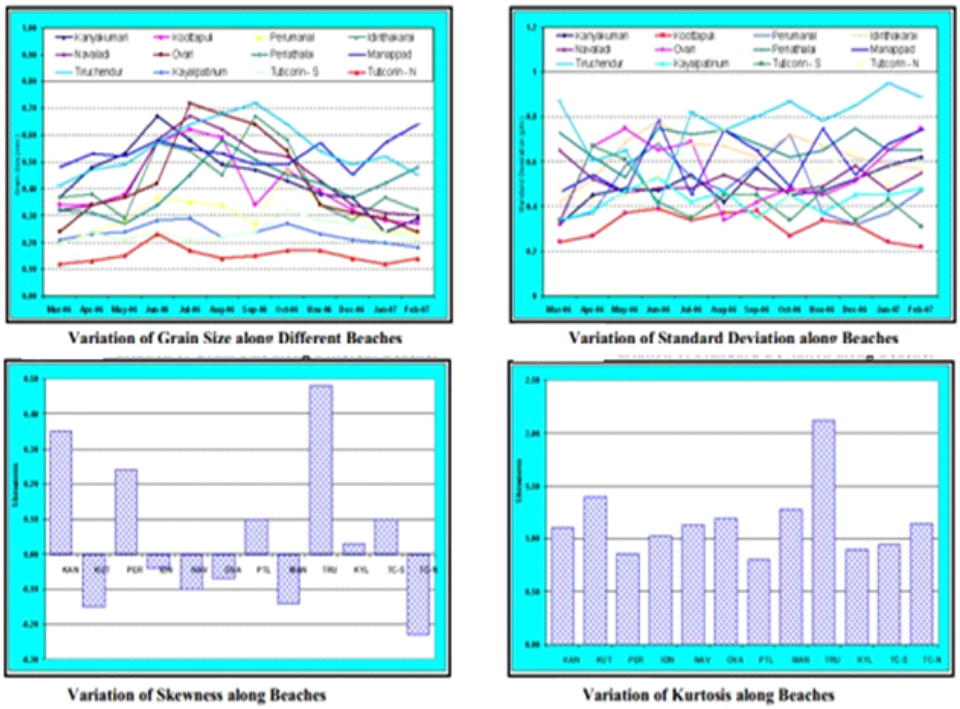


Fig.7. Annual variations of Sediment Grain size and SD, Skewness, Kurtosis along the SE coast

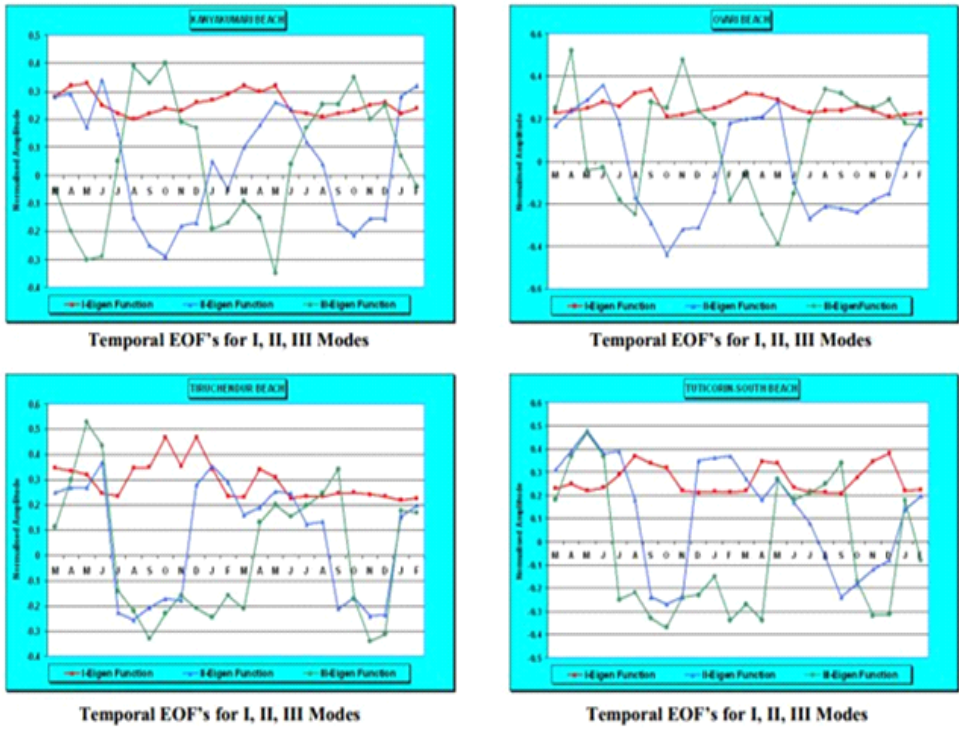


Fig.8. Spatial and Temporal variations of EOF characteristics along the SE coast

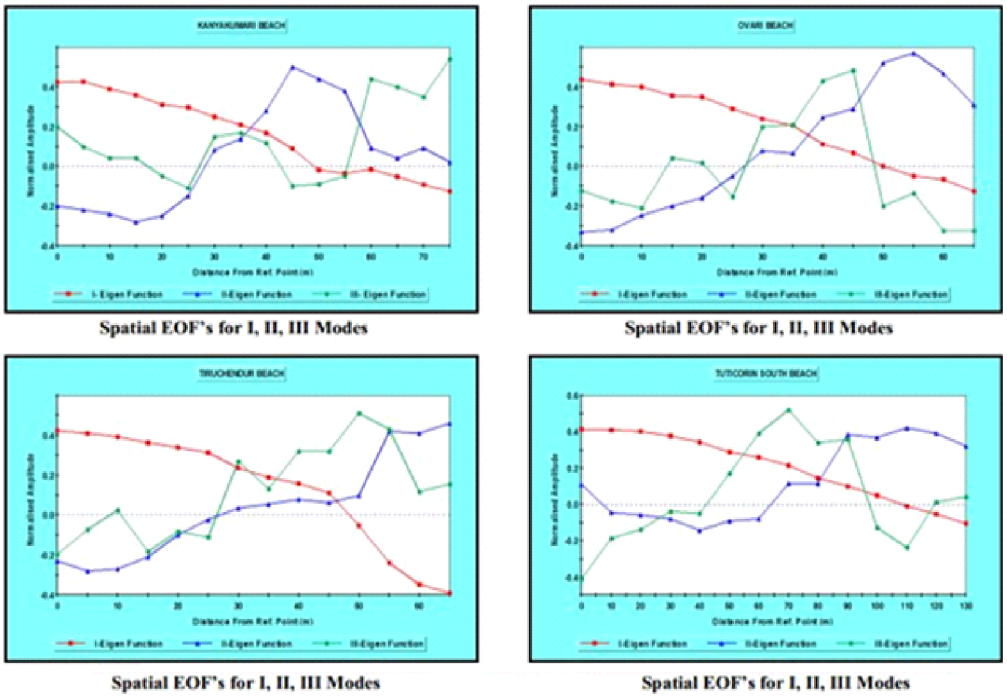


Fig.8. Spatial and Temporal variations of EOF characteristics along the SE coast (continued)

Table 6. Annual changes of beach slope along the SE coast

Beach Name	Beach Slope			Annual Changes in Beach Slope (cu.m/m)		
	Mar.- 06	Mar.- 07	Feb.- 08	2006-07	2007-08	Net
Kanyakumari	3.69	3.66	3.70	-0.03	0.04	0.01
Koottapuli	4.75	4.57	4.91	-0.18	0.34	0.16
Perumanal	3.13	3.49	3.24	0.36	-0.25	0.11
Idinthakarai	4.34	4.56	4.58	0.22	0.02	0.24
Navaladi	3.04	3.26	3.26	0.22	0.00	0.22
Ovari	3.42	3.45	3.42	0.03	-0.03	0.00
Periathalai	2.12	2.26	2.38	0.14	0.12	0.26
Manappad	3.47	3.62	3.45	0.15	-0.17	-0.02
Tiruchendur	3.38	3.77	4.08	0.39	0.31	0.70
Kayalpatinam	2.63	2.63	2.65	0.00	0.02	0.02
Tuticorin - S	2.56	2.23	2.29	-0.33	0.06	-0.27
Tuticorin - N	3.06	3.18	3.59	0.12	0.41	0.53

Table 7. Seasonal and Annual changes of beach width along the SE coast

Beach Name	Seasonal Changes in Sediment Volume (cu.m/m)					
	During Mar. 06 to Feb-07			During Mar-07 to Feb-08		
	Pre Monsoon	During Monsoon	Post Monsoon	Pre Monsoon	During Monsoon	Post Monsoon
Kanyakumari	122	105	110	119	89	97
Koottapuli	143	128	134	148	127	132
Perumanal	232	194	203	235	196	214
Idinthakarai	132	121	125	135	113	121
Navaladi	164	132	145	157	127	138
Ovari	103	82	92	102	87	87
Periathalai	411	390	404	459	399	424
Manappad	224	194	214	216	181	197
Tiruchendur	116	92	103	121	100	109
Kayalpatinam	265	237	257	265	252	259
Tuticorin - S	306	275	304	320	286	320
Tuticorin - N	101	88	96	100	89	98

Beach Name	Beach Sediment Volume			Annual Changes in Sediment Volume (cu.m/m)		
	Mar.- 06	Mar.- 07	Feb.- 08	2006-07	2007-08	Net
Kanyakumari	116	110	98	-6	-12	-18
Koottapuli	132	130	131	-2	1	-1
Perumanal	208	214	216	6	2	8
Idinthakarai	128	128	123	0	-5	-5
Navaladi	151	146	130	-5	-16	-21
Ovari	96	92	88	-4	-4	-8
Periathalai	383	412	424	29	12	41
Manappad	203	200	202	-3	2	-1
Tiruchendur	102	110	113	8	3	11
Kayalpatinam	243	262	263	19	1	20
Tuticorin - S	284	311	335	27	24	51
Tuticorin - N	100	103	105	3	2	5

Table 8. Seasonal and Annual changes of Sediment volume along the SE coast

Beach Name	Seasonal Changes in Sediment Volume (cu.m/m)					
	During Mar. 06 to Feb-07			During Mar-07 to Feb-08		
	Pre Monsoon	During Monsoon	Post Monsoon	Pre Monsoon	During Monsoon	Post Monsoon
Kanyakumari	122	105	110	119	89	97
Koottapuli	143	128	134	148	127	132
Perumanal	232	194	203	235	196	214
Idinthakarai	132	121	125	135	113	121
Navaladi	164	132	145	157	127	138
Ovari	103	82	92	102	87	87
Periathalai	411	390	404	459	399	424
Manappad	224	194	214	216	181	197
Tiruchendur	116	92	103	121	100	109
Kayalpatinam	265	237	257	265	252	259
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Beach Name	Beach Sediment Volume			Annual Changes in Sediment Volume (cu.m/m)		
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Kanyakumari	116	110	98	-6	-12	-18
Koottapuli	132	130	131	-2	1	-1
Perumanal	208	214	216	6	2	8
Idinthakarai	128	128	123	0	-5	-5
Navaladi	151	146	130	-5	-16	-21
Ovari	96	92	88	-4	-4	-8
Periathalai	383	412	424	29	12	41
Manappad	203	200	202	-3	2	-1
Tiruchendur	102	110	113	8	3	11
Kayalpatinam	243	262	263	19	1	20
Tuticorin - S	284	311	335	27	24	51
Tuticorin - N	100	103	105	3	2	5

Table 9. Grain size variations of Sediment along the SE coast

Beach Name	Mean Size of Beach Sediments During Mar. 2006 to Feb. 2007 (mm)											
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Kanyakumari	0.37	0.48	0.53	0.67	0.58	0.49	0.47	0.43	0.38	0.37	0.24	0.29
Koottapuli	0.34	0.34	0.38	0.57	0.62	0.59	0.34	0.47	0.39	0.32	0.28	0.27
Perumanal	0.21	0.24	0.28	0.37	0.35	0.34	0.27	0.47	0.34	0.31	0.24	0.24
Idinthakarai	0.37	0.38	0.29	0.57	0.54	0.45	0.67	0.58	0.34	0.28	0.37	0.32
Navaladi	0.32	0.34	0.37	0.58	0.67	0.62	0.54	0.52	0.43	0.34	0.31	0.30
Ovari	0.24	0.34	0.37	0.42	0.72	0.68	0.64	0.54	0.34	0.31	0.29	0.24
Periathalai	0.32	0.31	0.27	0.34	0.45	0.58	0.51	0.45	0.42	0.37	0.42	0.48
Manappad	0.48	0.53	0.52	0.58	0.55	0.53	0.49	0.49	0.57	0.45	0.57	0.64
Tiruchendur	0.41	0.47	0.49	0.57	0.64	0.68	0.72	0.64	0.54	0.49	0.52	0.45
Kayalpatinam	0.21	0.23	0.24	0.28	0.29	0.22	0.24	0.27	0.23	0.21	0.20	0.18
Tuticorin - S	0.19	0.24	0.21	0.24	0.21	0.22	0.24	0.32	0.28	0.27	0.24	0.21
Tuticorin - N	0.12	0.13	0.15	0.23	0.17	0.14	0.15	0.17	0.17	0.14	0.12	0.14

Table 10. Annual variations of Sediment Grain size along the SE coast

Beach Name	Average Values of Grain Parameters from Mar. 2006 to Feb. 2007 (mm)			
	Mean Grain Size (mm)	Standard Deviation	Skewness of Sediments	Kurtosis of Sediments
Kanyakumari	0.44	0.49	0.35	1.10
Koottapuli	0.41	0.31	-0.15	1.40
Perumanal	0.31	0.48	0.24	0.86
Idinthakarai	0.43	0.63	-0.04	1.03
Navaladi	0.45	0.51	-0.10	1.13
Ovari	0.43	0.56	-0.07	1.19
Periathalai	0.41	0.67	0.10	0.80
Manappad	0.53	0.61	-0.14	1.28
Tiruchendur	0.55	0.77	0.48	2.12
Kayalpatinam	0.23	0.43	0.03	0.90
Tuticorin - S	0.24	0.43	0.10	0.95
Tuticorin - N	0.15	0.53	-0.23	1.14

Table 11. Spatial and Temporal variations of EOF values along the SE coast

Beach Name	Function	Net	I EOF		II EOF		III EOF	
			λ	%	λ	%	λ	%
Kanyakumari	Spatial	4.52	4.43	98.0	0.057	1.26	0.006	0.13
	Temporal	7.81	7.63	97.6	0.079	1.01	0.005	0.06
Ovari	Spatial	3.53	3.43	97.2	0.010	0.28	0.004	0.11
	Temporal	3.37	3.25	96.4	0.112	3.32	0.003	0.09
Tiruchendur	Spatial	4.27	4.07	95.3	0.058	1.35	0.005	0.12
	Temporal	5.36	5.24	97.8	0.032	0.59	0.007	0.13
Tuticorin - S	Spatial	7.45	7.31	98.1	0.025	0.34	0.008	0.11
	Temporal	4.25	4.02	94.6	0.053	1.24	0.013	0.31

the monsoon the values are negative which indicates erosion. The time dependence of this function shows yearly periodicity. It is related to annual movement of sand towards onshore and offshore. The pattern of third spatial and temporal EOF functions indicates the rapid changes and random variations along the beaches. Therefore, the beach profile can respond efficiently to the morphological changes along the coast in the prevailing hydrodynamic conditions of beaches, by maintaining its equilibrium state.

Conclusions

The morphology of beaches along the study area undergoes dynamic changes in different spatial and temporal scales. Both cyclic (seasonal) and annual changes in the beach topography is more prominent. The morphodynamic and volumetric analysis of beach profiles indicates that the beaches of Navaladi, Kanyakumari and Ovari have experienced more annual loss of sediments and they poses severe beach erosion. The beaches of Tuticorin-south, Periathalai, Kayalpatinam and Tiruchendur have experienced more accretion. EOF analysis confirms the dynamic changes on the beach profiles of the region. The different morphological of appearance of the beaches show the morphodynamic behaviors have direct influence on the wave refraction, with the mechanical processes of a wave. Sediment transport processes in the littoral zone are of fundamental importance to beach morphology, shoreline stability and coastal landform dynamics. Beaches erode, accrete, or remain stable, depending on the rates at which sediment is supplied to and removed from the shore. Swash moves sand diagonally, while backwash moves it straight down. The net result of this zigzag movement is the downwind displacement of sand along the beach, known as beach drift. Littoral sediment transport implies that the beaches of Kanyakumari, Navaladi, and Ovari have more transport rates. More changes in beach sediment volume are observed in the beaches of Tamil Nadu. It can also produce various coastal landforms modifications in the regions due to intensive sand mining.

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PLENARY LECTURES

Plenary Lecture 1

INDIA'S GEOHERITAGE: A METHOD FOR CLASSIFICATION OF GEOMORPHOSITES IN INDIA

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India is a country with rich geo-wealth and outstanding geodiversity. There are numerous fascinating and exquisite landforms and landscapes in the Indian subcontinent that have immense scientific, cultural, and socio-economic value and are significant from the point of view of geotourism and geoeducation. In spite of the remarkable geodiversity, there are strategic gaps in the information about India's geodiversity and till date there is no inventory of geomorphosites at the state or whole-of-nation level. The preparation of a select and definitive list of India's geomorphosites is urgently needed.

An inventory card for geomorphosites is proposed in this paper. The first part of the inventory card includes the basic information about the geomorphosite. The second part deals with the numerical classification of the geomorphosite on the basis of some key scientific value criteria, additional value criteria and management criteria as well as the IUCN geo-theme code and the code number of the geomorphic province. The simple 10-digit geo-coding system has the potential to classify and sort geomorphosites on the basis of IUCN geo-theme code, scientific or intrinsic value, touristic value (aesthetic/scenic value), cultural value, ecological value, economic value, accessibility, integrity (state of preservation), potential threat and geomorphodiversity.

Plenary Lecture 2

EVOLUTION AND TRANSFORMATION OF RIVER CHANNELS IN THE HIMALAYAN FORELAND OF WEST BENGAL, INDIA

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The evolution of the Himalayan foreland in West Bengal is generally controlled by (i) the great Himalayan rivers i.e., Tista, Torsa, Raidak and Sankosh and (ii) the smaller streams draining the frontal zone of the mountains i.e., Jaldhaka, Mahananda, Kaljani etc. and are deeply incised into the bedrocks. Fan building started from the sharp edge of the Himalaya. Downstream, the fan is subject to gradual spread over which braided channels form up to the confluence with the Bhramaputra in case of Tista. River Torsa attains meandering pattern at a distance of 50 km from the mountain front. While, the latter group of rivers are highly dissected and receives the heaviest annual rainfall (5000-7000mm). Frequent floods carry heavy bed load supplied by landslides forming fans. These fans frequently form an inclined shelf at the base of the mountain scarp. With reduced gradient and finer over-bank deposits, the streams change their channel pattern to a meandering one.

Different local factors give rise to various modifications within the general pattern i.e., Piedmont features connected with relief and river network, deviations from the general model connected with young tectonic activities, anomalies in piedmont and foreland formation connected with climatic and hydrologic factors and anthropogenic acceleration of sediment loading and aggradations in the piedmont and foreland.

Present day evolutionary processes of landform in the piedmont and foreland is dominated by high intensity rainstorms induced accelerated sediment delivery, transforming channel geometry followed by flood induced avulsion, bank erosion, valley widening, shifting of river courses and thereby accelerating the processes of flood plain formation.

Plenary Lecture 3

CLIMATE CHANGE IN INDIA WITH SPECIAL REFERENCE TO RAJASTHAN: *ARE WE PREPARED FOR DRASTIC CHANGE?*

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Climate change is a global environmental problem. A fierce debate is on for the last three decades on the causes and implication of increasing use of fossil fuels for the health of Planet Earth. Several scientific studies including "Ice Core" have been made on the basis of analysis of data on temperature, rainfall, drought and floods both at regional and global scale. However, there is a need to put forward more and more data at the local and regional scale to validate the issue of global warming and resultant climate change. Scientific studies indicate an era of global warming very much in hand ,which would lead to increase in both average and extreme temperature and precipitation and consequent melting of ice caps, retreat of glaciers, rise in sea level, increasing coastal erosion , lengthening growing seasons and increasing range of many infections diseases. According to IPCC global warming has already started affecting the weather and climate although it is not possible at this early stage to pin any particular weather event on it. While most scientists subscribe to the view that global warming and it is being caused by human activities, there are those who consider it a part of normal natural cycle. They cite examples of weather changes in the past and challenge the data put forward by the IPCC and fellow scientists on melting of ice caps and glaciers. Let the debate on global warming and climate change continue for we do want incontrovertible scientific evidences on it . Without going into merits of the claims of the pro and anti warming scientists , there is a bit exaggeration on both sides. Keeping this background in view the present paper attempts to put forward more scientific data at a local and regional scale on temperature and rainfall trends with reference to climatically sensitive desert state of Rajasthan , India.

The studies related to temperature and rainfall trends in India have shown an increasing trends of temperature and year to year variability of rainfall pattern during last 100 years or so. It has been observed that during last more than 100 years the monsoon rainfall has been trendless particularly on all India scale but the trends in regional monsoonal rainfall in the past century have been observed. Trend analysis of 1 day extreme rainfall series based on the period 1951-2007 shows that extreme rainfall amounts are increasing at many places over India. In Rajasthan also some pockets show an increasing trend of extreme rainfall events such as Lower Luni River, July ,1979, Jaipur, July 1981 and Barmer, August 2006. The studies also indicate that the annual mean temperature for the period 1901-2007 over India and 1901-2012 over Rajasthan has shown a significant warming trend of 0.510 per 100 years and about 0.950 per 112 years in Rajasthan.

The trend analysis of rainfall and temperature to ascertain the climate change in Rajasthan has been done in the time frame of more than 100 years. The simple linear regression technique was applied to develop a model between the temperature / rainfall as dependent variable and years as an independent variable. ARIMA model has been used to predict the trend of temperature and rainfall in future. The spatial unit for temperature and rainfall has been taken as a district.

Correlation analysis of annual average temperature with time series at district level shows that fifteen districts of the state- Jaisalmer, Bikaner, Jodhpur, Banswara, Dungarpur, Barmer, Udaipur, Jalore, Jhalawar, Sirohi,Chittaurgarh, Rajsamand, Baran, Pali and Kota, have recorded very significant warming, while two districts- Bhilwara and Bundi, have witnessed significant warming trend at centennial time scale. The districts like Sikar and Dausa have shown a cooling trend although this trend is insignificant.

Annual total rainfall pattern also at district level shows that Banswara, Dungarpur, Jhalawar, Sirohi and Udaipur have recorded less rainfall than normal while rest 27 districts of the state have received more rainfall, although all correlation values are insignificant. The data of Pratapgarh district was not available.

Regression result of temperature and rainfall series shows that due to too much noise in the data, R2 values are very weak (noise is clearly visible in temperature and rainfall versus time scatter plots), however, temperature-time series association is positive and significant for 17 districts having F value above 4. For rainfall series, F value is weak in all cases, hence no significant trend was identified.

The paper also discusses mitigation measures initiated by government both at National Level and State Level.

Plenary Lecture 4

ARE LADAKH GLACIERS, KARAKORUM HIMALAYA, CURRENTLY IN STABLE PHASE?

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Glaciers are dynamic reservoirs of constantly exchanging mass with parts of global hydrological system, process by which glaciers gain or lose snow and ice and establish a link between climate, glacier mass and glacier fluvial dynamics related directly to the behaviour of climate. Here, i report on glacier status over the past 50 years (1962-2013) on remotely- sensed volumetric changes of glaciers in Drass valley, Suru-Zanskar valleyand Nubravalley of Ladakh, North-West Himalaya. Drass valley, Suru-Zanskar valley and Nubra valley houses 150, 268, and, 114, glaciers of different dimensions predominantly (nearly 75%) by small sized glaciers. The glaciers monitored on multi-temporal satellite images of the year's 2001, 2013 for short term basis, and, Survey of India topographic sheets of 1965(surveyed in 1963) on long term basis. Machoi, Saichin and Drung Drung glaciers haves been selected for detailed study to assess health and fluctuation record on which observation has been made since the year 1875. The long- term monitoring(1965-2001) of glaciers shows that 16-24% of glaciers have gained the area whereas 14% 0f large glaciers lost area 5% to15%, and remaining 62-70% glaciers lost area marginally(<5%). The short-term monitoring(2001-2013) shows that 80% glaciers do not show any change in area, even large glaciers vacated 0.64-2.6% area and small glaciers 1.68% to 9% glacier area. The studies been investigated to assess the role of meteorological parameters in governing the snow cover assessment, it has been found that annual changes in glacier extent is due to wintertime anomalies in accumulated snow and anomalies in maximum temperature during summer. The trends in annual, ,seasonal ,and , monthly maximum / minimum temperature and precipitation (snowfall and rainfall) of Drass , Kargil ,and ,Leh for period 1987-2013 shows two different patterns of weather conditions ,1988-2001 a cold moist winters with dry summers ,and 2002-2013 a period of long winters and cool and moist summers, corroborate with transitional phase of glacier behaviour. This phenomenon has resulted in incorporating no change in area of 80% of glaciers, and remaining 20percentage of glaciers show marginal loss in area. The positive balance mass for last four years (2011-2014) in benchmark Machoi glacier (2011-2014). Durung Drung glacier (2005-2009) and Saichen glaciers (2007-2009) with cumulative specific balance +0.16m w.e/km²/yr further indicate about the stability phase of the glaciers.

Plenary Lecture 5

RECENT TRANSFORMATIONS OF THE INDIAN SUNDARBAN: HOW FAR IS CLIMATE CHANGE RESPONSIBLE?

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The IPCC reports on climatic changes have unequivocally stated that increase in sea surface temperature would increase numbers of cyclonic storms in the tropics. This, coupled with rise in sea level, would have dire consequences in regions like the Indian Sundarban where the elevation of some 27 reclaimed tidal islands (825 km2, excluding Hugli estuary) are lower than spring tide levels. Flood is often considered beneficial for crops as it deposits fertile silts, but in Sundarban it precipitates salt as well and severely degrades farmlands. As shown by the relatively low-magnitude Aila event of 2009 (highest wind speed: 110 km h-1), cyclone

landfalls, coincided with high tides can easily breach or overtop marginal embankments and waterlog vast areas of the Sundarban islands for weeks. However, if the West Bengal coast is considered and the period of cyclone landfalls since 1891 are divided into 30-year spans, records show that incidents of cyclones have actually reduced during the recent decades.

It is generally agreed that at least 50 years' continuous data are required to get any reliable indication of sea level trends from tidal stations. Permanent Service for Mean Sea Level (www.PSMSL.org), the world's repository of long term tide gauge data pertaining to sea levels, has only one observatory close to Sundarban that fulfils this criterion: Diamond Harbour. The 61-year record of sea level change data of this station denote a rise of 4.61±0.37 mm yr-1 which is nearly twice the rates recorded by other regional stations of India and Bangladesh. The squeezing banks of the Hugli estuary, aided by continuous sedimentation, probably play a key role in long-term increase in the tidal levels at Diamond Harbour, which is situated 70 km inland from the seafront. The 48-year data of the Sagar observatory indicate a negative trend of sea level at the seafront, which makes data accuracy of this station questionable. Thus, no tidal observatory with reliable and sufficient length of gauge records exists in any sea board location in Indian Sundarban. On the other hand, the 23-yr record of sea level change off the Indian Sundarban from satellite altimetry indicates a nominal rise at 0.41±0.05 mm yr-1 against a global mean of 3.28±0.31 mm yr-1. It may be noted here that none of the recent estimates in print that put the rate of sea level rise at Sagar Island between 3.14 and 12 mm yr-1 was sourced from PSMSL and all fall short of technical accuracy.

A number of reports and articles have recently been published on erosion of the Sundarban islands and nearly all of these have used this phenomenon as an evidence for sea level rise and climate change. These works have overlooked the fact that the western Ganga-Brahmaputra delta is retrograding for the last 200 years and that the changes in island areas can also be convincingly explained by delta abandonment and time-velocity asymmetry of Sundarban's tidal currents that intensely rework the estuarine sediments. Many of the region's emerging socioeconomic problems, which are also being linked to climate change, largely result from growth in population that registered a four-fold increase since 1951, taking the region's carrying capacity to the brink.

YOUNG GEOMORPHOLOGISTS COMPETITION

CHANNEL MORPHOLOGY UNDER RIVER REGULATIONS: A GLANCE ACROSS THE JALDHAKA HYDRO-ELECTRIC PROJECT, EASTERN HIMALAYAS

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Prior to the question of regional development through power generation, flood mitigation and promoting tourist attractions, a large number of rivers elsewhere on the planet have been pushed towards prolonged control under the aegis of dams and barrages. However, scientific communities are still in puzzle whether and how much responsible these regulations are for far-reaching impacts upon the corresponding river morphology as both fatalities and feasibilities have been reported by scholars around the world. Guided by such a confronting dilemma, the present study has peeped into the Jaldhaka Hydroelectric Project to understand the pre-barrage and post-barrage channel morphological conditions with repetitive field studies and Geospatial techniques. Constructed in 1960's, the Jaldhaka Hydel Project is one of the oldest initiatives to control rivers in the name of development in the Eastern Himalayas falling in the North Bengal of India-Bhutan frontier region. Since then, serious morphological alterations have been observed across the immediate and downstream reaches of the river. With significant co-operation by channel controlling drivers such as low channel gradient, tectonic activities, decreasing rainfall trends and erosion prone lithologic composition, the barrage has been found to be exaggerating the overall channel morphology. In an immediate neighborhood, the main channel is rapidly narrowing down by vigor deposition while it is found to be widening itself far downstreams with gradual rise in braid indices dominating over falling sinuosity which is transforming the river into a wandering one from a meandering one. Depositional propensities have overtaken the incision capacities and the river bed levels at various stations have been found to be rising. Planform geometry over the specific timeframe has further shown significant controls of the barrage on the river.

HUMAN INTERFERENCE ON THE MORPHOLOGICAL CHANGE OF THE HAORA RIVER, TRIPURA, INDIA

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Since the early 20th century the Haora River, the lifeline of the Agartala city, Tripura has been intensely used by the city dwellers for fulfilling their own needs. The dwellers, directly or indirectly are not only polluting the river water but also altering the morphology and dynamics of the river. Till date most of the researches are mainly concentrated on the degradation of the river or the impact of river pollution on human health, but the impacts of human activities on river dynamics are neglected, as it is difficult to detect.

The Haora River is originated in Tripura, India and meets with the River Titas in Bangladesh. This river has a total length of about 61.2 km among which 52 km is flowing within Indian Territory. Within this 52 km, three long stretches have been identified where the course of the river as well as the flow has been changed more due to anthropogenic activity than the natural causes. Different temporal maps of the River have been analyzed in order to get the pattern of changes of these stretches. Several cross sections

(for three consecutive years 2010-2012) have been taken in those stretches individually for detecting the nature of changes. Sediments samples have also been collected from the river bank as well as the bed to get idea about the probable causes behind such changes. Starting from the International boundary, individually those stretches cover 5.35km, 4.74 km and 5.47 km of length respectively. The major activities which are responsible for such changes are construction of distributaries (canal) for diverting flood water, dumping of huge brick waste of the brick fields along and within the river and dumping of market garbage along the bank. Excepting these three stretches, some other areas along the Haora River are also noticed where minor changes in river dynamics (formation of bars, course change, bank erosion etc.) are initiated by construction of causeways, bridge piers and other anthropogenic activities.

Keywords: River Morphology, Course change, Anthropogenic activity, Garbage disposal

GROUNDWATER RESOURCE ESTIMATION AND CHARACTERIZATION OF ITS DYNAMICS FOR SUSTAINABLE MANAGEMENT IN DHALAI DISTRICT, TRIPURA, INDIA

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Groundwater is a dynamic resource as it varies temporally as well as spatially. In order to ensure the sustainable use of ground water, the ground water assessment, development and management have become essential. Keeping this view, the present study attempts to identify and delineate groundwater potential zones using relevant data, estimation of groundwater and the fluctuation of ground water level. In order to delineate the groundwater potential zones, Analytical Hierarchy process (AHP) and relative importance based weight-rating system have been used. Results of ground water potential zonation indicating that very high potential zones (16.87 %) are flood plains and inter-hill valley regions with low elevation (<100m). The low (14.35%) and very low (6.24%) potential zones comprises high degree of slope (>300), structural hill ranges and act as run- off generating zones. Estimation of Ground Water Resources in Dhala District has been computed according to GEC'97 methodology. In GES'97 methodology, water level fluctuation method (WLFM) and rainfall infiltration method (RIFM) have been used to calculate the amount of recharge from monsoon rainfall. Monsoon and non-monsoon rainfall recharge shows that monsoon recharge accounts for 65% and non-monsoon recharge accounts for 35% of total rainfall recharge. The pre-monsoon depth to water level data (2011) of the Ground water Monitoring stations (GWMS) of Dhalai district show that the wate levels vary from 3.03 to 5.47m bgl and the average preonsoon water level of Dhalai District is 4.49m bgl. The water level fluctuation ranges from 0.8m to 4m with the average fluctuation of 2.46m in the district. Ground Water Resources estimated in the district show that the balance ground water available for future irrigational development is 44,822 ha-m. This Balance Ground water have the potentiality to irrigate of 37352 ha of paddy fields or 74703 ha of dry crop fields by way of constructing 14,940 number of new shallow tube wells in a in the area.
Key words: Groundwater, AHP, Potential zones, Fluctuation, Estimation

QUANTITATIVE ANALYSIS OF GEO-HYDROLOGICAL RESPONSE TO POTHOLES MECHANISM: A CASE STUDY OF SUBARNAREKHA RIVER BASIN, GHATSILA, JHARKHAND, INDIA

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Abstract: The present work is mainly concerned about the approaches of pothole mechanisms with special emphasis on geo- hydrological and mathematical background. The study gives an ample scope for defining the process of analysis micro landforms both in respect of time and scale. This paper includes the mechanism by pothole morphology, development, growth and dynamic changes in micro level. The present study highlights some the inter linkages of some specific parameters like geological and hydrological river bed pothole mechanism of Subarnarekha River. Reviewing our geomorphological knowledge potholes are mainly found to be concentrated in upper most part of the river where the stream energy is maximum but here our study area is included in the middle part and lower part of the Subarnarekha River which is a typical example of rejuvenated Antecedent River in Chhotanagpur plateau and exist like a bedrock river. Concerning the mechanism of pothole due to both shearing (geological) and huge discharge (hydrological) are response the development of potholes as micro fluvial landforms. One the basis of the analysis it is necessity to give a new threshold of quantitative methods in landforms study under a systematic scientific geographical background. Regarding the hydrological parameters like discharge, suspended load, stream power, velocity have been considered and some morphometric attributes like slope, bedrock character, rocky exposed on the riverbed etc. are the main influence factors. This type of work will be help to open a new window for studying the micro landform mechanism in a contemporary method.

FLOOD HYDROLOGY OF THE PAR RIVER: WESTERN INDIA

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An attempt has been made to understand the magnitude, variability and frequency characteristics of floods on the Par River on the basis of available annual peak discharge data and field data. The Annual Maximum Series (AMS) data were available for the Nani Vahial site with Gujarat Irrigation Department for 49 years. The peak discharge values have also been estimated for more than a dozen cross-sections on the Par River. The time series plots of the AMS data reflect considerable interannual variability. High variability is also indicated by the very high value of coefficient of variation (1.03) and the flash flood magnitude index (0.42). The largest discharge is about 5 times higher than the mean annual maximum discharge. All these indices reveal that the possibility of the river experiencing significant geomorphic work during large floods is higher. Extraordinarily high unit discharges (7-101) indicate much greater potential of floods. The magnitude-frequency analysis based on Gumbel Extreme Value type I distribution reveals that the mean annual peak flood has a recurrence interval of 2.33 years, large flood has 6.93 years and maximum peak discharge has 185 years. The discharge-area envelope curve shows that the basin produce extremely larger flood peaks than drainage basins with comparable basin area in the other part of the world. Two general conclusions emerge from the analyses. First, the river displays extraordinary hydrologic characteristics of a flood-dominated river. Second, large floods are relatively frequent. This fact suggests that large-magnitude events have an important role to play in the bedrock channel morphology and coarse sediment transport of the Par River.

TRACES OF RARE EARTH ELEMENTS IN INTRA-FORMATIONAL CONGLOMERATES AROUND WEILOI - TYRSAD VILLAGES, EAST-KHASI HILLS, MEGHALAYA AND ITS SIGNIFICANCE

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Rare Earth Elements (REE) is a group of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium and are non-toxic elements. Despite their name, rare earth elements are relatively plentiful in Earth's crust, with cerium being the 25th most abundant element at 68 parts per million, or as abundant as copper. However, because of their geochemical properties, rare earth elements are typically dispersed and not often found concentrated as rare earth minerals in economically exploitable ore deposits. It was the very scarcity of these minerals (previously called "earths") that led to the term "rare earth". However, these metals are very difficult to mine because it is unusual to find them in concentrations high enough for economical extraction. REE resources are contained primarily in bastnasite and monazite and also in apatite, cheralite, eudialyte, loparite, phosphorites and rare-earth-bearing (ion adsorption) clays.

In the intra-formational Conglomerates around Weiloi -Tyrsad Villages, East-Khasi Hills, while carrying out the sedimentary analysis for the palaeo-environmental studies of the traces of Rare Earth Elements like dysprosium, cerium, praseodymium, samarium, europium and lutetium has been deciphered using the Energy-Dispersive X -ray (EDX). For our study around 50 samples of the conglomerates are collected and 8 samples are selected for detailed investigation using the EDX. It is inferred using the EDX data that 7 samples have REE content ranging from 900-84000 ppm. The REE present in the samples is represented by Ce, Pr, Sm, Eu, Dy and Lu. The detailed study is being carried out for locating the area with rich pockets of REE.

Key words: Dysprosium, Cerium, Praseodymium, Samarium, Europium and Lutetium

APPLICATION OF MODERN TOOLS AND TECHNIQUES IN GEOMORPHOLOGY

GEOSPATIAL TECHNOLOGY IN THE TWENTY-FIRST CENTURY REDEFINING THE BOUNDARIES OF TRADITIONAL GEOGRAPHY

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The rapid growth in geospatial technology in the latter half of twentieth century laid the foundation for an interdisciplinary approach. The key feature of geospatial data is geo-referencing and thus it encompasses maps, imagery and point information generated by GPS as well as other means of data acquisition. Meanwhile, imaging sensor technology improved further to meet the users' requirement. In view of necessity to understand key aspect of Earth objects and its phenomenon more precisely, Mini and Micro satellites are two latest entrants among the Earth resources satellites to assist study on global climate change, pre-disaster warning and anthropogenic pressure and changes on landscape with 3D and 4D models. The technology got a further boost by Microdrone, a form of Unmanned Aerial Vehicle (UAV) low flying instrument that operates via manual remote control and autonomously with GPS waypoint navigation providing an ideal low altitude platform. It enables large scale accurate minor topographic relief mapping of mineral excavation sites equipped with LiDAR sensor, landform analysis, comprehensive Tourism Management Information System and monitoring precious wildlife and biodiversity conservation Hotspots. UAV is a game changer for quick appraisal for resource monitoring in a way that we are not anticipating right now. An interesting area of geospatial application is satellite tracking of migratory route followed by intercontinental flight of birds by satellite tag PTT (Platform Transmitting Terminal), a miniaturised transmitter tied to the birds that sends messages to the Advanced Research and Global Observation Satellite (ARGOS), a global satellite-based location and data collection system. In turn, the polar-orbiting satellites orbiting the Earth pick up signals, storing them and relaying back to earth. The real time location can be viewed on satellite imagery for actual route followed by birds, animals, aircraft and ships for the purpose of rescue and research. Two new interesting geospatial applications emerged recently vig. Volunteered Geographic Information (VGI), a tool for harnessing, create, assemble, and disseminate geographic data, provided voluntarily by individuals in a form of Open Street Map (OSM). Other one is unfolding of new kind of interactive Story Maps combining maps and multimedia content into elegant user experiences to inform, educate, entertain, and inspire people in binding knowledge in simple and effective way through power of map and stories.
Keywords: LiDAR. Microdrone, Nano Satellite, OSM, PTT, Story Map, VGI. Waypoint

APPLICATION OF RELATIVE TOPOGRAPHIC POSITION (RTP) INDEX FOR CLASSIFICATION OF LANDFORM IN DUDHATOLI REGION (GARHWAL HIMALAYA)

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GIS and DEM technique is very useful and convenient to classify landforms of hills, mountains and plateau region. Following Relative Topographic Position (RTP) index, landscape can be classified in different slope position classes. This method is used by geomorphologist and geologist in the past. Therefore, RTP index is applied for the analysis of Dudhatoli high mountain region of Garhwal Himalaya.

The study area is located in Pauri and Chamoli distinct of Uttarakhand state which covers 493 Km2 areas. The whole terrain varies with elevation ranges from 1000 m to 3100 m msl.

It is the water tower of region which is the source zone of Ram Ganga, Bino, Nayar and Ata Gad.

The basic aim of the study is to classify the landforms into different morpho units and sub slope units of the Dudhatoli region using RTP method.

Achieving the objective, Aster DEM was taken for the entire area. RTP index is used for identifying landform pattern. The data are generated in grid format with cell size of 20*20 neighborhoods. The final output raster contain values are classified into 5 natural breaks between 0 and 1.The result shows that the range of RTP index values are between 0.38 and 0.82 which is classified into 5 landform units i.e. ridge, nose, mid slope, hollow slope and valley. The results are verified in the field which is found correct succession of landforms. Landform units are correlated with topographic attributes of

slope, aspect, drainage density, and relative relief. The results are shown on tables and maps.
Finally it is concluded that RTP index approach is useful to explain the landform units of mountain region. RTP provides a powerful tool to describe topographic attribute of a study area.

RELATIONSHIP BETWEEN TERRAIN UNITS AND LAND USE/LAND COVER IN DUDHATOLI REGION OF GARHWAL HIMALAYA

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The area of the study Dudhatoli is located in central part of Uttarakhand state which covers 493 km2 areas. It is the water tower of lesser Himalaya in Uttarakhand region which is the sources of all spring fed perennial rivers. The whole terrain varies with elevation ranges from 1200 m to 3100 m from msl. The total geographical area of the region is approximately 493 km2.
The basic aim of the present study is to establish the relationship between landforms and Land Use/Land cover (LULC) of Dudhatoli region of Garhwal Lesser Himalaya.
For the achievement of the objective topographical sheets, Landsat 8 (ETM+), Aster DEM, and Remote Sensing data are used for the analysis. The terrain units are classified on the basis of Z score values of 571 one km2 grids. The highest aerial coverage is found in nose terrain unit (27%) and lowest is in Peak terrain unit (13%). Analysis shows that about 63 % area of the Dudhatoli region is under forest cover and 17% area is under agriculture. Rest of the land is under waste land and pasture land. Out of the total forest area maximum 20% area is under nose terrain unit while minimum (7%) in foot slope terrain.
Oak is dominant forest species in the Dudhatoli region which covers about 50 % of total forest cover. About 13% area is under Pine species while 8% area is under Himalayan fir. The mixed broad leaf forest covers 25% of total forest area. It shows that the maximum 25% forest cover is under nose terrain unit. Side slope unit covers maximum mixed broad leaf species because of the wet and humid N.W aspect of the hill ranges. Finally terrain units are correlated with land use classes.

BANK EROSION ALONG THE LOWER SUBANSIRI RIVER, ASSAM : A GEOSPATIAL ANALYSIS

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Subansiri is the largest tributary of the river Brahmaputra and second largest river in Assam contributing as much as 11% of the total flow. The maximum discharge recorded at Chowldhoaghat is 18799 cubic meters per second in the year 1987 during its peak season of discharge. It is one of the most dynamic and unstable river originating in the Eastern Himalayan Region. Flood and drainage congestion are the major problems in the plains of the Lower Subansiri. The hydrological characteristics of the river and the geology of the surface indicate that it is an active zone of river bank erosion. Every year a considerable amount of land loss has caused due to bank erosion in the flood plain region. The primary aim of the present study is assess the amount of lateral bank erosion of Lower Subansiri River and map out the erosional areas between the years 1956 to 2010 (duration 54 years). It also justifying the geology, slope and aspect of the area in terms of sever bank erosion. The methodology is based on GIS techniques and required mathematical as well as statistical analysis. The overall outcomes denote that bank erosion in Lower Subansiri River has been active and severe through-out the last few decades, particularly in the right bank. The channel behaviour and configuration of the river under goes dramatic changes in response to variation in flow regime. The study also attempts to project the possible fluctuation of river with for the years 2020 and 2030.
Key words: Bank erosion, channel characteristics, fluvio-geomorphic changes, land loss.

ESTIMATION OF SURFACE RUNOFF FOR SUBANSIRI RIVER BASIN USING ARC SWAT

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Hydrological research deals with the distribution and circulation of water with environment. The amount of water which falls as rain into a catchment will either flow as surface runoff in the river or sinks into the ground and become ground water. GIS is the most important tool in estimating runoff as remotely sensed data can be synchronized with the conventional database for analyzing runoff. In the present study, Subansiri sub catchment area located in inter-national basin of India and China, were selected for the estimation of surface runoff using SWAT model. The SWAT (Soil and Water Assessment Tool) works in conjunction with Arc GIS 9.3. Various parameters Digital Elevation Model (DEM), slope derived from DEM, Land use/Land cover (LULC) , Soil data and temporal data for temperature and precipitation was used as input for the model to predict runoff at the catchment outlet. Capability of the model for generating rainfall has been evaluated for 21 years (1990 - 2010) period. The runoff estimated from the SWAT model was then used to know the variation of runoff potential in different years for Subansiri River Basin.

Keywords: Watershed, Surface Runoff, SWAT, GIS, Subansiri.

TOPOGRAPHIC PARAMETERIC MODEL FOR HORTICULTURE LAND SUITABILITY ANALYSIS: CASE STUDY OF SAKCHI KHO WATERSHED, SHERGAON, ARUNACHAL PRADESH, INDIA

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Topographic characteristics like elevation, slope, aspect, upslope area and dissection and its various measures reflect how the earth surface variations affect the biosphere and especially anthroposphere. Mountainous terrain has limitations in resource endowments as well as provides less opportunity in pursuing livelihood options. Arunachal Pradesh, with a geographical area of 83743km2 ranks 14th in terms of geographical area but ranks 26th in terms of GDP due to constraints of mountainous topography. Economic development is seen through exploring suitable areas for expanding agriculture and horticulture in the state. This process of expansion can be suitably modelled taking topographic parameters after correlating with the existing areas under cultivation. For this apple plantation in one of the state operated farm has been taken as an ideal site to derive the range of topographical parameters suitable for successful apple plantation. Sakchi Kho (river) watershed has an area of 400.5 hectare and out of it 14.1 hectare is used for apple plantation and 11.9 hectares of land is being now cleared for expansion. For this exercise Cartosat I stereo data have been used for DEM generation. The DEM is further interpolated from derived contour for 5m pixel. Slope, curvature, aspect and distance from channel have been derived to relate with the old orchard area and new expansion area and rest of the catchment. It has found that north-west and west aspect (covering 78.6 percent of old orchard area) with slight concave to slight convex area (100% area) over a slope up to 15o (99.4 percent area) and up to 200m from channel form the best topographical parameter range for apple plantation. New expansion pushes the topographic parameter range marginally for aspect, curvature and distance from channel but slopes up to 30o has been utilised. These parametric ranges can be utilized to derive other areas with similar soil and climate condition to augment economy of the State.

TRANQUILIZING FLOOD EFFECTS: A CASE OF FLOOD FORCASTING AND EARLY WARNING SYSTEM USING GEOSPATIAL TECHINQUES IN NANOI RIVER

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River always attracted man from antique times. It is said that every river has a different story to tell, characteristics of rivers are unique and therefore needs a clinical approach to study them. The eastern Himalayan Rivers are also very unique in nature. Present paper is an effort to study the hydrological characteristics of river Nanoi flowing from Bhutan Himalayas drained to the mighty river Brahmaputra. Use of geospatial technology is made in order to study the hydrological characteristics of the river Nanoi and to put forward some measures to mitigate the flood hazard in the basin.
The present river under investigation flows from 91045'33E and 26025'42" N to 91045'33E and 26025'42" N cover parts of Bhutan and India. The etymological meaning of the name Nanoi in Assamese language is 'new river'; it is because this river has changed its course several times in the known history of civilization and always takes a new shape. Such meandering river in high rainfall prone areas often causes disastrous floods in the monsoon time. The people of the Nanoi river basin area faced severe flood in recent years causing a huge damage to life and property. This paper is an attempt to study the characteristics of the river and to suggest some possible measures of river training work to minimize the hazardous impact of flood in the area.
Keywords: flood, geospatial techniques, early warning

IDENTIFICATION AND MAPPING OF RELATIVE ACTIVE TECTONIC ZONES IN UPPER BEAS BASIN, KULLU VALLEY (LARJI-KULLU TECTONIC WINDOW),HIMACHAL PRADESH, INDIA

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Advancement in geo-computational techniques and easy availability of high resolution Digital Elevation Models (DEM) provides an exceptional opportunity to quantify the attributes of complex geomorphic systems. Current research is focused on identification and mapping of active tectonics zones in upper Beas basin in Kullu District, Himachal Pradesh using Geomorphometric indices of Active Tectonics. (GAT).
The study area bounded by N 320 30'to 310 30' Lat and 760 54' to 770 54' E Long, belongs to higher Himalaya. The major structural units; viz. Main central Thrust (MCT) and Kullu Thrust underline the tectonic set-up of this region. It is considered as a single tectonic unit, comprising of the High Himalayan Crystalline Sequence (HHCS), thrusted during Early Miocene over the low-grade sediments of the Lesser Himalaya. The area is tectonically active and falls under category V on the Seismic zones of India. The morphotectonic parameters used in the present study were computed using in-house developed 'VisMorphoTech' software tool. Digital Elevation Model (DEM) of ASTER with 30 meter resolution was used. The morphotectonic indices extracted using this tool are Mountain front sinuosity (SMF), Valley floor width-height ratio (VF), knick point zones (KZ), Basin Asymmetry Factor (AF), Hypsometric Integral (HI), Elongation Ratio (Eb) etc.
The result of the study indicate reactivation of MCT in this part of Himalayas, followed by the Kullu thrust, which is the next thrust of the progressive deformation front of the MCT. The most active tectonic zone is as inferred by GAT is located in between the Kullu thrust and MCT. The newly developed 'VisMorphoTech' was found to be very useful tool for identification and mapping of relative active tectonic zones.
Keywords: Tectonic Geomorphology, Morphotectonic indices, VisMorphoTech.

GEOMORPHOMETRIC ANALYSES OF DARU RIVER WATERSHED, WEST GARO HILLS, MEGHALAYA

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The geomorphometric analysis of the Daru River is carried out quantitatively using remote sensing and GIS techniques. The Daru basin is a 5th order drainage basin and it follows a sub-trellis to sub-parallel drainage pattern aligned along the attitude and structural features of rock formation. The spatial, linear, aerial and tectonic aspect of the drainage network has been computed so as to understand the role of geomorphology, geology and climate of the area controlling the river flow.

The analysis has revealed that the total number and length of stream segments is found maximum in first order streams and decreases as the stream order increases. The bifurcation ratio (Rb) between different successive orders varies revealing the geo-structural control. The drainage density of the watershed is 2.97 km-1. On the basis of geomorphometric analysis the study reveals that the Daru River is evolving consequently which is fed by groundwater and have high infiltration capacity over badlands topography. The amount and type of precipitation directly influence the quantity and character of runoff. The bedrock differences, structural variations and epiorigenic activity causes the abrupt differences in the stages of stream development. This work carried out may be useful for identifying and planning the ground water potential zones and watershed management (including the whole gamut of natural resources connected with the basin).
Keyword: Geomorphometric, GIS, Drainage pattern, Watershed, Meghalaya

VIS-MORPHOTEC - SOFTWARE FOR VISUALIZATION OF MORPHO-TECTONICS

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Morphometric studies are increasingly been undertaken to enumerate role of tectonics in shaping geomorphic character of the region. Morphometric indices until recently were computed by protracted manual efforts using topographical sheet and Planimeter, Opisometer for area and distance measurements. Availability of high resolution digital elevation models (DEM) and GIS and Image Processing software's the task has made the task less arduous. Software packages like ArcGIS, TecDEM etc commonly used of this purpose however, requires formal training and manual digitization and editing and at times not easily accessible to researcher.

Vis-MorphoTec - a software application is primarily developed to overcome these constraints and computation and visualization morphometric indices of active tectonics at regional scale. This s/w application requires minimal user interaction and proficiency in s/w application. Vis-MorphoTec computes morphometric indices like hypsometric integral (HI), valley width height ratio (VF), valley asymmetry factor (AF), stream gradient length ratio (SL), stream nick points, circularity ratio (Rc), elongation ratio (Re), form factor (Ff), active and moderately active mountain fronts with orientation diagram etc. The computation was tested and verified for areas of active and moderately active tectonics in Himachal & Garhwal Himalaya, Nilgiri Hills and Deccan Volcanic Province around Pune. Results obtained using Vis-MorphoTec is quite promising and indicative of wide scale applicability of this s/w utility in morphotectonic application.

A GIS-BASED APPROACH IN DRAINAGE MORPHOMETRIC ANALYSIS OF USRI RIVER BASIN, INDIA.

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An attempt is made to study drainage morphometry of Usri River basin (latitude: 240 04'00"N to 240 34'00' N & longitude: 86005'00"E to 86025'00"E) lies in north-eastern parts of Chhotanagpur Plateau using remote sensing and GIS. Digital Elevation Model (DEM) has been generated by Cartosat Stereo pair data at 10m resolution. The morphometric parameters considered for the analysis includes the linear, areal and relief aspects of the basin. Morphometric analysis of the river network and the basin revealed that the Usri Basin has 6th order river network with a dendritic drainage pattern. The dendritic drainage pattern indicates that the basin has homogeneous lithology, gentle regional slope and lack of structural control. The bifurcation ratio between different successive orders varies but the mean ratio is low that suggests the higher permeability and lesser structural control. Drainage density and stream frequency of Usri-river basin are very low which indicates that the relief is mature and permeability is good. The drainage texture of Usri-river basin also indicates that basin has low relief, gentle slope and mature topography. The shape parameters indicate that the basin is elongated in shape with low relief, high infiltration capacity and less water flow for shorter duration in basin. The 50% of the basin has altitude below 300m and the general slope is towards southeast direction. The dominant part of the terrain has erosional landforms that signify mature to early old stage topography.
Key words: Morphometry, GIS, Cartosat-1 stereo pair, DEM, Usri River.

GEOMORPHOLOGY AND LAND USE STUDY OF BHAUNAK RIVER BASIN, MAHARASHTRA

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Bhaunak river is a northern tributary of river Tapi and covering an area of 240.5 sq.km. It lies between 21°5' N to 21°10' N latitudes and 75°30' E to 75°45' E longitudes. Covering northern part of Jalgaon district of Maharashtra State. The present basin was selected for the study of impact of geomorphology on the land use. The main objective of the study was to identify major geomorphic units on the basis of landforms, soils and correlate them with the land use study of Bhaunak basin by using IRS-IB Geo-coded and LISS III data on the scale 1:50,000 major landforms of the study area were identified and classified in to denudational, fluviodenudational and fluvial. Major soil types of the river basin were also identified and correlated with landuse pattern. The hills of Satpura are covered with vegetation the piedmont plain is brought under pasture and animal grazing. The floodplain is under intensive cultivation of cash crops like banana, cotton and chilly. There is deep gully erosion along the Tapi river channel forming the ravines.
Key words: geomorphic units, landforms, denudational, gully erosion, landuse.

ESTIMATION OF SOIL LOSS SENSITIVITY IN THE BELSIRI RIVER BASIN USING UNIVERSAL SOIL LOSS EQUATION IN GIS

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This study is an attempt to estimate soil loss sensitivity based on universal soil loss equation (USLE) and GIS in the Assam part of the Belsiri River basin for the year 2014. It is estimated that total soil loss from the basin is 1885 ton. The average rate of soil loss from the catchment of the study area is estimated to be 0.06 t/h/y. If this rate of soil loss continued then there is most likelihood of occurring fluvial hazards like drainage congestion, flood, etc in some areas of both side of the river particularly in downstream part of the basin. This study also reveals that although high and extreme

soil loss sensitivity areas occupied less area compared to other soil loss sensitivity zones yet they are mainly located in the thickly populated and intensively cultivated areas which are also the economically rich areas of the study area. This high and extreme soil loss sensitivity has been adversely exerting great pressure on the rural economy and thus required to be noted as the priority areas in soil and water conservation planning and erosion control.

STUDY OF RIVER CHANNEL SHIFTING AND IT'S IMPACT ON SURROUNDINGS USING GEOSPATIAL TECHNIQUES

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Channel shifting due to erosion, transportation and deposition are the common phenomenon in river hydraulics. Due to such event river morphology changes and creates different landforms and brings about changes in its course. The temporal changes of bank lines as a result of bank erosion, as well as a range of changes in the channel have been studied for Singora River, a tributary of Subansiri River. This study has been carried out using Toposheets and Satellite Images for 1965, 1977, 1990, 2000, 2007 and 2013. The bank line has been marked to study the channel shifting and erosion in those years. Channel was static during the period of 1965 to 1977, upstream of the village Konwarpur, Lakhimpur. Major shift in the river course has been marked at same location about 4.36 Km towards the eastern direction during the period of 1965-1990. At downstream it shifted towards east by a distance of 1721 m, 2298 m, 2509 m and 33 m during the period of 1965, 1977, 1990, 2000, 2007 and 2013 respectively. Channel course are found to migrate in the period (2000-2013) due to the consequence of floods in the vicinity of the river. Due to this channel shifting, Built up areas near to the river bank disappear and massive changes in land use pattern have been evidenced in the study area.
Keywords: Channel Shifting, Bank Lines, Bank Erosion, Upstream, Downstream

A GEOMORPHIC AND GEO-TECHNICAL CHARACTERIZATION OF THE HILL SLOPE TO ASSESS SLOPE INSTABILITY IN THE SHIVKHOLA WATERSHED OF DARJILING HIMALAYA: A RS & GIS BASED FREQUENCY RATIO MODEL AND ANALYTICAL HIERARCHY PROCESS

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To prepare landslide susceptibility map of Shiv-khola watershed, one of the landslide prone part of Darjiling Himalaya, RS and GIS tools were being used to integrate 10 landslide triggering parameters like lithology, slope angle, slope aspect, slope curvature, lineament, drainage density, upslope contributing area (UCA), road contributing area (RCA), settlement density and land use and land cover (LULC). Analytical Hierarchy Process (AHP) was applied to quantify all the factors or to derive factors weight on MATLAB Software with reasonable consistency ratio (CR) and their hierarchical arrangement were made accordingly. Frequency ratio model (FR) was used to derive class frequency ratio or class weight incorporating both pixels with and without landslides and to determine the relative importance of individual classes. All the required data layers were prepared in consultation with SOI Topo-sheet (78B/5), LIIS-III Satellite Image (2010), Erdas Imagine 8.5, Arc View and ARC GIS Software. The weighted linear combination (WLC) method was performed to combine factors weight and class weight and to determine the landslide susceptibility coefficient value (LSCV or 'M') on GIS platform. Greater the value of 'M', higher is the propensity of landslide susceptibility over the space. Then, the Shivkhola watershed is classified into five landslide susceptibility zones using classification techniques on GIS platform. Finally to understand the hills slope materials, cohesion, friction angle, major principal stress, minor principal stress and normal stress were estimated applying Tri-axial soil testing mechanism. The study revealed that the places registered with high susceptibility to slope failure is also characterized by less resisting force, more driving force and greater probability to landslip.
Key words: Slope instability, FR & AHP, RS & GIS, and geomorphic threshold.

UNDERSTANDING THE SOURCES OF SEDIMENTS FROM MINERAL COMPOSITION AT LOWER REACH OF THE RUPNARAYAN RIVER - AN X-RAY DIFFRACTION (XRD) BASED ANALYSIS

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Sources of sediments have been studied through identification of mineral composition of sediments at lower reach of the Rupnarayan River, in West Bengal, India by X-Ray diffraction technique to understand the causes and mechanisms of sedimentation. Collected sediment samples are washed by hot and distilled water, dried and disaggregated manually with a mortar and pestle. 5gm of each sediment samples are scanned at 7°-45°2? interval by XPERT-PRO diffractometer at Central Research Facility, IIT, Kharagpur. The Diffractogram generated from XRD analysis reveals that the entire reach under study shows the dominance of minerals like Quartz, Biotite, Chlorite, Chloritoid, Chamosite, Zoethite, Oligoclage, Sillimanite and Corundum etc. having their origin in the upper catchment. Only exception is found for Laumontite and Strontianite that are present in sediments at Amberia (0.93%), without its presence in upper catchment. Chamosite is transported up to Kolaghat from upstream, beyond that it is absent downstream. There is no general trend in the spatial distribution of the minerals in the area under study. The minerals drained from upper catchment are caught up in the estuary and again redistributed upstream by stronger flood tide. This leads to a haphazard and irregular distribution of minerals in the study area.
Key words: Sedimentation, Mineral Composition, X-Ray Diffraction, Sediment Sources

CLIMATE DYNAMICS AND LIVELIHOOD VULNERABILITY ASSESSMENT USING FUZZY COGNITIVE MAPPING APPROACH IN WESTERN HIMALAYA

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A series of integrations using the PRECIS (at about 0.5°×0.5° resolution) were performed to investigate the regional-scale impact of land cover change. The existing studies in the context of assessing vulnerability to climate variability and change delineate, rather inadequately, interconnected interactions occurring within the climate-human-environment interaction space. This paper aims at constructing a livelihood vulnerability index for climate variability and change capturing interconnected interactions based on people's perceptions while providing indicators for evidence based decision-making. A semi-quantitative fuzzy cognitive mapping (FCM) approach has been deployed to capture climate induced perturbations and adaptations. Combining the FCM approach with a sustainable livelihood framework warrants an understanding of assets sensitive to climate variability and change along with those serving as adaptive capacities. The aim was to determine the impact of historical climatic variability on the regional-scale climate over western Himalayan district. The change from natural past to current anthropogenic was estimated using HadCM3 to predict the natural vegetation type, and then remotely sensed data has been used to estimate the locations where the climatic variability had been increasing. The impact of land cover changes on regional climate also provides support for the inclusion of land surface models that can represent future land cover changes resulting from an ecological response to natural climate variability or increasing carbon dioxide. PRECIS model was used for downscaling of a domain over the district level, was run from 1960 up to 2050 continuously. It verifies statistically significant changes in the averaged 500 hPa wind field, mean near-surface air temperature, maximum near-surface air temperature and the latent heat flux over the region, where land cover change was imposed. The level of CO2 enrichment had increased the yield of many crops compared to normal level of CO2 (330ppm) but there with no definite trend.
Keywords Downscaling; climate modelling; fuzzy cognitive mapping; diurnal temperature range

MORPHOMETRIC ANALYSIS AND PRIORITIZATION OF SUBWATERSHEDS USING GIS AND REMOTE SENSING TECHNIQUES: A CASE STUDY OF UPPER DWARAKESWAR RIVER BASIN IN PURULIA DISTRICT OF WEST BENGAL

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The area of study has been confined to the north-eastern part of the Purulia District covering an area about 103 sq k.m., extending from longitude of 86 31'E- 86 41'E and latitude of 23 19'N to 23 28'N consisting of parts of 3 blocks of Hura, Para and Kashipur, having 35 mouzas falling in the upper part of the Dwarekeshwar river basin. Poor soil cover, sparse vegetation, erratic rainfall and lack of soil moisture characterize the study area for most part of the year. Recurring drought coupled with increase in ground water exploitation results in decline in the ground water level. So the entire study area has been further divided into 12 subwatersheds named SWS1 to SWS12, ranging in geographical area 103 sq km has been taken up for prioritization based on morphometric analysis using GIS and remote sensing techniques. The drainage density of subwatersheds varies between 1.09 to 3.36 km/sq km and low drainage density values of subwatershed SWS11 indicates that it has highly resistant, impermeable subsoil material with dense vegetative cover and low relief. The elongation ratio varies from 0.6 0.8 which indicates high relief and steep ground slope. The high value of circularity ratio for SWS11 subwatershed (0.8) indicates the late maturity stage of topography. This anomaly is due to diversity of slope, relief and structural conditions prevailing in this subwatershed. The compound parameter values are calculated and the subwatershed with the lowest compound parameter is given the highest priority. The subwatershed SWS1 has a minimum compound parameter value of 4 is likely to be subjected to maximum soil erosion and susceptible to natural hazards. Hence it should be provided with immediate soil conservation measures.

GEOMORPHOLOGICAL CHARACTERISTICS OF DOON VALLEY IN UTTARANCHAL BASED ON REMOTELY SENSED DIGITAL DATA AND GIS TOOLS

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RS and GIS are being considered as most important tool in geomorphological study since 1970s. In earlier days, geographers have often been handicapped in the pursuit of their fieldwork by considerations of time, expenses, distance and weather. The present study area, the Doon Valley is an intermontane valley located within Siwalik foreland basin in Garhwal Himalayas. It is 80 km in length and 20 km in average width with Siwaliks range to its south and Mussorie range to its north. Along the northern margins of the Doon valley, the Main Boundary Thrust (MBT) brings the Precambrian rocks of the lesser Himalayas zone to override the Siwalik group, whereas a sudden topographic rise of the Siwalik range demarcates the Himalayan Frontal Thrust (HFT), locally called the Mohand thrust that separates the Siwalik group from the recent alluvium of the plains. The large part of the valley is occupied by a broad synclinal depression, called the Doon syncline. To its south, lies a complementary fold structure, Mohand anticline, and to its north is the Satokgarh anticline. The fold structure has folded the Siwalik strata and owes their origin as fault-propagation folds developed as a result of southwestward propagating Mohand Thrust. The Mohand anticline, a growing fold structure, uplifted the Siwalik range and retracted the drainage within the Doon valley. The upliftment of Siwaliks created a water divide separating the northeast flowing streams into the valley from the southwest flowing streams across the Siwalik ranges into the Bhabar plains. In the northern part of the study area, streams originated from the southern slopes of the Massurie range flowing south and southwest and joining south east flowing river Song (Thakur, 1995). The Doon gravel, the post-Siwalik sediments, was deposited as co-eval sediments with the growth of fold structures and neotectonic activity along the main boundary thrust.

GEOHAZARDS AND THEIR MANAGEMENT

LANDSLIDE STUDY OF FRAGILE GARHWAL & KUMAON HIMALAYAS AN ARCHITECTURAL PERSPECTIVE

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The Garhwal and Kumaon Himalayan ranges is the part of Central Himalayas. The Mussorrie, Uttarkashi, Harsil and Gangotri are part of Garhwal Himalayas and is quite prone to landslide occurrence.
Recent past in 20 July 2015 and 23 Sep 2015 Uttarkashi, Varnavat Hills experienced the landslides. The close frequency of occurrence is quite alarming. Wide cracks at the tunnel at Tamba Khani and at Indira colony adjoining Varnavat Hills created panic on 20 July 2015. This was due to heavy rains and incomplete repair work by the department assigned for the job.
At the same time Harsil area also experienced landslide due to heavy rains and fragility of the hilly regions. Author had visited the area right from Mussorrie Hills, Dharasu and there to Uttarkashi, Harshil and Gangotri. A very picturesque sight was observed across the water channel opposite to main Gangotri temple during the year 2002. Even a subsidence near ITM, Mussorrie was studied.
The author was also detailed to study avalanche occurrence at Joshinath Temple during 1982 and had embarked on a journey with 234 Engineer Regiment with Army Contingent starting from Moradabad, Rudrapur, Tanakpur, Pithoragarh, Jipti and Kalapani towards Mansarovar lake. The Contingent went upto Kalapani (3370 m) only as no permission was given by Chinese Government to go through Lipu (5334 m) Pass to Mansarovar lake (Kailash Parbat) (6690 m).
But today Chinese Government has announced and opened the route via, Gangtok, Nathula Pass to Mansarovar lake a motorable route making it easier to reach Kailash Parbat.
In the present paper, briefly the two case studies have bear suitably presented. The various geomorphological features at the Gangotri temple and landslide occurrences and their remedial measures also have been suggested.

COAL FIRE SUSCEPTIBILITY ZONATION IN THE RANIGANJ COALFIELD

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Recent studies revealed the uncontrolled coal fire as a global problem due to its catastrophic effects on environment and loss of valuable resource. Presently, coal fire is the most frequent phenomena in Raniganj Coalfield (RCF). Present study aims for susceptible fire zonation over the abandoned underground coalmine and working opencast patches in the RCF. Thermal Infrared band of LANDSAT TM satellite images have been used to detect surface temperature as the indicator of potential fire hazard using band 6 (thermal band) having spectral resolution of 10.4 - 12.5?m. Multi-temporal TM images (1989, 2006, 2009, and 2010) have been used for temporal analysis of spatial variation of land surface temperature using Spatial Modeller of ERDAS Imagine (image processing) software. The study shows that the villages like Jamgram, Rashunpur, Sarashthali and Panuria in Barabani block, Shyamdi and Lohat in Salanpur block, Andharia, Chichurbil and Churulia in Jamuria block of West Bengal and Mugma in Nirsa block of Jharkhand are getting severe fire occurrences in the recent years. The field study and previous data have conformed this result. But, inhabitants are still living in those areas despite being susceptible to fire hazard.
Keywords: Coal fire, Thermal image, Spatial modeller, Underground and opencast mine

STATUS OF FLOOD IN EASTERN PART OF UTTAR PRADESH

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Disaster around the world occurs due to flood, wind and storm, land slide, waves and surges, droughts, feminine, earthquake and water related epidemic. A flood is an unusual stage of a river due to runoff from rainfall and /or melting of snow in quantities too great to be confined in the normal water surface elevations of the river or stream as the result of unusual meteorological combination. When flood takes place people face very problem. Flood damages are divided in two parts direct damage and indirect damage. Direct damage results due to physical contact of floodwater, crop damage, property, loss of life and cattle. Second one is indirect damage may be caused by cessation of normal economic activities due to flood even though the persons or assets affected may not come in contact of flood. The selected study area Ballia district falls in Central Ganga plain. As per 2011 censuses district has population 3,239,774 of which rural population is 2491676 and urban population is 269944. The district has a population density of 1,081 inhabitants per square kilometer. The normal annual rainfall is 983 mm while monsoon rainfall is 864.8 mm. The average annual rainfall in the district is 1,013.1 mm. In the last calamity of flood (2013) flood water covers 324 villages and affected 273600 population, in which 16 people and 06 cattle died people lost their 3525 homes and 210738 hectare crops that cost was about 43863000 rupees. This research paper tries to find out the main cause of flood and its affect on study area and make a better management plan to mitigate the problem. In the area the amount of rainfall is high so the banks of the rivers should not be used for settlement and improvement of drainage system.
Keywords: Flood, Mitigation, Prone areas, management

LANDSLIDES IN DARJEELING HIMALAYAS IN JUNE-JULY, 2015

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Landslides are the major disaster in the Himalayan region that have had faced by the local people since the long past. The occurrence of landslides is most significant in the monsoon season mainly. Torrential rainfall has triggered the landslides in Darjeeling Himalayas during June-July, 2015, like past incidents of landslide in this region. The landslides have occurred mainly at Mirik, Darjeeling and Kalimpong area. The landslides are the effect of multiple causes. Though it is being doubted that the Nepal earthquake has a significant role in the landslides. It is firmly mentioned that the torrential rainfall over 200 mm in just 24 hours is responsible for the landslip, but the anthropogenic factors (cutting of the vegetation, construction of the multi-storeyed buildings and roads) also have a significant role in this disaster. The Mirik Lake is also taken into consideration for the recent occurrences of the landslides in this region. The landslides have resulted with the disconnection of the communication in the hilly settlement areas and the scarcity of food and shelter for the people. Debris accumulation in the streams has obstructed the natural flow and. The landslides are mainly caused by the natural phenomena but the intensity and magnitude are enhanced by the anthropogenic activities.

ENVIRONMENTAL IMPACT ASSESSMENT OF LANDSLIDES: A CASE STUDY OF UDHAMPUR-PEERAH STRETCH ALONG NH1A

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With the increasing pressure on the earth's surface for development, there has been destruction of the natural environment. The impact of human activities is felt by the environment. It has therefore become mandatory to assess the environmental impact of landslides.
Environmental impact assessment is very essential for the development of any area. It describes the present condition of the environment in and around the study region. It describes us how to deal with the environment in order to minimise the loss caused by the landslides.
The present paper deals and demonstrate the environmental impact assessment of landslides has to be done if proposed development projects, such as construction of New Highway, railway lines, hydro-electric projects, and even the defence bases has to carry out studies on impact of these projects on the environment before proceeding for their projects.

EARTHQUAKE HAZARD ZONATION USING PEAK GROUND ACCELERATION APPROACH FOR WESTERN CENTRAL DISTRICTS OF NEPAL

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Natural Hazards and catastrophers are recurring phenomena which effect one or the other part of the world every now and then. Among all such hazards, the most devastating are the earthquakes with intensity over 5 on Richter scale. Recently, during the months of April- May 2015, a number of devastating earthquakes occurred in Nepal with a magnitude varies between of 3.7mb to 7.9 mb. Attempts have been made on the study to develop seismic hazard area zones for the event using Peak ground acceleration approach, which is calculated using attenuation function that describes the correlation between the local ground movement intensity the earthquake magnitude and the distance from the earthquake's epicentre. The data used in the study comes from UNITED STATES GEOLOGICAL SURVEY (USGS) earthquake catalogue, 2015. The PGA value is calculated based on an attenuation relationship for the study area, which is log(A)= -1.072+0.3903M-1.21log(X+e0.5873*M). A program have been developed in C environment in order to process large amount raw data to calculate the PGA values. The study also focuses to present the relationships between PGA and magnitude as well as PGA and depth of the earthquake. Finally, PGA values were interpolated by using Spline algorithm to prepare a hazard zonation map for the Nepal Earthquake 2015.

LANDSLIDE SUSCEPTIBILITY MAPPING BY USING MULTI CRITERIA EVALUATION TECHNIQUE: A CASE STUDY OF EAST SIKKIM

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Landslide is a common hazardous phenomenon in the hilly areas.In East Sikkim such phenomena is very common. The main causes of the landslides are high amount of rainfall, excavated slope, natural slope failure and earthquake etc.The area experiencesregularlandslides in each year due to such causes. As a result people suffer from property damages, economic loss and loss of life. The study is on landslide susceptibility mapping for thearea; so that appropriate landslide disaster risk reduction strategies can be developed. In this study the multiple criteria decision analysis method is used to assess the landslide susceptible area in East Sikkim. For this study total nine thematic layers of landslide geo-environmental factors are considered. These are geology, thrust, lineament, relative relief, land use, fault, slope, drainage density, road network. The index includes five levels from very low to very high. After this three different types of maps are generated to show landslide susceptibility in different period. Later, the performance of the method is validating by using the area. The verification result shows the satisfactory agreement between the susceptibility maps produced and the existing data on historical landslidelocation.
Key words: Landslide susceptibility. Multi criteria decision analysis, Rainfall and Geo environmental factor.

FLOOD HAZARD ZONE MAPPING OF BALBOLA WATERSHED OF GOALPARA DISTRICT IN ASSAM USING GEO SPATIAL TOOLS

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Flood is one of the most severe problems in the Balbola watershed of Goalpara district in Assam. Flood Hazard Mapping is a vital component for appropriate land use planning in flood-prone areas. It creates easily-read, rapidly-accessible charts and maps which facilitate identification of areas at risk of flooding and also helps priorities mitigation and response efforts. Flood plains are thickly populated because of their economic significance. The present study area, Balbola watershed of Goalpara district in Assam, experienced repeated flash flood hazard in 2008 and 2014. The study aims to prepare flood hazard zone maps of Balbola watershed based on multi criteria assessment using remote sensing and GIS tools. The study is limited to factors such as rainfall distribution, slope, drainage density, land use, soil type, population density, and roads density to prepare Flood hazard risk zone map. The thematic maps of these factors are prepared using Arc GIS and ERDAS Imagine tools. All these themes and their individual features were then assigned weights according to their relative importance in flood hazards to prepare the Flood hazard risk zone map. Thus, different flood hazard risk zones were identified, namely 'Very high', 'High', 'Moderate' and 'Low' and 'Very Low' of the study area. By preparing the risk zone maps, we can propose measures to reduce the risk of these hazards in Balbola watershed. Flood hazard maps can support planning and development by identifying high risk locations and steering development activities away from these areas.
Keywords: Flood hazard, Multi Criteria Assessment, GIS, Weighted Overlay Analysis

SEDIMENTATION AND CHANNEL BAR FORMATION: A CASE STUDY OF THE GUMTI RIVER, TRIPURA

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Sedimentation is the process through which sediments carried by the running water are deposited in suitable places. When the quantity of sediment in the river water exceeds its transport capacity sedimentation takes place. It is considered to be a hazard because it hinders the navigability of the rivers. Besides, due to gradual sedimentation the depth of the river gradually decreases and the water holding capacity of the river reduces which increase the probability of flood hazard. Gumti is the longest and largest river of Tripura with a catchment area of 2250 km2. The river was used as a trade route between India and Bangladesh in the past. But due to sedimentation the river has lost its navigability. Moreover, this process leads to the enlargement of mid-channel bars and point bars within the channel. As a result, the morphology of the river is changing frequently. Thus the objective of the study is to analyze the main controlling factors behind the problem and to identify the temporal change in the extent of different channel bars. In order to fulfil the objective, intensive field work has been carried out; slope map, land use map of the Gumti River basin have been prepared. Temporal variation in the area of the major bars has been measured using Global Mapper11 software. The findings indicate that both natural and anthropogenic factors are controlling the sedimentation problem of the Gumti River. Due to large scale sediment deposition within the channel, the area of bars is increasing with alarming rate, especially the mid-channel bar at Radhakishorepur, whose area has been increased by 73% from 2009 to 2014.
Keywords: Gumti River, Sedimentation, Land use, Bar

AN INVESTIGATION INTO UTTARAKHAND DISASTER: A NATURAL PHENOMENON OR A RESULT OF MULTITUDE OF FACTORS?

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A natural disaster with torrential downpour and subsequent flash flood led to a disaster on 16-17 June 2013 devastating Kedarnath region in Uttarakhand. This region is geo-morphologically vulnerable and tectonically active, making the region fragile and disaster prone. Anthropogenic activities causing LULC (Land Use Land Cover) changes, unplanned construction, unregulated tourism etc. contributed towards enhancing the disaster impacts. Continuous precipitation since few days before 16 June 2013 accumulated, but sudden increase in precipitation during 16-17 June 2013 led to massive flooding of rivers. Loss of life, destruction to infrastructure, property and ecological devastation labelled it as one of the worst disaster that India had faced post Dec 2004 Tsunami. High intensity precipitation cause a flash flood leading to debris flow, sediment deposition, blockade, glacier melting and movements with several landslides. Preliminary data showed that a total of 745 landslides occurred along the river valleys of Mandakini, Mandani, Kali and Madhyamaheshwar. Most of the studies regarding the disaster are based on geo-morphological and hydrological aspects. The current study, however attempts to seek the answer to the most pertinent and obvious question that intrigued the scientific world on a broader aspect, 'Was the Uttarakhand disaster solely a natural phenomenon or a result of multitude of factors?'

To seek answers, we relied on meteorological models and baseline surveys. WRF model is used to simulate the Kedarnath disaster during 16-17 June 2013. Model simulated precipitation on comparison with corresponding observation and station data showed similar intensity and spatial distribution of precipitation. Our baseline surveys pointed out unplanned development of the region, increasing population and unrestricted human establishments are some of the pivotal causes that lead to such humongous loss of life and property as an effect of the disaster.
Keywords: Uttarakhand disaster, meteorological aspects, WRF, Indian Summer Monsoon

GEO HAZARDS OF TORSA JAINTY INTERFLUVIAL AREAS, ITS IMPACT ON THE LAND USE OF NORTH BENGAL, INDIA

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Present paper embodies some findings and observation made by the author on the geomorphic hazard with reference to land use problem of Jalpaiguri and Coochbehar districts of North Bengal. The northern boundary of Torsa Jainty interfluve is delimted by the hillside slope of Bhutan Himalaya while subdued relief of moist Terai and gently undulating plain in part delineate its southern limit. The terrain unit is endowed with valuable natural resources, together with diversified topographic expression like hills, piedmont plain, alluvial fans ,floodplain with terraces, scarps in combination which are evolved under multiple cycle of erosion. This geomorphic facet has undergone repeated intense folding faulting and thrusting in a highly complex manner Neotectonic activities are reflected in the tectonic lineaments and cross faults in the drainage basins.

The present study is based on modern methodology and field investigation in terms of (1) Pre field (2) Field (3) Post Field methods. Related IRS LISS III Geocoded data of satellite imageries has been registered to SOI Toposheet in MAPINFO GEOMATICA and ERDAS for image analysis.

In the catchment areas of the rivers the mountain ecosystem has been disturbed mainly due to anthropogenic activities which cause increased rate of runoff, soil erosion, subsequent siltation or raising of river bed thus resulting in landslide and flood, the ecological catastrophe in the basin. Slope failure in the Bhutanghat and Mohakal ranges, lateral shifting, raising, and widening of river beds in dilluvial areas, in the south of piedmont zone creates tectonic hazard in this unstable terrain of eastern Himalaya. Loss of precious teagardens of Radharani mouza, (Torsa basin) Kohinoor tea garden (Jainty basin) loss of forest areas of Buxa duar, loss of kharif and rabi crop land of Ambari, Deutibari mouza and loss of Sal forest of Santrabari area affects the basin dwellers.

FLOOD CHARACTERISTICS IN PARTS OF BANSLAI - PAGLA FLUVIAL SYSTEM : A STUDY IN MURARAI BLOCK, BIRBHUM DISTRICT, WEST BENGAL

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Flood by river is a natural event which, because people often choose to live in flood risk areas, becomes a hazard. The floods of Banslai and Pagla rivers are the yearly phenomena to the people of Murarai block in Birbhum district like the other parts of lower Bengal. Almost every year flood destroys lives and properties and adds several difficulties to the life in the block. The prime objective of conducting this study is to find out the spatio temporal dimension of flood in the concerned block since 1995. A flood zone map based on frequency of flood analysis has been prepared by using liss-iv Satellite images. So that, the planning for the flood affected people can be implemented for their placing during the hazard time. Impact of flood on agricultural pattern has also been analyzed by performing different overlay analysis using GIS techniques. Finally, some optimal measures have been suggested as non structural policies.

COASTAL VULNERABILITY ASSESSMENT OF THE PREDICTED SEA LEVEL RISE IN THE COASTAL ZONE OF KRISHNA GODAVARI DELTA REGION, ANDHRA PRADESH, EAST COAST OF INDIA

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The Krishna Godavari coastal region in East India has a 525.15 km long coastline with low lying tidal mudflats, beaches, mangrove swamp, creek and tidal channels. Recently, the increasing frequency of tropical cyclones in the Bay of Bengal i.e., Phylin and Hudhud in Andhra Pradesh coast, and the devastating impact of the 2004 tsunami in India increased the significance in assessing the vulnerability of the coastal lands to inundation and flooding, notably in the context of climate change is induced sea level rise. This study aims to estimate a coastal vulnerability index (CVI) for the coastal sub region of Krishna Godavari delta and to use the calculated index to evaluate the vulnerability of 14 coastal taluka of the Krishna Godavari Delta region. This CVI is calculated by using 4 geological and 3 physical parameters characterizing the vulnerability of the study coastal region, including regional slope, coastal elevation, geomorphology, significant wave height, mean tidal range and relative sea level using different conventional and remotely sensed data. Using a composite coastal vulnerability index based on the relative risk rating of those parameters, each of the 14 coastal taluka were classified according their vulnerability. The CVI results depict that coasts are least and most vulnerable to inundation, flooding and erosion of coastal lands where geological parameters are more efficient to CVI. The paper alerts to decision makers and planners to mitigate the natural disaster and manage the coastal zone, and is a primary step towards priorising coastal lands for climate change adaptation strategies in the view of increased storminess and projected sea level rise.

FLOOD HAZARD MAPPING OF WEST TRIPURA DISTRICT, TRIPURA, NORTH EAST INDIA

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Abstract: Flood means inundation of extensive land area for several days in continuation and it is the most recurring, widespread, disastrous and frequent natural hazards of the world. This geomorphic hazard is common in West Tripura District as it is situated in a tropical monsoon region. West Tripura District extends from 23040'N to 24007'N latitude and 91012'E to 91032'E longitude and covers an area of 1006.86 km2. Piedmont plain (areas of flash flood) and the alluvial plains cover about 70% of the District out of which 60% area experiences flood hazard and 55% population are affected due to this hazard. Here two rivers namely the Haora River (47.21km) and the Lohar Nala (20.53km) are affected by flood which causes tremendous loss in terms of property, crop lands, roads and houses. Therefore, this study aims to prepare Flood Hazard Map of West Tripura District to manage this hazard, where flood pose a recurrent danger. This map has been prepared according to Forkuo's method (2011). For preparing this flood hazard map, a composite flood hazard index was prepared incorporating five variables namely, distance of the particular village from the particular river, population density, number of households, agricultural losses and availability of high ground (for shelter) in each affected village. Based on these five variables three flood hazard categories have been identified in this district. About 24% villages fall under high flood hazard category, 26 % under moderate flood hazard category and 50 % village fall under low flood hazard category. This flood Hazard Map, based on administrative units, is a quick, accurate and cost effective means for planners and administrators to formulate remedial strategy.
Keywords: Flood, West Tripura District, Flood Hazard Mapping.

COUPLING OF GIS-ANALYTICAL HIERARCHY PROCESS BASED SPATIAL PREDICTION OF SOIL EROSION SUSCEPTIBILITY IN KELEGHAI RIVER BASIN, INDIA

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Soil erosion susceptibility maps can be an essential tool in erosion prone areas as they explain and display the distribution of risk and areas likely to be affected to different magnitudes. Therefore, it is very useful to planners and policy makers initiating remedial measures and for prioritizing areas. In this study, thematic data layers of sixteen soil erosion conditioning factors were integrated to prepare a soil erosion susceptibility map using a weighted linear sum model (WLSM) in GIS environment. The Analytical Hierarchy Process (AHP) was used to derive the preference scale factor rating values and Frequency Ratio (FR) model was applied to obtain the prioritized vector weights for all the soil erosion conditioning factors considered in the study. The integration between and was made in weighted linear sum model (WLSM) on a GIS platform to estimate the soil erosion susceptibility value (SESV) for each pixel and a suitable classification technique was incorporated to prepare the soil erosion susceptibility map (SESM) of the Keleghai River basin. The multicolinearity, receiver operating characteristic (ROC) curve and kappa index of agreement were used for the assessment of overall performance of the AHP. The results depicted that in general, a high to severe susceptibility condition of soil erosion was found in the study area and the proposed approach was also able to identify the areas under high and severe susceptibility that require urgent intervention on a priority basis. Based on this study, comprehensive erosion susceptibility management strategies were anticipated for the efficient management of present and future erosion disaster in the area.
Keywords: Analytical hierarchy process (AHP), Frequency ratio (FR), weighted linear combination model (WLSM), Soil erosion susceptibility map (SESM)

CHANNEL DIVERSION: AN APPROACH TO MANAGE FLOOD IN THE LOWER PART OF NOA-MANGALDOI RIVER BASIN, ASSAM

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By virtue of its unique geographical location along with humid tropical monsoon climate, Assam is a land of dense river network. Floods are the common feature in both the major valleys of Brahmaputra and Barak. Being a north bank tributary of the Brahmaputra in Assam with characteristic topographical and hydrological bases, the lower part of Noa-Mangaldoi river basin has been regularly experiencing the occurrence of high magnitude floods of devastating dimension. The state government efforts through various structural and non-structural measures have not attained satisfactory level so far towards reducing the severity of floods. In spite of some measures taken by government there is always high risk of floods especially in the lower reach of the basin. The size of population affected by floods has increased significantly. Considering the increasing impact of flood hazards especially in the Mangaldoi town and its surrounding villages, a 3500 feet long canal was dug to divert the Mangaldoi river near the outfall in order to reduce the flood severity. This paper is thus an attempt to analyse various geo-environmental aspects of the channel diversion in the lower part of Noa-Mangaldoi river basin.
Keywords: Channel diversion, canal, flood hazard, geo-environmental aspects.

ARSENIC FOOTPRINTS IN SURFACE WATERS: A REPORT FROM RIVER GANGA AND ITS TRIBUTARY JAMANIA AT BHAGALPUR, BIHAR (INDIA)

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The present study aims at reporting the arsenic contamination of surface water from the river - channel Jamania and pollutants transport to river Ganga at Bhagalpur in Bihar (India). Samples were collected from Jamania, an off-shoot of River Chanan, in pre-monsoon period at 16 sampling points on the downstream southern bank i.e. from Champanala Bridge to Vikramshila Bridge in Bhagalpur. The spectrophotometric analysis of water samples revealed the concentration of arsenic in the side - channel (Jamania) and the main channel (River Ganga) in the range of 10.69 ppb - 55.92 ppb. The levels of arsenic in all the 16 river water samples were found above the permissible (safe) limit of WHO standard for drinking water. Out of the 16 samples, 3-samples are very close to permissible limits. Remaining 13 samples ranged between 16.41 to 55.92 ppb. The arsenic in side - channel and main - channel of the river at these sampling points beyond the permissible limit are possibly due to multiple anthropogenic activities in the catchment of the river, such as use of arsenical pesticides in floodplain agriculture and discharge of detergents, untreated raw sewage,, effluents from loom industry, etc. Further, the random survey and interviews with the local people revealed that they were mostly suffering from Keratosis on their palms and soles and some with Melanosis on their body parts including face and neck. Results of possible health hazards and arsenic level in river water indicate long term exposure of arsenic in surface waters and that may cause serious health hazards in vicinity. So, it is high time to educate and aware people about dangers of drinking arsenic contaminated water. At the same time it is advisable to enforce the arsenic remediation measures and provide the people alternative source of drinking water.

IMPACT OF FLOODS AND ITS MANAGEMENT: A CASE STUDY OF ALLAHABAD CITY

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Todays India is suffering from various sorts of " water -related syndromes" Among these ,floods are the most alarming and has affected wast areas of the country. Allahabad is one of the city which is effected by the floods. Floods is a natural event in which water bodies like rivers , drains ,lakes ,tanks gate overflow of water resulting vast expansion of water logging area. It may be a slow process or may be a severe in few hours without any warning.

The present paper is concerned with impact of floods and its management in Allahabad city . the study area extents from 25?28?N Latitude and 81?54?E Longitude at the scared confluence of the river Ganga , Yamuna and mythical the saraswati is known as "Thirthraj Prayag".

Ganga and Yamuna is lifeline of the Allahabad city , but assumes a devastating stance during the raining season due to heavy rainfall in its catchments areas , back flow phenomena and other metrological factors. Average annual rainfall at Allahabad is 1017.3 mm. out of this 1017.3mm rainfall occurs during three months i.e. july to September . this reflect very strong seasonality in rainfall patterns In fact,about 88.4% of the total rain falls during the rainy season which last from mid june to September .out of this remaining 11.6% , 4% falls in October ,1.9% in January and 1.5% in February . the driest month is December with 0.34% of total rainfall closely followed by april with 0.57% . during the monsoon period many areas around the city may come under the inundation of river water and some areas in the city may get chocked with water logging.

Research paper tries to find out causative factor for such increase of areas prone to floods and also suggests approaches to be adopted by the government and administrative authorities as well to the public , at large to modify floods, to susceptibility to floods damages and to modify loss burden.

SOCIO - ECONOMIC AND ENVIRONMENTAL IMPACTS OF LANDSLIDES

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Landslides are common natural hazards in the hilly regions. Channel incisions, seismic activity, heavy rainfall and anthropogenic effects are the main triggers of landslides. In spite of improvements in recognition, prediction, mitigative measures, and warning systems, economic losses and casualties due to landslides in the hilly regions appear to be growing day by day as a result of increasing development of landslide-prone areas due to population pressures. In most of the nations , landslides have caused major socioeconomic impacts on people, their homes and possessions, industrial establishments, and lifelines, such as highways, railways, and communications systems. Socioeconomic losses due to slope failures are great and apparently are growing as the built environment expands into unstable hillside areas under the pressures of expanding populations. Human activities disturb large volumes of earth materials in construction of buildings, transportation routes, dams and reservoirs, canals, and communications systems, and thus have been a major factor in increases in damages due to slope failures and responsible for considerably greater economic and casualty losses than is generally recognized, they represent a significant element of many major disasters in which the magnitude of their effects is overlooked by news media. Landslides directly shows the impact on the elements of the natural environment: the topography/morphology of both the subaerial and submarine surfaces of the Earth, rivers, streams, forests, and grasslands, and habitats of native fauna, both on the Earth's surface and in its streams and oceans. Environmental disturbances are results of general tendency toward degradation of the Earth's surface by gravitational mass wasting and erosion. This paper highlights the outstanding examples of socioeconomic and environmental losses in the hilly region and relatively the effects of landslides on the natural environment and its preventive measures.
Keywords: Landslide, environment, debris flow

AN INVESTIGATION OF THE FLASH FLOOD AND ITS CAUSES AND CONSEQUENCES IN THE GOALPARA DISTRICT, ASSAM, INDIA

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Goalpara district is vulnerable to a variety of natural calamities namely earthquake, flood, flash flood, cyclone etc. and man-made hazards like ethnic clashes etc. that hinder the district's economic prosperity. The management of any disasters requires a deep scientific study to understand the nature and magnitude of the events and to find out the ameliorating mechanism so that the loss from the disaster can be reduced. A disastrous flash flood was occurred in the downstream basin of the Jinary and the Krishnai river and upstream basin of the Jinjiram river in Goalpara district of Assam on 3-8 October, 2004. Similar flash flood covering Goalpara and South Kamrup (Rural) districts of Assam occurred again in September 20-25, 2014 after a gap of ten years. This time the amount of losses become more and the grievances of the people are more concentrated.
Considering the aggravated problems of the flash floods in the region an attempt has been made to study the causes of flash floods and to find out the measures to ameliorate the miseries of the people living in the area.
Keywords: Flash Flood, Hazard, Jinjiram

HAZARDS OF MINING IN THE RANIGANJ COALFIELD: AN APPRAISAL

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History of coal mining in India started with the opening of collieries in the Raniganj Coalfield (RCF) in West Bengal in 1774. Development of mining industry resulted into population growth and emergence of urban centres in the western part of Bardhhaman district of Bengal. Although coal mining contributes to the country's economy and is a rational replacement for wood as a fuel, it also brews with it hazards and environmental pollution. There are not only issues of physical deformation and degradation of land in the form of subsidence but also social hazards like illegal mining. Health and safety of mine workers as well as those living in and around collieries are also cause of concern in the Raniganj Coalbelt. The study area in this paper is restricted to the part of RCF in Bardhhaman District bounded by river Ajoy in the north and river Damodar in the south, because heart of RCF lies in this district and this part is home to the second largest urban agglomeration of West Bengal namely Asansol-Durgapur, thus, leaving millions exposed to the hazards of mining. This paper attempts to trace the areas prone to land subsidence and mine fires along with impact of coal mining on quality of ambient air, water and human health. Various reports of Government, oral investigation and field survey results have been used to complete the study. A spatio-temporal analysis has been carried out on the extent to which coal mining affects physical and social environment in RCF. The efforts taken up by Eastern Coalfields Limited (ECL) as the controlling authority of mining activities in RCF also finds place in this study; thus focusing on the management of disaster induced by this economic activity, in order to reduce the scale of damage to society.
Keywords: Coal Mining, Collieries, Land Subsidence, Environmental Pollution, Social Hazards

CHANNEL SHIFT AND VULNERABILITY ANALYSIS OF THE TORSA RIVER, WEST BENGAL

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An attempt has been made to study one of the most severe hazards of economically backward and tectonically active terrain of the northern plains in West Bengal. Channel shifting is perhaps the most rampant quasi-natural hazard that is commonly experienced in the foothills of North Bengal. The present Study has been carried out to analyze and report of the chronological riverbank shifts since 1977 due to morphometric changes of the Torsa, downstream of Sajherpar - Ghoramara railway bridge up to Ghugumari railway bridge for a long time, which has recently reached an alarming proportion. The primary objectives of this paper are to identify the different factors responsible for such menace, identify the processes involved, and mapping the changes using topographical map and satellite images. For this, the sinuosity, braiding index, paleo-channels and proportion of area under channel bar have been measured for 1977, 2005, and 2014. The analysis shows a radical change in all of those parameters over the period. For increasing sinuosity, the river has been engulfing the large areas of left bank every year. A set of 15 cross-sections have been drawn to get that shift statistics along each cross-sections. It is followed by vulnerability analysis to assess the risk for the villages and Coochbehar municipality on its banks. These risk prone zones have been identified by applying different statistical methods for each cross-section after proper field validation. The attributes and management of such hazards have been discussed both qualitatively and quantitatively.

CHANGES OF LANDUSE PATTERN AFTER 2011 EARTHQUAKE IN LACHUNG AREA, NORTH SIKKIM

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Sikkim, the smallest state among all 11 Indian Himalayan States, comes under seismic zone IV. Due to strong shaking (6.9 Mw) by the earthquake of 18th September, 2011, a huge destruction took place in all over the Sikkim. As a result, a drastic change is visible in the pattern of land use and land cover. The present paper is concentrating on Lachung area of North district of Sikkim very precisely. The primary target of present study is to determine the changing pattern of land use and land cover of Lachung area in pre and post-earthquake time on GIS platform (with reference to Landsat ETM+ and Google earth) and calculate the amount of change in land use practices with special concentration on landslide with temporal variation from 2009 to 2011 and 2014. This study is determining the changed pattern of forest cover and the build-up areas due to the occurrence of landslides.

LANDSLIDE HAZARD ZONATION OF THE WESTERN UPLAND MAHARASHTRA

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On 30th July 2014 an unexpected devastating landslide took place in Malin village located in Ambegaon Tehsil of Pune district. This unexpected event in this part of the Western Ghat region claimed more than 130 lives. Subsequently various institutional enquiries were carried out to infer the causes of landslide in this area. On the basis of field investigations and with the help of remote sensing data it was found that the geomorphic set up such as topographic depression, bench/ terraces and major structural feature that could have played an important role. Human activities are also the possible causes of alteration of hill slope hydrology that triggered the landslide. With this background the present study was aimed to carry out landslide hazard zonation and identify all such villages located at the base of Sahyadri mountain range. For the same more than ten thousand settlements from the Western Ghat region were mapped. With the help of remote sensing and GIS data, different geomorphic factors such as slope, aspect, structural features were mapped and by using AHP method, the landslide hazard zonation was carried out. On the basis of settlement distribution and hazard zonation map, the villages were categorized in different landslide hazard zones. The study carried out is a preliminary work towards a comprehensive data base creation, risk assessment followed by setting up of early warning systems based on various landslide hazard zones and precipitation thresholds.

STRESSES ON EMBANKMENT LEADING TO FREQUENT BREACHING AT INDIAN SUNDARBANS

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Mechanisms of embankment breaching at Indian Sundarbans are studied to understand the source of stresses active for breaching. The hydraulic stress is mainly active for toe erosion and overtopping. Geotechnical stress is active for fracturing, slumping, and toppling failure. Study shows that hydraulic stress is generated by tidal asymmetry and associated sedimentation, closure of internal drainage system by irrational occupancy for human use. Geotechnical stress is generated at vertical slope and greater height of the bank. For effective stability, embankment should have 5.25m height from average tidal level, 2.6m top width and 2-8 ?side slopes.
Key Words: Hydraulic stress, Overtopping, Geotechnical Stress, Tidal Asymmetry.

ASSESSMENT OF RIVER BANK VULNERABILITY: A STUDY ON KUNUR RIVER BASIN OF RARH BENGAL

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A river changes its cross sectional form for several times, by means of scouring, sediment transport and deposition processes. High stream bank erosion and failure rates on streams bank may be liable to land use change and degradation of riparian areas. Now a days for stabilizing the optimum economic developmental strategies, knowledge regarding cause, nature and extent of bank failures is necessary. The BEHI is an empirical bank erosion model initiated by Dave Rosgen in 2001. It is an useful tool for estimating bank erosion of any small river, since it is intensively field based and helps to assess the erosion risk based on several parameters related to the river course. Kunur River Basin is one of the important meso level river basins of West Bengal and total length of river is 112 km. BEHI model has been used in this river basin for assessing the river bank vulnerability zone from source to mouth.

Data of different parameters for 12 spots along both banks of the River Kunur from source to mouth have been collected for estimating bank erosion. The value of BEHI increases downstream that means the erosion rate as well as probability of channel modification is more in the lower catchment area due to presence of loose bank materials, less woody vegetation cover and high volume of water discharge. It is also being observed that the rate of erosion is more on right bank of the river. Such unequal rate of erosion between left and right banks is indicating the right side migration tendency of channel and the erosional vulnerability limit of zone.

CHANNELIZATION AND FLOOD HAZARD VULNERABILITY: A CASE STUDY OF LOWER BARALIA BASIN, ASSAM

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Human can modify the landscape in many ways. Modification of drainage systems to prevent flooding and bank erosion has adverse effects and causing hazard in other areas. Channel modifications involve measures such as the straightening the channel, deepening or widening the channel, clearing vegetation from the banks or lining the channel with concrete. These modifications are referred to as channelization. The Baralia River originates from the Bhutan hills and it flows in southern direction for a few Km and it takes westerly turn and after winding its way falls into the Pagladiya River. Due to severity of flood hazard in the areas like Dusutimukh, Baulighat, the lower part of the Baralia river was diverted by constructing 15 Km long channel in 1985 from Bhairatola to the Velkar. Though provided protection to crops and land from floods in the initial years this diversion of late has become ineffective and instead became a flood and bank erosion accentuating factor. About 15 flood free villages are severely affected by flood and bank erosion. In Khupanikuchi village about 5 hectares of land area were affected by flood in the year 2012. In Melkipara village from 2009-2012 about 42 households have loss about more than 5 Bighas of land. Vulnerability assessment regarding flooding and bank erosion depicted that peoples' livelihood are worsening each year. Special response mechanism and appropriate mitigation measure is needed to solve the flood and bank erosion problem in the study area. This paper considers the flooding and erosion problem created by the Baralia River and presents an in-depth analysis of flood hydrology. Field data and secondary data with remote sensing and GIS were used for flood monitoring and bank erosion in the study area.
Keywords: Channelization, Flood, Bank erosion, Remote sensing, Geographic information system

FLOOD FREQUENCY ANALYSIS OF THE MAHI RIVER: WESTERN INDIA

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An assessment of the effectiveness of flows depends much on the magnitude and frequency of the events than mean discharges. In flood hydrology, Flood Frequency Analysis (FFA) is a statistical measure and is considered to be an effective tool to interpret past records of gauge data in terms of future probabilities of occurrences. In the current paper, one of the most commonly used probability distributions namely Gumbel Extreme Value type I (GEVI) is applied to the Annual Maximum Series (AMS) data of 3 sites on the Mahi River and 3 sites on its tributaries. By using GEVI probability distribution, peak flows have been estimated for different return periods such as 2, 5, 10, 25, 50, and 100 years. The distributions have also been employed to estimate the recurrence interval of mean annual peak discharge (Qm), large flood (Qlf) and actually observed maximum annual peak discharge (Qmax) at each site. Three sites namely Mataji, Paderdibadi and Khanpur on the Mahi River and Rangeli on Som, Dhariawad on Jhakham and Chakalia on Anas River have been selected for the graphical presentation. The magnitude-frequency analysis of the annual peak discharge series, based on GEVI distribution indicates that the mean annual peak floods has a recurrence interval of 2.33 years, whilst the return period of large floods is 6.93 years. The recurrence interval of maximum discharges is between 21 and 396 years. Such events are geomorphologically more effective than frequent floods of low magnitude.

THE JULY-AUGUST 2015 DELUGE IN THE LOWER DAMODAR VALLEY REGION: A STUDY OF THE FLOOD HAZARD AND CONSEQUENT VULNERABILITY

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Overflow of large amount of waters beyond the distributary channel limits of the Damodar River including the Amta Channel has always been a recurrent hazard for the people living in the lower Damodar Region of West Bengal. The study area extends from 87.74ºE to 88.24ºE and 22.51ºN to 23.21ºN comprising of 16 C.D. Blocks of Howrah, Hugli and Burdwan districts. The total delineated area is 2783 km2, in which the highest elevation is 48 m while lowest altitude is only 1 m. In the very recent past, Komen - a deep depression was transformed into a cyclonic storm on the 30th July 2015. Moreover, on the 3rd August, 2015 the Damodar Valley Corporation (DVC) released about 95,000 cusecs of water from its dams and barrages, which was definitely a significant contributing factor of the flood in the region. Usually around 20,000 cusecs of water can be discharged through the Amta Channel, but from 30-07-2015 to 05-08-2015 almost 32,000 to 55,000 cusecs of water were released, and the synchronized effect of high intensity rainfall, high tidal condition and huge river water discharge caused massive flood in the region.

In 2015, West Bengal with more than 12 districts marooned, happens to be one of the worst flood-affected states resulting in loss of human life, degradation of cultivable lands, and destruction of economic and social infrastructures. From the field surveys it is noted that in this region water remained stagnant up to a metre for about 7 to 10 days. It took only about 48 hours of intense rainfall for the waters to spill onto the agricultural and residential lands and mostly the lower income groups, having less disaster preventive capacities were badly affected. Most of the respondents did not receive the pre-flood warnings in time to evacuate themselves with all their belongings, and nor did they take any prevention against the post-hazard diseases as a consequence of contamination through flood water and unhygienic surroundings. It is observed, in this study, that vulnerability to the devastating effects of the July-August 2015 floods of the lower DVC region is indeed an outcome of the interactions between social, economic and political processes.

COASTAL EROSION AND SALINE WATER INTRUSION IN BOATKHALI AREA OF SAGAR ISLAND, HUGLI ESTUARY, WEST BENGAL

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Saltwater intrusion means the process of increasing salt content in surface and ground water. The Boatkhali area of Sagar Island is facing the problem of severe coastal erosion for many years and saline water intrusion is becoming a major problem for the people of Boatkhali. The main theme of the paper is to study the effect of salt water intrusion and how it is affecting the life and livelihood of the people of this region.

The amount of surface salinity was measured through salinometer from the soil samples collected from various locations of Boatkhali, and the positions were carefully located by taking GNSS points. The ground water salinity was measured by taking the water samples from tube-wells and subsequently the chloride concentration was determined by volumetric titration. A questionnaire survey was also carried out to find out the problems related to saline water intrusion.

The salinity is high near the coastal area and less in the interior part. The main causes behind the saltwater intrusion is breaching of embankments along with the coastal erosion. The salt water intrusion increases the amount of salinity in agricultural field and most of the people of this area are changing livelihood practices from agriculture to fishing. Increasing salinity in drinking water is also becoming hazardous for the people living in this region.

GEOMORPHOSITES AND GEOTOURISM

NEERMAHAL AND RUDRASAGAR: A HERITAGE AND GEOTOURISM SITE OF TRIPURA, INDIA

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The words "Neer" means water body and "Mahal" means palace. The Neermahal or lake-palace located in northern portion of the Rudrasagar Lake which is about 53 km away from the capital city, Agartala. The physiographic environment of Rudrasagar and the heritage of Neermahal are gaining focus as an important Geotourism site. The catchment areas of lake comprises of several charas or narrow perennial channels [The satellite images (ETM+, SRTM DEM)]. As a result the lake gets supply of water throughout the years. With the passage of time, paddy cultivation developed using marginal area of the lake and people started to settle down in adjacent to the paddy field. Gradually, a portion of lake is transformed into paddy field and land-fill areas like Brick-fields. Moreover, the heritage of Neermahal is under serious threat due to poor infrastructure of state tourism. Under these circumstances the present study is focusing on the problems and prospect of this heritage and geotourism site. The published literature has been consulted for understanding the archaeological imprint in the mahal-structure. The methodology comprises of systematic questionnaire, schedule survey and analysis the perception of the tourists and the stakeholders. The survey reveals that State tourism department promote this place as a mega destination of tourism but Government should control anthropogenic activity and protect the lake environment otherwise value of tourist attraction will bring to an end. Standard accommodation, accessibility and reasonable tourist package will help to increase the tourist flow which is provided maximum revenue to the Tripura Tourism Development Corporation.

GEOMORPHOSITES AND GEOHERITAGE SITES OF ASSAM AS RESOURCE FOR GEOTOURISM

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The beauty of the nature is the great provision for identifying the geosites as tourist attraction places over the earth. Geomorphosite includes a geomorphological resource that can be used by society and a landform to which the value can be attributed. The dominant value may be economic, ecological, aesthetic or cultural and this focuses the assessment of a particular landform is a geomorphosite. The geosites and geomorphosites represent a fundamental resource for Geotourism. Tourism is an important sector of Indian economy and contributes substantially in the country's foreign exchange earnings. The Annual Report on tourism, 2012-13 highlight upon the gradual improvement of inflow of tourists likewise the total arrival of foreign tourists are 66,48,318 persons which increase 5.4% over previous year. The North-East region has a wide variety of products in the form of its pristine natural beauty, forests and wildlife, rivers and mountains, and a unique multiethnic cultural heritage to offer to the tourist. Accordingly, the diverse natural environment includes hills, dense forests, valleys, large waterways and rich bio-diversity, is the platform for potentiality of geomorphosite indirectly geotourism in Assam Himalayan region. This study focuses upon the location and importance of geomorphosites in the state of Assam as plateform for geotourism development. The value of a geomorphosite is very important for considering their future protection and touristic capitalization.
Keywords: Geomorphosite, Geosite, Geotourism, Cultural Heritage, Natural Environment and Sustainable, Capitalization

UTTARAKHAND: A POTENTIAL SITE FOR GEOTOURISM

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Geosites are an integral part of Himalayan geology and Uttarakhand keeps an immense potential of geotourism. Geotourism is defined as tourism that sustains or enhances the geographical character of a place- its environment, culture, aesthetics, heritage and the well-being of its residents. It is a form of natural area tourism that specifically focuses on landscape and geology.

Tourism worldwide, serves as an important employment generator, source of foreign exchange and economic growth. Uttarakhand Himalayan region is visited by more than two million tourists every year but the critics consider that tourism development is self-destructive and in the long run, it contributes to environmental destruction. The Rio+20 Outcome Document " The Future We Want" highlights the role of sustainable tourism so as to come out of the adverse effects of tourism. Here comes the role of geotourism as a way to achieve the future we want.

The present research paper tries to identify the sites that has potential to be developed as geotourism site and to suggest the ways by which these geosites can potentially attract optimum no. of tourists so as to be economically viable too.

GEOTOURISM ALONG THE RIVER HOOGHLY- A CASE STUDY OF CHANDANNAGAR, HOOGHLY DISTRICT, WEST BENGAL

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Geotourism, that sustains or enhances the geographical both the physical and cultural character of a place - its environment, culture, aesthetics, heritage, and the well-being of its residents. One of the heritage and geosite is Chandannager in the left bank of Hooghly River which is famous for the French colony in India. In 1673 the first construction was done by the Dutch's. To restore the heritage of the Dutch's former colony Archaeological survey has put forwarded their step to preserve the archives and buildings. This paper has an aim to highlights the encroachment of the township on heritage site and to a prospect of tourism in the surrounding place as the place enchants the history along the flowage of Hooghly River. The study has been done in three steps, at first colonial and cultural importance has been indentified, in the secondly assessing the potentiality of tourism in the area and finally change detections of the land use has been identified with the help of advance techniques.

GEOTOURISM POTENTIAL IN ASSAM

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Assam has considerable diversity of geological structure and relief, as well as numerous changes in the landscape. Here great variety of natural or semi-natural objects exist which can be of immense interest to tourist. In this paper an attempt has been made to study the geotourism potential in Assam. Again in this paper a modest endeavour has been made to identify some of the potential geomorphosites located within the boundary of Assam. Geomorphosites are commonly regarded as landforms having scientific value. But since many geomorphosites have scenic component, they can also have economic value in the sense that they are exploitable for the purpose of tourism. In this study, using library and field studies an attempt has been made to identify various geomorphosites that are located in Assam, their geotourism potentials has been studied and various measures has been recommended for geotourism development in the study area.

TREND AND FUTURE PROSPECT OF GEOTOURISM IN OOTY: THE QUEEN OF NILGIRIS

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Geotourism, probably the newest term in the field of tourism implies tourism that sustains or enhances the geographical character of a place. It mainly focuses on the geophysical characteristics but also includes environment, culture, aesthetics, heritage and the well-being of the residents (Geographic study, 2002). India is a land of diversity with a perfect combination of natural and cultural heritage (national geography). Ooty is one of those unique places. Ooty has taken its place as a Niligiri tea plantation hotspot. Mountain Railways of Ooty (Nilgiri) has been enlisted as UNESCO world heritage. A huge number of tourists are attracted to the annual Tea and Tourism Festival. Now a days, Ooty is on its way to achieve a special attention of tourists as a geo-heritage site. Thus geotourism is becoming prominent in the trend of tourism in Ooty. In spite of only leisure the tourists are becoming more curious towards the place's geographical specialities. Its rich historical base and cultural diversity contributes to the prospect of geo-tourism of this place. GTS or GEOTRAVELLER TENDENCY SCALE has been introduced to distinguish geotravellers from vacationers. This also reveals an increasing trend towards geotourism.
The purpose of the paper is to find out the trend and prospect of geotourism in Ooty. The database of Ooty provide an inventory covering key sites, terrain on the Nilgiri Mountains and the cultural heritages of this place. This inventory is based on the secondary data, retrieved from Ooty Municipal Corporation, Irrigation department of Ooty, Tourism department of Ooty, Geological Survey of India and the primary data produced by field survey.
Keywords: geotourism, geo-heritage site, geotraveller tendency scale.

GEOTOURISM: A STUDY ON ITS EMERGING ASPECTS

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Based on outstanding geomorphological features attracting visitors, geotourism has emerged as an aspect of applied geomorphology. It provides an opportunity to exploit the landforms as resources generating income and employment along with offering a better understanding of the earth to its stakeholders. Geosites are usually visited for appreciation and learning. As geomorphologists are able to cater the visitors by explaining the processes that have created such wonders, they can earn benefits from the world's largest expanding industry i.e. tourism industry not only for themselves but also for the conservation of geosites which are otherwise getting depleted due to anthropogenic encroachment in many instances. The badland topographies of West Bengal called Khoaifound in Santiniketan and Garhbetain Bibhum and PaschimMedinipur districts respectively are its examples.
Geotourism is not only an educational tourism but emerged with the goal of attaining sustainability of such vulnerable sites aiming to conserve the natural area itself. Geotourism addresses the pressure of tourism activities of the geosites concerned. A geosites may be arock outcrop or single landform in micro scale, a fossil park in macro or regional scale and even a landscape like karst or badland. This paper is an attempt to study the scope of geotourism with reference to its impact and its management.
Keywords: opportunity, geosites, processes, vulnerable, conserve

CHANGING TRENDS OF HABITAT OF HARIKE WETLAND AND ITS IMPACT ON TOURISM

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Hari-ke-Pattan with the Harike Lake in it, is the largest wetland in northern India in the Tarn Taran Sahib district[1]in Punjab .The wetland and the lake were formed by constructing the headworks across the Sutlej river, in andis located downstream of the confluence of the Beas and Sutlej rivers. The rich biodiversity of the wetland which with its vast concentration of migratory fauna of waterfowls including a number of globally threatened species (stated to be next only to the Keoladeo National Park near Bharatpur) has been responsible for the recognition accorded to this wetland. This man-made, riverine, lacustrine wetland spreads into the three district of Amritsar, Ferozepur andKapurthala in Punjab and covers an area of 4100 ha. Conservation of this Wetland has been given due importance but since some time past the anthropogenic activities have lead to a devastating fact on this harike wetland and a visible change has been seen at various levels of flora and fauna.this gradual change in the habitat of harike pattan.The analysis reveals the degree and extent of decline.

GARH PANCHKOT: THE ECO-TOURISM CENTRE IN PURULIA DISTRICT, WEST BENGAL

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The study area is situated in the southern part of Panchakot hills, the ruins of Kashipur kingdom who are known as Panchakot Raja and the title by Singbeo present generation K.P. Singbeo is the M.L.A of Purulia town. The story of the ruins initially found in the book of stain Ghiby book written by Miraza Nathan ; the old monuments and gates are already been the destroyed and has become a ruin. It is look like Raghunath temple of Bishnupur, also looks like Shyam Roy Temple of Old Bishnupur. The main temple is known as Pancharatna Mandir which is being renovated at present for the attraction on the incoming tourists and historians for viewing the ancient Terracotta beauty of Bengal style. David Macarchem the (famous archeologist) judged that this temple are of pre Muslim period. Presently all the temples having no statue of God. The Eastern Temple is also made of Terracotta and having a beauty of its own. The old hills of Panchakot represent all these temples were the property of Kashipur kingdom which is under present Adra Division and near Adra station. There is a big jungle in the back side of the hill. Any tourist can visit the beauty of Panchakot hill and ruins of the temple from the forest banglow. We can visit the fish market of Panchet Dam in the morning from 7a.m. to 10 a.m. any enthusiastic tourist, student, geographer can go and stay in this beautiful eco tourism centre of forest development corporation during October to February. The time of rainy season is also beautiful to view the Panchet Dam the full of water and water suffary on the Dam by machine boards is also possible by the management of tourism department. The tourist also can visit the Bhairabnath Temple on the hill top. Adra is the nearest railway station in the south eastern section of Indian Railway which can give pleasure to the nature lovers, eco tourism sectors and also to the archaeological students of our country and abroad.

My finding is to discuss the possibility of eco tourism sector for the incoming regular tourist building one or more lodge to view the night and winter beauty of old ruin ancient history of Bengal.

HUMAN IMPACT ON DIFFERENT GEOMORPHIC SYSTEMS

ANTHROPOGENIC LANDFORMS, HUMAN ACTIVITIES AND LAND DEGRADATION IN THE THAR DESERT; ASSESSMENT USING HIGH RESOLUTION SATELLITE IMAGES AND GIS

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Since Palaeolithic age, man has been utilizing natural resources for upgrading the civilization. Mining, whose landscapes represent the by-products of excavation, perhaps, have the most remarkable impact among the human activities. Western Rajasthan where agriculture is dominantly rainfed, and not providing assured income, many farmers opt for land lease for open cast mining of hard rocks of economic importance like limestone, China clay, Fuller's earth, calcite and gypsum. Mining of these resources generate huge quantity of fine particles, that are washed away downslope by run-off and gets deposited in adjoining cultivated fields, creating impervious layer on the earth favouring stagnation of water and salinity.

The present article discusses the terrain conditions of anthropogenic landforms, change in the extent and morphology of these lands over the years and assess any degradations in western Rajasthan.

For mapping anthropogenic landforms at 1:50,000 scale, we have used satellite images (IRS-LISS-III) having spatial resolution of 23.8 m. IRS-LISS-IV (MX) (5.8 m resolution and at 10,000 scale) were interpreted for understanding micro-morphological features. SRTM DEMs with 90 m resolution were used to derive slope and topography. Google Earth Images have been referred for precise delineation.

Based on above mapping, it was found that significant landforms, 0.13% area (267 sq. km) have been shaped up in the form of mine dumps, mine depressions and mine wastes in Jodhpur Jaisalmer, Bikaner, Nagaur and Pali districts showing impacts of human developmental activities. Makrana, Degana, Parbatsar and Jayal in Nagaur district, Kapurdi, Kawas, Akli in Barmer district, Balesar, Jodhpur, Shergarh and Mathaniya towns in Jodhpur district and Khuiyala, Sanu, Chacha and Mohangarh in Jaisalmer districts are some of the known sites. Similarly, salt pans used for salt extractions are another form developed in 119 sq. km or in <1% area, mostly in Nagaur (Nawa, Didwana), Jodhpur (Kaparda, in Phalodi), Barmer (Pachpadra, Thob, Samooja), Rann of Kutchch and in Bikaner (Lunkaransar).

CAUSES AND CONSEQUENCES OF VANISHING CHAMBAL BADLAND: AN ANALYSIS IN THE PERSPECTIVE OF HUMAN NEED AND GREED!

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Changing human perspective towards environment particularly changing geomorphology is no longer an unknown issue for last few decades. Growing population, and trying to achieve the demand and supply for basic need for food, is the major responsible factor for changing landscape in present century. In the new era which is known more for technology oriented life style has also been witnessed people not only looking food for their need beyond the basic demands, but also are shifting towards food crops to cash crops practice either by choice or by force at certain geomorphological fragile areas. The land degradation is a very space specific context. Ecology and socio economic conditions are very different in Indian context where we can see the diversity of topography, climate and socio-political scenario. The infamous Chambal bad land is one of such fragile ecosystems in India. The area is highly degraded by topsoil erosion, which plays a major role for bad land formation. Chambal Valley, highly populated regions where around 80 per cent of rural people depend on agricultural activity. The time series data analyses and primary survey have been shown that the total ravine land has been decreased significantly over the time. But it also been observed that most of the shallow ravine area of Chambal is levelled and used for intensive agriculture practices. Some part of ravine in this Region also levelled during the said period. The purpose of this study is to understand how sustainable this land levelling is in long run and will it be really beneficial for the locals or how environment will respond towards this alteration! Is it really a need or their greed, which is playing role for changing the landscape of Chambal region!

IMPACTS OF BRIDGE SITE CONSTRICTION - A COMPARATIVE STUDY ON NORTH AND SOUTH BENGAL

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Bridge site is one of the major points of conflict of anthropogenic interferences on fluvial geomorphic system. This paper endeavors to explain the fundamental difference between the impact of flow constriction at bridge site on fluvial system in a Himalayan foothill set up in North Bengal and plain land framework of the South Bengal. River Chel and River Kansai have been chosen as the representative constricted channel of North Bengal and South Bengal respectively. On-field measurements involving channel forms, channel patterns, velocity distribution, energy distribution and sediment characterization of the channel forms the basis of this study. These parameters are further used to compute important indicators like Reynold's Number, Froud's Number, Bed Shear Stress etc. to understand the working dynamics of such a constricted flow. DEM from ASTER image is prepared to contextualize the impact on regional set up. The outcome of the study reveals that such constriction of flow resulted in the modification of the channel planform both in upstream and downstream of the bridge site, but their degree of modification is distinctively different in North Bengal and South Bengal. Considerable difference is observed in the rate of downstream scouring and nature of sedimentation at bridge site in North Bengal and South Bengal.
Keywords: flow contraction, bridge site, channel planform

HUMAN INTERFERENCE AND LANDSCAPE DYNAMICS IN WILDLIFE SANCTUARY: A CASE STUDY IN AMSING WILDLIFE SANCTUARY, KAMRUP (M) DISTRICT, ASSAM

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This study attempts to examine the high growth of population of Kamrup (m) district during the 21st century. The growth of population has resulted in a change in the landscape pattern and its negative impact by human interference on protected areas. The tremendous growth of population changes the total environmental scenery of the wildlife sanctuaries at present time. The increasing rate of exploitation of resource leads dynamics landscape pattern and changing land use/land cover of the wildlife sanctuaries which is threatening for endangered species in the wildlife sanctuaries.
The objective of the study is to identify the negative impact of Human being on the wildlife sanctuary. Both primary and secondary data are used to carry out this study. There are six main encroachment areas are selected for survey.150 household are select foe interview. The collected data are analyzed by using statistical techniques.
Keywords: human interference, landscape dynamics, tremendous growth, wildlife sanctuary.

IMPACT OF HUMAN ACTIONS ON RIVERS

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Our water resources face a host of serious threats, all of which are caused primarily by human activity. They include sedimentation, pollution, climate changes, deforestation, landscape changes, urban growth etc. One of the most serious threats to water resources is the degradation of ecosystems, which often takes place through changes in landscapes such as the clearance of forests, the conversion of natural landscapes into farmland, the growth of cities, the construction of roads and surface mining. Each type of change in landscape will have its own specific impact, either directly or indirectly on natural ecosystem and water resources.
Although it is difficult to integrate the intricacies of ecosystems into traditional assessment and management processes, a holistic ecosystem approach to water management is strongly recommended.

WATER POLLUTION OF HINDON RIVER OF GHAZIABAD : IMPACT OF INDUSTRIALIZATION

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The phenomenal growth of industries at Ghaziabad during last 20 years had led to emergence of city as the second most important town of U.P. after Kanpur. Tremendous increases in industrial activity here, however owns largely to the role of government bodies in boosting up the cause of industrialization in the city. Industrial process can have negative environmental impact, causing many problem such as one of them water pollution.
Hindon river is a major source of water to the highly populated and predominantly rural population of western U.P. The main goal of the present study was to assess the impact of industrial activities on the water pollution of Hindon river at the Ghaziabad.
The major water pollution parameter such as PH, BOD, DO, Nitrate, conductivity were manifold higher than the prescribed limit by the National Pollution Control Agency.
The study to show the inter-relationship of human industrial activities and river water quality makes the study significant and interesting to access the pollution load discharges in catchments of Hindon at Ghaziabad.

DAMS-A SYMBOL OF DEVELOPMENT OR CATASTROPHE IN WAITING? A CASE STUDY OF BHAKRA NANGAL DAM

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A dam is a barrier that impounds water or underground streams. The reservoirs created by dams not only suppress floods but provide water for various needs that include irrigation, human consumption, industrial use, aquaculture and navigability. Simply put dams are built to serve these purposes. But all this comes to a cost. Negative impacts of dams are also numerous. These include direct impacts to the biological, chemical and physical properties of rivers and stream side environments. It transforms upstream of the dam from a free flowing river ecosystem to an artificial slack water reservoir habitat. Below the dam, the river water flows from the clear water directly behind the dam. Because the river no longer carries any sediment, the erosive potential of the river is increased.

HUMAN IMPACT ON RIVER SYSTEM: CASE STUDY OF GHUTKANDAR RIVER BASIN

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Human interactions with natural resources left some imprints on it. The impact may be positive or negative though the concept is a relative one. Specifically for stream flow analysis of human interaction is very relevant. Sometime the neighbour people of the stream mainly in the upper or middle courses use the water resource very unscientific way and finally water flow in lower course is hampered. Therefore, proper utilization of stream water is necessary not only to the beneficiaries, but also to maintain the natural flow of the stream.
Human impact on the Ghutkandar river, a tributary of the river of Dwarka is quite visible. The river basin is evolved in the southern part of the Rajmahal highlands. The river is the prime source of irrigation water for the surrounding upland. Spring recharged Ghutkandar is negatively affected by the local people. Therefore, this work is a humble attempt to analyse the human impact on the Ghutkandar, the source for agriculture base neighbour villagers and to find out the solution.

PEOPLE, INSTITUTIONS AND LAND DEGRADATION: PERSPECTIVES OF POLITICAL ECOLOGY

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People are the principal agents of mass movement and land degradation. Millions of tons of soil is moved from land annually worldwide due to human activities. About 75 Giga tons/year is actually eroded from the farmland by wind and water. Most of the moving soils are deposited only a short distance from the field on slopes and floodplains. Out of the eroded soils, 10-15 Gt may be transported with long-range to the oceans. But, soil is being removed from farmland at about 10 times higher at which it is formed by weathering processes. Soil-movement has been dealt with the framework of land degradation which is ultimately leading to a landscape change. In fact, people are the moving the earth-soil for their living that has been leading to the land degradation worldwide. In many cases, peoples' activities are classified as per social mechanisms. Peet and Watts argued that level of ownership and control over land may vary the degree in contributing land degradation. In this perspective, concept of political ecology could be attributed to interpret a kind of human - nature relations.

Within the framework, nexus among People, Institutions and Land Degradation is discussed in reference of Jogbuda valley, Western Nepal, which is surrounded by Churia and Mahabharat hills. Its westward endpoint is the Mahakali river, border with India. The valley has been divided by Rangoon River and tributaries. Previously, the valley was declared as under-populated by the Government which influenced surrounding people to migrate. The valley was covered with thick sub-tropical forest until 1970s but heavily logged by British India during the construction of Northern Railway. Now, the valley has been severely affected by land degradation and floods due to multiple factors.

UNSCIENTIFIC HUMAN INTERFERENCE IN DRAINAGE SYSTEM OF INDIAN SUNDARBANS

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Evolution of deltaic landscape in Indian Sundarbans is very much complex and the complexity become more complicated due to unwise interference of greedy nature of human being. Disorderly closing of the live tidal creeks and encroachment of natural drainage system force the habitat under potential inundation in monsoon periods or flood in spring tide and creates diseconomies in paddy-fish system.

Through the help of modern cartographic techniques, as ArcGIS, Erdas Imagine, Map Info along with quantitative as well as qualitative information, concerned problem has been investigated in Pathar Pratima C.D. Block, situates, in a fragile, deltaic, estuarine landscape in Indian Sundarbans.

The study area (88019'20"E & 21059'33"N - 88029'19"E & 21035'42"N) is one of the most backward coastal block, surrounded by estuarine rivers and crisscrossed by several saline tidal creeks. Poor paddy-fish practice is the main economic activity of the inhabitants; frequently suffer from meteorological (Severe Tropical Cyclone) and geomorphological (flood) hazards. As per the Toposheets (S.O.I., 1968), 36.01 Km2 area was covered by tidal creeks and 10.25Km2 area was occupied by palaeochannel what, in 2011 (Satellite Image), has reduced into 26.10Km2 and 6.07Km2 respectively. The changed area as 9.91 Km2 has been unscientifically encroached through expansion of agricultural land and settlement. Without considering the natural slope of the landscape, haphazard establishment of homestead, construction of concrete village path and legal distribution of encroached land or illegal occupancy make the drainage systems beyond manageable what create worsening inundation in heavy rainfall or in flood due to breach of fragile earthen life saving embankments.

Keywords: Estuarine Landscape, Tidal Creeks, Paleochannels

LANDUSE OF PUNE AND STORM WATER MANAGEMENT PERSPECTIVES

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Ingress of population from rural to urban region is so fast that only development plan of any city goes haywire. And, the same case is that of Pune city. Many modifications impart pressure and stress on the city's plan. The development plan becoming unplanned is the biggest challenge such is the case with Pune city as well.
Discussing landuse, for Pune it has become unwieldy rather unmanageable but at the same time PMC and PCMC (Pune-Chinchwad Municipal Corporation) are successfully managing the development plan now. About landuse the observation is that the built up area infrastructures have increased along with the green belt as well. About storm water at Pune, which is primarily generated by the precipitation events from clouds/atmosphere is being managed as storm water management. As population of Pune city has increased three folds in the last 3 decades, which has resulted into paved (or impervious area), leading to enhanced quantity of run off. This has coupled with blocked natural drainage, thus increased flow of water has caused flooding in low laying areas.
Also the fluctuating rainfall in the present and recent past has put additional pressure on the water supply system. This has also resulted in more water supply by water tankers. Thus, the main cause of increased run off is due to the enhanced area of impervious surfaces. A study of Kothrud area has been carried out BOD (Biochemical Oxygen Demand) COD(Chemical Oxygen Demand), Total Solids(TS) and Total Suspended Solids (TSS) have been analyzed. We can further indicate that Integrated water management (IWM) of storm water has the potential to address many issues affecting the health of waterways and water supply challenges facing the sprawling growth of modern urban cities. The quality of runoff water requires to be improved considerably. Some rain gardens bio-infiltration and other filtration system requires to be implemented for coping of the impervious surface enhancement etc.
In the present paper a brief case study of Pune - selected sectors - has been cited. However, a detailed study of Pune landuse and water management system is required.

EVOLUTION OF DRAINAGE SYSTEM IN LOWER DAMODAR BASIN DUE TO FAN DELTA FORMATION AND HUMAN INTERFERENCE

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Damodar River has been changing its course in different direction since the historical past. Now it is flowing southwest ward through Kanki-Mundeswari and Amta channel leaving its northeast ward course through Khari River. In this study authors have attempted to find out the probable causes of this shifting in connection to fan delta development and human interferences. Radial drainage pattern in the Lower Damodar Basin is developed on 'The fan delta' that has been started to form since early Creataceous age in response to tectonics events active in this part of Bengal Basin. The northeast and east flowing distributary rivers like Khari, Banka, Behula, Gangur, Ghia, Kana, Kana Damodar gradually lost their capacity and beheaded from the parent stream Damodar as the later is facilitated for rapid downcutting by active tectonism along Damodar fault. This disconnection was confirmed by construction of left bank embankment along the Damodar running across the mouth of these distributions in the year 1752. The drainage system took important role to divert excess flood water during rainy season. These natural as well as human actions of disconnecting most of the distributaries from river system, that intern, made this lower Damodar Basin flood prone.
Keywords: Damodar fan delta, sea level change, embankment, channel change

RIVER-BANK SETTLEMENTS AND THEIR SOCIO-ECONOMIC CHARACTERISTICS IN AIE-MANAS-BEKI INTERFLUVIAL REGION OF ASSAM

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The socio-economic characteristics of the people living in an area are directly or indirectly controlled by its prevailing environmental conditions. The role of physical environment becomes crucial when the human activities are more close to various physical phenomena. It is more so in the case of an area drained by a considerably large river. This paper tries to focus how the dynamic courses and behaviours of Aie, Manas and Beki rivers, the most complex and influential tributary system of the Brahmaputra river in lower Assam, controls very existence of human settlements on their banks and prevailing socio-economic characteristics of the people living there and their mode of adjustment with the rivers. The study is based on data obtained from secondary sources such as Survey of India, Census of India, etc covering the period 1971-2001 and field investigation conducted during 2011-12. The data so obtained have been processed and analysed by using certain simple statistical techniques and presented through appropriate cartographic techniques. The study reveals that the mode of living of the people and their socio-economic characteristics in this region has been greatly influenced by highly dynamic fluvial character of these three influential rivers.

EFFECT OF DAM AND BARRAGE ON HYDRO-GEOMORPHOLOGICAL CONSEQUENCES OF MAYURAKSHI RIVER, WEST BENGAL

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Channel engineering technology has been considered as the pillar of development since last century. But, with the ascendancy of this knowledge the hydrogeomorphological characteristics of the channel are being modified in such an extent that it becomes root cause of current rising trend of many natural disasters related to it. In the present study, hydrological, sedimentological and geomorphological characteristics of Mayurakshi River of West Bengal have been assessed with sufficient spatio-temporal resolution in relation to regulated flow characters of Masanjore Dam and Tilpara Barrage. The present work is based on direct field measurement and reliable secondary sources. Results show that, 1. Trend of seasonal water level is declining, 2. Fluctuation of water level has increased and duration of high flow period during monsoon has reduced, 3. Regular diversion of outflow from the barrage to other river system during non-monsoon period causes drying up of the river Mayurakshi, 4. Consequently bed load carrying capacity has reduced and downstream deposition occurs in the channel bed. Decline of stream power is responsible for the growth of sand shoal as observed in various sectors of the downstream stretch 5. Narrowing of active channel, coarsening of channel bed materials, lowering of lateral stability, accelerating rise of braiding index etc. are some other significant morphological alteration, 6. Huge sedimentation has reduced about 27% water retaining capacity of the dam in last 59 years, 7. Peak monsoonal discharge from the dam and barrage and modifying channel form are liable for downstream flood. The frequency of flood has increased after the regulation of the flow.
This is the high time for re-evaluation of the older approaches and initiation of the new notion for the future.

HUMAN RESPONSE TO GEO-CLIMATE IN LAHAUL AND SPITI HIMALAYA

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Lahaul and Spiti district of Himachal Pradesh lies in the trans-Himalayan region and is home to one of the most enchanting spread of landscapes, natural beauty that accounts for its numerous geosites. In the present study, human response has been assessed in terms of agriculture (including horticulture and pastoralism), habitat construction and the seasonality in tourism and their management for living in this high altitude trans Himalayan district that gives a unique identity to this interface of geomorphology and cultural attributes. The adversity of living conditions, hostility of extreme climatic conditions and spirited people who have made it their home makes it an exotic tourist centre. The main objective of the study is to assess the human response to the stimuli of geo-climatic factors. The study is largely based on the field work conducted in the study area in May-June, 2012, October, 2013 and June 2014. The data has been collected through structured questionnaire survey regarding the human response to diversity of geo-climatic factors and SWOT analysis has been done accordingly. The locations of these geoanthropic sites have been marked using Global positioning System (GPS) and Google earth images have been used to demonstrate the physical setting. Overall, the major issue is inaccessibility which needs to be taken care with better management efforts. Paradoxically, the per capita income in the district is highest among all the districts in the country yet the incidence of poverty is extreme as the most of the concentration of wealth is in the eastern part of the Lahaul while rest of the district remains poor. The various problems and prospects have been studied and analysed through the analysis of the data collected during the various field visits

Keywords: Stimuli, Human Response, Trans-Himalaya, Geo-climatic factors, Lahaul and Spiti, SWOT analysis, Geoanthropic sites

CHANGING HUMAN IMPACTS ON WETLAND ECOSYSTEMS: A CASE STUDY OF HNAHILA BEEL, NAGAON, ASSAM

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Wetlands are diverse, productive systems of ecological, economic, social and cultural value. Wetlands are the habitat of numerous flora and fauna which have their own ecological significance. They are mainly the abode of variety of species of aquatic life. The Brahmaputra valley is endowed with numerous large and small wetlands (beels). In Assam, 10123 sq. km. has been occupied by wetlands i.e. 9.7% of the total geographical area of Assam.

Nagaon district of Assam is located in the flood plains of the river Brahmaputra having large number of wetlands. The district has a total of 379 wetlands accounting 11.15% of the total land area (ARSAC, March 2011). These wetlands play a very significant role in socio-cultural lives of local people. Traditionally, people had utilized the resources of the wetlands without causing any harm to its ecology. But during recent times, mainly due to rapid growth of population and change in human activities, the way of utilization of resources of the wetlands has totally been changed which ultimately led to the degradation of wetland ecosystems. This paper is an attempt to study the changing impacts of human activities on the aquatic ecosystem of Hnahila Beel. The data collected for this purpose is based on both primary and secondary sources.

Keywords: wetlands, ecosystem, aquatic life, human impact etc.

GEO- ENVIRONMENTAL DEVELOPMENT OF THE URBAN FRINGE OF KANPUR: A CASE STUDY OF VILLAGE PARGAHI KACHHAR, DISTRICT KANPUR URBAN, U.P.

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In this age of rapid urbanization, the suburban growth and the development of urban fringe has acquired new dimensions in view of the fast deteriorating eco-system, which threatens the very existing of man. The metropolis of Kanpur is no exception. The ever increasing population is likely to settle predominantly in the suburban areas or the unban fringe. Consequently the arable land is decreasing fast through the expansion of urban colonies than being won by the labourious land reclamation practices. However, there is an effort develop the eco-enviorment and expand the city on scientific basis through land reclamations and allied agro-eco-development in Pargahi Kachhar, a village situated about 14 Kms away from Kanpur towords the west, along the G.T. Raod.

Pargahi Kachhar is a low- lying area in the Ganga Khadar having a large number of user patches. About 46 % of the area of the village is under the category of wasteland and only 40 % area is cultivated. The development process should leave the cultivated area and develop urban housing and other associated, activities only on the wasteland. The Model Dairy Farm and a co-operative housing society have done a poineering job in this direction. They have acquired hactares of wasteland and developed it into the agricultural land, showing fodder, suggercane and vegetables, developed a cattle breeding farm, poultry farm and have set up demonstration projects in the alternative uses of energy systems like solar energy and wind mill as well as full infra- structural facilities for urban housing. The scheme is approved and fully recoganised by the State Government. The advantages of such residential expansion and the simultaneous reclamation of land for agriculture is a rare site in the urban fringe. It serves as model for the Geo-environmantal development in the urban fringe of Kanpur.

GEO- ENVIRONMENTAL STUDY OF SON- GOPAD-BANAS INTER-STREAM REGION OF MADHYA PRADESH THROUGH REMOTE SENSING TECHNIQUES

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The present study covers the maximum part of Sidhi District of Madhya Pradesh. Aerial photographs and land sat imageries of the related areas are used for the identification and demarcation of various land units, landforms, lineaments, hydromorphic units, landuse pattern and hazardous spots and places for their geo-environmental aspects and importance areas. Ground truth collections are followed by the laboratory studies in order to take certain results for the purpose. Slope aspects are calculated through the toposheets of Survey of Indian of 1:50,000 scale. The major rock types in the area are shale, gneiss, granite, schist, phyllite, sandstone and quartzites ect. Lithology is totally influenced by the geology of the area. Quartz veins are in plenty, traversed through the area in multidirections. Structural landforms and denudational landforms are cotegorised on the basis of geo-environmental parametres. Change in base level of erosion is conspicuously evidenced at rock cut benches which stand at about 14-15 metre height at the river banks mainly of Son, Gopad and Banas. Very big alluvio-colluvial fans have also taken place in the inter-stream basin area. Soil creep gullying and sheet erosion are the major geo-environmental hazards that have come up within hardly the last fifty years of human development. Recommendations and suggestions are given for the better management, planning and prosperity of the area under discussion.

WATER SCARCITY AND AGRICULTURE: INDIA SCENARIO

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India agriculture sector consume over 90 per cent of the total water resources, yet the full potential of irrigation has not been achieved. With increasing demand from other sectors, other sectors, and need to augment food production, efficient ways to manage the water resources are being worked out.
India draws 80 percent of its irrigation water from groundwater which often leaders to drying up of wells and creates groundwater shortages. Experts have cautioned that the entire replenishable ground water of the world could be utilized by 2025 AD. Due to lack of adequate storage and related infrastructure, around 48 percent of the rainfall ends up in the rivers due to lack of storage and related infrastructure. While efforts are being made to store the runaway water to rivers, there are studies which say, that the river themselves are drying up due to climate change. A recent study of 900 rivers in the world has found that the Ganga is one of the worlds rapidly shrinking rivers.
Despite the constraints and problems associated with the scares water resource the irrigation potential of India has been increasing over the years. The irrigation potential created up to the beginning of the first year plan was only 23 million hectares which has increased to 103 hectares by the end of the ten plans. The 11th plan envisages creation of an addition potential of 16 million hectares at an estimated required outlay of about 2, 10,000 corer rupees. Since irrigation is the state subject, most of the amount has been earmarked for financing by states and an analysis of states own preliminary planning year allocations show that this might actually be exceeded. In the research paper discuss the various issues related to increasing irrigation potential and managing the scare water resources.

CHARACTERIZATION OF INSTREAM SAND DEPOSITION IN CONTROLLED ENVIRONMENT IN RIVER KANGSABATI, WEST BENGAL

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Channel morphology is triggered by transport capacity, velocity of water, volume and size of the supplied sediment. Changes in grain size, critical shear stress and bed roughness can increase transport capacity in response to high sediment supply where men have been acting as an important agent of fluvial dynamics by removal of bed materials. In a stable sand feeding condition, sediment transport may gradually increase towards river bed due to the increasing shear stress. When the sediments are removed naturally or anthroprogenically from river bed, sand feeding condition is interrupted and generate the hungry water. It also reduces the shear stress on convex slope. This situation creates an environment of sand-gravel mixture. This study aims to find out the relationship between grain size and bed shear stress and also to observe the effects of human activity on the interruption of sediment inflow. Recent research work has been conducted in three selective mining spots from three courses of Kangsabati River i.e. Sarenga (upper), Mohanpur (middle) and Palaspai (lower). DuBoys equation and Shields formula has been taken to explain the mechanisms of shear stress and critical shear stress in connection to the course wise variation of the transport capacity of sediment in different mining and non-mining environment. Flow velocity was measured by floating method. Textural analysis of collected sediments was measured by sieve technique and GRADISTAT is used to determine the mean, shorting, peakness and skewness of the grain sizes distribution. Result shows that critical shear stress is higher in Sarenga and gradually decreases in Mohanpur to Palaspai. So, sediment erosion highly occurs in the upper portion of the basin and relatively lowers in Palaspai. Grain size distribution reveals that, most of sediments are coarse in nature, well sorted and very leptokurtic in Sarenga while Palaspai has mostly medium sand, moderate well sorted and Mesokurtic in nature. The coarse sediments are deposited by higher threshold value of bed mobility in Sarenga while finer particles are deposited due to lower threshold value in Mohanpur

ANTHROPOGENIC IMPACT ON GEOMORPHOLOGY OF BHOGDOI BASIN: A CASE STUDY OF JORHAT DISTRICT

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Geomorphology is a systematic and organized description and analysis of the landform of the earth. It has been derived from the Greek words: "geo" meaning "earth", "morphe" meaning "form" and "logos" meaning "discourse". With scientific growth and technological development since 1860 in general and after II world war in particular man has emerged as a significant geomorphic agent / process and is capable of changing the earth surface at the rate many times faster than natural geomorphological processes. 'Man is many more times more powerful as an agent of denudation, than the entire atmospheric denuding forces combine' (R.L. Sherlock, 1922). In this paper an attempt has been made to study the anthropogenous geomorphological processes on Bhogdoi basin. The river Bhogdoi is a small but perennial river coming down from the foothills of Assam-Nagaland border into the plains of Assam and finally pours into the Brahmaputra. The course of the river has undergone tremendous changes due to physical and anthropogenic factors during the last two centuries. In view of this, it is realised that a detailed chronological study of these changes will enable us to understand the behaviour of the river and relevant issues.
Keywords: geomorphological, anthropogenous, denudation, Bhogdoi basin, chronological.

IMPORTANCE OF SLOPE IN CITY PLANNING: CASE STUDY: SOUTHWESTERN SUBURBAN AREA OF KOLKATA, INDIA

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Settlement on deltaic plains always develops on river levee, which being the highest point in the site and having slopes on both sides is naturally free from waterlogging. The future growth of settlement also follows the levee crest along the river, the result being an elongated pattern of settlement. Originally the city of Kolkata also grew over the natural levee of the river Bhagirathi for over a length of 50 km in a north-south direction following the same trend. But due to enormous population pressure it has encroached into the backswamp and marshy lands to the east and southwest by way of filling up extensive areas in unplanned manner. The physical features of the area have been dominated by surface water systems, the proximity of the sea in the south, and the human induced influence on the entire hydro-geophysical characteristics of the region. However, the latter has been the most dominant influence of all in recent decades, leading to profound subsequent implications on social and economic aspects of the inhabitants. The filling up of backswamp in a haphazard way leads to frequent waterlogging in the area paralyzing the daily chores of life in the rainy season. As the land was low, individual developers filled the land without caring to maintain the general slope of land, which is very necessary for easy draining of accumulated rain or waste water. Thus over period on the imperceptible slope of the delta, an anthropocene micro relief developed due to such reckless landuse leading to distortion of natural slope. The paper presents a glimpse of the severity of the waterlogging problem in the southwest part of Kolkata megalopolis where every individual distorts the micro-relief and natural slope of the area in the absence of any master plan.
Keywords: river levee, backswamp, waterlogging, anthropocene micro relief.

NOAI RIVER: A GEOMORPHIC AND ENVIRONMENTAL APPRAISAL

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Noai river was originally a spill channel of Hugli discharging into the Bidyadhari river situated in north 24 Parganas district of West Bengal. Noai originated from Barti beel near Barrackpore. Along its 28.2 km course the river flows through three major landuse/ landcover classes like rural area, urban area and industrial area. It is an important river of this area where urban and industrial waste water is discharged. The objective of the paper is to evaluate the present geomorphic and environmental condition of the river.

During field survey 20 cross sections were surveyed with the help of theodolite and positions were marked by GPS. Tide monitoring was carried out at three stations along the river to determine the limit of tidal influence. Water samples were collected for estimating the pH, DO and alkalinity. Concentration of phosphate, CO2.and faecal coliform was also determined. Environmental impact on the river was determined through interviews with local people and land use survey along the bank of the river.

The study revealed that both the depth and velocity of the river have decreased substantially through time. Due to heavy siltation the width of the river has decreased, hampering the navigational activity. Tidal effect is not uniform along the entire river course. Water of the upper course of the river (up to 4.47 km) is used for irrigation purpose. The river water is no longer used for domestic purpose, due to the presence of faecal matter. The entire urban waste water is discharging into the river which is degrading the water quality. Due to industrial effluent the alkalinity of the river has increased and the DO is low throughout the river. This is harmful for fishes and other aquatic species.

AN ANALYSIS OF CHANGING PATTERN OF LAND USE /LAND COVER AND ITS IMPACT ON UPPER TONS BASIN, MADHYA PRADESH USING SPATIAL TECHNIQUES

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Along with development of human civilisation, the interrelationship between man and physical environment changing continue which transform geographical regions and creates new regions. That is why it is relevant and necessary to analysis of these changes. The current study considers land use / land cover pattern as well as its positive and negative impact on environment of Upper Tons Basin according time, using IRS-IC, LISS-III (2000), IRS-P6, LISS-III (2008, 2012) and CARTODEM v-2 (2014) satellite images along with conventional data and Remote Sensing & GIS techniques. Generally the land use of the region firstly affected by physiography of the region then various human activities. The current study area is a part of Vindhyan system, mostly covered with Bhander plateau and Kaimur range, in the middle, Tons / Tamsa River valley plane separates these two upland regions. More than 45 percent area covered with agriculture and savannas type grassland including increasing percentage of scattered build-up areas mostly in plane region of valley other side near about 50 percent area covered by hilly plateau upland with monsoon deciduous forest and semi-arid vegetation. In present time the land use pattern of the region is changing due to increasing number of limestone base industries, cement industries, increasing population and use of innovations in all sectors of life specially agriculture sector. The results of analysis supported by field survey also, these results can be used in regional planning and management.

DETERMINING THE CHANGES IN LANDUSE-LANDCOVER (LULC) IN IRIL CATCHMENT AND ITS IMPACT ON FLOOD

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Flood has been a major natural hazard facing worldwide. Various factors are responsible forfloodviz. topography, nature of landscape, vegetation cover, type of soil, slope, etc. The severity of flood is enhance mostly by anthropogenic activities such as deforestation, overgrazing, increase impervious surface and other activities causing a change in the land useland coverin the uplands which has led to a drastic change in the overallflow velocity and pattern of the rivers. The Iril catchment is one such region where such changes have been witnessed over the past few decades. One of the major concerns about such changes is the occurrence of frequent floods in its lower catchment encompassing parts of the Imphal valley. The present study detects the changes in lulc in GIS environment using vector images for the year 2005 and 2012.Moreover theLog Pearson type III Distribution analysis has been worked out to estimate the frequency of flood for a recurrence interval of 2, 5, 10, 25, 50 100 and 200 years. It is evident from this study that land use and land cover changes which promote slow down runoff and accelerated runoff respectively are more likely to lead to increased frequency of flooding in the region.
Keywords: hazard, lulc,Log Pearson type III Distribution, GIS.

EVALUATING THE IMPACT OF RECHARGING OF SALINE GROUND WATER: A STUDY OF A VILLAGE OF MEWAT DISTRICT OF HARYANA

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Safe drinking water is one of pressing problem, particularly in the rural areas of country. This problem becomes acute when ground water is saline and not fit for human and bovine consumption. It is therefore, it become imperative to mobilize the local water resources by recharging the ground water with innovative technique, so that the villagers may meet their daily consumption as well as for their cattle. The paper examines the impact of innovative technology for mobilizing the local ground water resource which suits to the local conditions. The study area is the village Ghagas, situated under the foothills of Aravalli hills in Nagina Block of Mewat district of Haryana. The village often suffers with drought-like conditions and the supply of drinking water is inadequate and irregular, often fail to meet the safe drinking water regularly for human and bovine consumption. However, the quality of water of sub-surface water has been contaminated with high level of chloride, fluorides and other undesirable salts in the sub-surface water of village and its neighboring areas. Keeping in view these problematic areas, a local NGO and the people of the village have realized that some of innovative technology could be proved conducive to recharge the ground water by erecting check dams, soak pits etc. As a result, a micro-watershed has been executed with the result a considerable improvement in quality and the quantity of water has been taken place to meet the growing demand of drinking water in the village. It has been observed that a steady growth of village economy has been experienced within one year of execution of the micro-watershed project in the village and its surrounding areas.
Keywords: Innovative water technology, suitability, ground water, micro-watershed project

IMPACT OF URBANISATION ON DRAINAGE NETWORK OF RAM NADI, PUNE, MAHARASHTRA

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Human-induced land-use changes, unplanned construction, urbanization, changing watershed hydrology can all contribute to stream channel degradation with respective to surface and groundwater depletion, changes in geomorphic features and flooding, and disrupts the physical behaviour of channel system. Impermeable surfaces are one of the many human fabrications that disorder hydrological processes. Impervious surfaces are simply substances that stop the penetration of water into the soil. The result of this barrier is increased runoff, higher stream channel velocities and greater flooding.
In the present paper, an attempt has been made to assessing stream degradation impact on Ram Nadi watershed which is a part of Mutha river basin in Pune. Since last two decades Ram Nadi has been in spot light due illegal construction activity by local people along the channel and dumping of construction debris to urban enrichment. For the detailed analysis of the watershed, Landsat satellite image were used to classify land use and land cover of study area for the assessment of the linear, areal and relief aspects of change detection. Disappearing streams are identified on the basis of LU and LC analysis and spot survey.

A STUDY OF SPACING OF RURAL SETTLEMENTS IN DHULE DISTRICT, MAHARASTRA

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In the present paper an attempt has been made to study the spacing of rural settlements in Dhule district. For this Walenty wineed formula, standard deviation and mean distance is used. In the study of human settlements, spacing is termed as extension of areal size, therefore, spacing of villages belongs to relative locational arrangements of them. It is an important base for analysis of distributional pattern of villages in the district. As per the 2011 census Dhule district consists of 678 villages. The spacing of rural settlements is depends on fertility of soil, productivity of agriculture, nature of crops grown, distribution and availability of water, density of rural population. In the study area it is observed that there is no much variations in spacing between villages.
Keywords: Spacing, Standard deviation, mean distance.

PATTERNS AND DYNAMICS OF LAND USE/LAND COVER CHANGE IN INDIAN DESERT

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The land, particularly in an arid environment, is one of the important natural resources, and plays a very important role in the determination of man's economic, social and cultural advancement. The Land Use Capability Classification forms an important criterion for assessing the resource potential of the area. The limitations, which primarily determine the land use pattern in Indian desert, are extreme aridity, coarse sandy texture of soil depth with very low water retention capacity, wind erosion, thin effective soil depth, high salinity hazard, excessive biotic interferences and high stress of human and livestock population. Land Use/Land Cover Indicators represent Uncultivable Lands, Cultivable Wastelands, Fallow Lands, Current Fallow Lands, Net Sown Area, Area Sown more than once, Grazing and Pasture Lands, Irrigated Area and Dryland Farming Areas. The land use/land cover figures reveal the regional disparities and the corresponding vulnerability levels within Western Rajasthan.
In the present paper, an attempt has been made to examine the dynamics of land use changes in Indian desert. An attempt has been made to assess the role of human and meteorological factors in the patterns and dynamics of land use changes in arid environment.

MINING AND LANDFORM: A CASE STUDY OF RAIGUNJ COAL FIELD, WEST BENGAL

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Uninterrupted mining in Ranigunj area for over last hundred and fifty years have exerted great influence on surface topography, land level, physical characteristics and conditions of sediments of surface layer, rate of soil erosion and obviously on land use. Mining here is done by two important methods - underground mining methods and opencast mining methods. The effect of underground mining on surface topography is mainly restricted to gradual and sudden subsidence lending to change in local land level and formation of depression and hollows. However the effect of open cast mining on surface topography is amazing which may broadly be classified into two groups: 1. Sudden changes in the form of low hills of loose sediments, large depressions, steep scarp topography and 2. Slow changes in the form of slumping, increased erosion of loose sediments resting on steep slope and their deposition in nearby low land or fluvial outlets leading to gradual sedimentation.

Therefore, the basic aim of the researcher is to study this complete change of landscape and land-use due to anthropogenic activity and to suggest ways leading to minimum change and best uses of such areas. To fulfill her aim of assessing the anthropogenic influence on landforms the researcher has selected two open cast mines: 1. Sonepur Bazari Open Cast Project, which is one of the biggest and highly mechanized mines under Eastern Coal Field Ltd. and 2. Bansra Open Cast Mine, which has been abandoned in the year of 2003 after a production of long seventeen years.

GEOMORPHIC CHARACTERISTICS AND ITS IMPACT ON REGIONAL DEVELOPMENT: A CASE STUDY OF DUBRAJPUR BLOCK, BIRBHUM DISTRICT, WEST BENGAL

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The present study analyses the geomorphic characteristics of Dubrajpur Block, Birbhum District, West Bengal. It also assesses the impact of existing configuration of the study area on regional development. The study area covers an area of 342.71 km2 with a total population of 1,81,412 (Census-2011) and is characterized by undulating terrain with lateritic patches. As geomorphic characteristics of the area play a key role on agriculture, ground water potentiality, transport network, settlement pattern of the region, Human beings always show their interest on modifying it to gain maximum benefits. Anthropogenic processes are very active in filling up water bodies to construct settlements, cutting forests to change it into agricultural fields, transforming undulating surfaces into plane to build transportation networks like roads and rail tracks have been noted in the area. In this paper, some important measures have been suggested for the integrated development of the study area.

DELINEATION OF SOIL LOSS ZONE OF DIFFERENT LANDUSE CLASSES USING SATELLITE IMAGES- A CASE STUDY ON NAYAGRAM BLOCK OF WEST MEDINIPUR, WEST BENGAL

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Soil erosion is considered as one of the most significant aspect in soil degradation dynamics. Such geomorphic process naturally continues all over the world with varying level of intensity. Often the intensity of soil erosion is triggered by some unplanned anthropogenic interference like, inappropriate agricultural method, over grazing, over exploitation of forest resource etc. to transform it into a serious hazard. Thus monitoring of soil erosion is essential not only to trace the ill affected area by soil erosion but also to identify the risk zone of different land uses which promote soil erosion. Present study was carried out in the Nayagram block of West Medinipur district located in the south eastern fringe of Chotanagpur plateau. Soil loss of the selected area is estimated by using RS and GIS techniques based modified soil loss equation (MSLE) which is a derivation of universal soil loss equation (USLE). Different factors, namely the rainfall and runoff (R), soil erodibility (K), slope length and steepness (LS), crop management (C) and support practice (P) have been measured by the processing of either geospatial data like satellite image and digital elevation model (DEM) or conventional data like rainfall data and soil map. A land use land cover (LULC) map with 11 individual classes was prepared and finally LULC is combined with soil erosion map in order to estimate mean soil erosion value of each class. By applying MSLE, mean soil loss of the study area was estimated as 6 ton per hectare per annum. On the slope of the agricultural fallow, grass land and degraded forest class, risk zone having annual erosion rate more than mean value are identified. Thus the work transmits immense potentiality for proper estimation of soil loss according to land use class. This result will help for proper planning for soil conservation.
Keywords: Soil loss, USLE, MSLE, LULC.

HYDROLOGICAL RESPONSE OF LAND USE CHANGE: A STUDY ON CHUNDIA RIVER BASIN

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Moyna, Panskura-I, Sabang, Pingla, Debra and Kharagpur-II blocks of West Bengal falling in Chundia Basin are prone to water logging and flood that lasts for long time due to lack of drainage. This ultimately leads to transformation of agricultural land to fisheries. Land use transformation and its hydrological responses are estimated by standard techniques. These fisheries acts as water bodies that produces hundred percent runoff from certain amount of rain and thus leads to further water logging and flood. Clayee basement of these fisheries doesn't allow to water infiltrate. In dry season those fisheries draw huge ground water to maintain certain level of water for the fisheries. Evaporation in dry season leaves saline in crustation on soil that ultimately lowers the productivity.
Keywords: Chundia river basin, water logging and flood, land use change, ground water level

HUMAN-INDUCED GEOMORPHIC CHANGE AND LANDSCAPE DYNAMICS IN SOUTHWEST BIRBHUM DISTRICT, WEST BENGAL

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Human being armed with intelligence and technology act as a catalyst in the ongoing geomorphic processes by either accelerating or decelerating the natural rate of change. One of the interesting fact is that, human being plays a dual role simultaneously of being the only disturbing element to the otherwise peaceful/resilient environmental system as well as one of the most worst affected respondents of the biotic counterparts of the environment. In the web of natural environmental system, change in any parameter of environment may depreciate the entire system by transmitting the change through linkages and or interlinkages.

The Southwest Birbhum District geomorphologically represents a plateau fringe area. In spite of being devoid of any hasty urban influence, the study area is confronting with severe human-induced geomorphic change as a consequence of unscientific landuse practices. Agriculture in the study area is constrained by both surface and subsurface elements which make it low profitable or in some cases unprofitable. At the same time the southern part of the study area is endowed with coal bearing strata of Barakar and Raniganj formations. So, most of the villagers are engrossed to the mining activities which confer them easy access to the cash incomes. Another unscientific landuse practices which is proliferating since the last 10 years is brick kiln. In this very context the present paper aims to identify the existing unscientific landuse practices, the impact of existing landuse on geomorphology and to suggest some remedial measures to make a balance between existing landuse practices and local geomorphic change. The study incorporates both primary and secondary data sources. One of the most important revelations of the study is the direct linkages of unscientific landuse practices and negative geomorphic change which, in turn, is perturbing the entire environmental set up of the area concerned.

Keywords: Geomorphic change, landuse, Southwest Birbhum District

HUMAN RESPONSE TO THE RURAL WETLANDS: A CASE FROM BRAHMAPUTRA FLOODPLAIN, ASSAM

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The central intention of the study is to explore the pattern of distribution of diverse type of wetlands and their functions in a village situated in Brahmaputra floodplain, Assam .The people of village have a long history of eco-friendly utilization and management of wetland resources. The wetlands are prevalently known as manmade ponds, natural ponds, dead channel, water loggings and channel which endow with resources. Villagers make use of all kind of aquatic resources .Rural wetlands have been playing a enormous role in the rural life by providing reach for fishing, collecting edible plants, bathing etc. The aquatic resources stand as a potential alternative to livelihood of the village environment. The study is based on an intensive field work. It was carried out during 2014-2015 with a survey schedule covering all the 800 households of the village. Wetlands have been maped with the help of updated cadastral map (dag map) of the village and ground survey .Human response to their wetlands should be positive and sustainable, with this rationale in mind the present study has been undertaken for investigation.

Keywords: human response, rural wetland, eco-friendly, wetland resources.

CHANGING GEOMORPHOLOGY OF KOLKATA METROPOLIS AND INCREASING RISKS OF EARTHQUAKE HAZARDS

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The ground motion in earthquake is caused by tectonic activity. Seismic hazards, the outcome of earthquakes, result in slope instability, subsidence or ground collapses, liquefaction of underground soil, structural destruction and Tsunamis. Intensity of seismic hazards depends on the rate of oscillation. Quick oscillations shake apart small buildings, whereas, slower ground-shaking at intervals of four to five seconds devastate tall structures. During Nepal earthquake of April, 2015, slower rate of shaking resulted in falling down of great structures fast.

BIS grouped India into four seismic zones, viz. Zone II, III, IV and V (IS 1893, Part I, 2002). Kolkata metropolis covers the contours of Zones III & IV, with a triangular zone of IV having its tip from the north traversing to the south margins. A major faultline lies about 4.5km below the surface of the area. This fracture, Eocene hinge-zone and the shelf-area traverse many other interfering faults.

The metropolis, situated on the Bengal Basin with fluvomarine sediments cover alternate layers of clay, silt and sand horizons. Due to sharp drop in number of waterbodies and unchecked extraction of underground water through pumping, groundwater level is going down alarmingly. The piezometric level is now 8 to 10 metres below ground. There appears intermittent gap between the surface soil and groundwater levels in many parts of the city, giving way to subsidence. Compounded with this, unplanned growth of highrise buildings and other structures with pillar construction are dotting fast along the very congested urban sprawl, old buildings and shanties. The conglomeration poses major risks from any earthquake induced ground shaking. Propagation of any quake through faultlines across the metropolis can lead to liquefaction of soil. If transmitted oscillation of resultant ground shaking is slow, alluvium-rich soil would fail to hold the structures - leading in instantaneous major devastations.

HUMAN IMPACT ANALYSIS OF RIVER GANGA AROUND KANPUR METROPOLIS

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Human impact on rivers is a large-scale process that leads to diverse negative consequences and reflects in the form of redistribution of river flow, river flow withdrawal, physical disturbance of river-beds, pollution of river water, water clogging etc. These characteristics are observed in river Ganga around the Kanpur Metropolis due to construction of barrage, creation of reservoirs, diversion of river flow along the different ghats, location of tanneries, encroachment in various ways and extraction of sand etc. Ganga barrage divides its length into upstream and downstream. Before the contruction of barrage river flow had been changed from city side to other side and a large have been emerged as deposited lands known as Ganga katri which submerge only floods. The water of river is used in municipal sector. Currently river bund have been constructed for the development of new city in the riverside in upstream and downstream. The aim of this paper to identify these occurrences and to explain the physical changes in river bed. Heavy water contamination starts from Kanpur due to various tanneries set up along the river Ganga. Primary and secondary sources of information related to human impact and landscape are used for analysis in this paper.

Keywords: Barrage, upstream, downstream, pollution, river flow.

PROCESSES AND FORMS IN GEOMORPHOLOGY

ASPECTS OF GEOMORPHOLOGY IN THE TRIPLE DRAINAGE BASINS, INDIA AND SURROUNDING AREAS

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The Triple Drainage-the Brahmaputra, the Barak and the Manipur basins (the BBM drainage basins) covering almost the entire North East-India i.e the eight states and surrounding areas even now a days known as terra in cognita. The Brahmaputra - the main channel for drainage - especially its wide valley stretches made bu Eocene to Miocene sediments and upper riverine deposits. The Brahmaputra basin, a East -North to West South-West valley, evolved during the last two million years. The evolution of the Bramhaputra basin has witnessed many subsidences including alleviation of foreland depression due to southward compression of the Himalayan mobile belt. These have also been influenced by the Brahmaputra north-west ward compressions of the Indo-Myanmar orogenic belt and relative upliftment of the Meghalaya Plateau in the south. The valley is underlain by up-arched basement complex at a depth of 3000-4000m, overlain by flexure Eocene to Miocene sediments hidden by recent deposits as present in the valley areas. On the other hand, the imbricate thrust and fold belts of the Upper Assam and Nagaland are typified by the formation of linear hills and valleys as found there. The thrusts have brought the older rocks over the younger ones. There are a number of thrusts in this area which are bounded by the outer Naga thrust and the inner Disang thrust etc. Naturally, the drainage patterns are influenced by these thrusts thus developed. The terrain is highly dissected with trellis drainage pattern with many erosional linear valleys and sharp crested hills in the undulating area. Almost all the rivers are found to coalesce and then bifurcate along North South strike due to East - West compression on the semi consolidated lithified sediments.

SIGNIFICANCE OF PERIGLACIAL, NIVAL AND CRYONIVAL PROCESSES IN THE SOUTHEAST-FACING SLOPES OF KANCHENJUNGA SUMMIT COMPLEX, SIKKIM HIMALAYA

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The ostensible geomorphic features produced through periglacial, nival and cryonival processes in the southeast-facing slopes of Kanchenjunga Summit Complex in Sikkim Himalaya reflect typical Quaternary history of this region. As the southeast-facing slopes of this summit complex provides a rich legacy of the periglacial, nival and the cryonival phenomenon. Quaternary landforms resulting from periglacial, nival and cryonival processes (frost-shattering, heaving and translation) have been identified in the recently deglaciated valleys of Rathong and Onglakthang. This study has characterized and classified characteristic Quaternary slope deposits into the groups of relict and contemporary rypes. The large and small scale Quaternary slopes deposits comprise debris slope, talus slope, detritus slope and scree slope, pro-talus rampart, avalanche track/scars, felsenmeer, soil polygons, solifluction sheets and lobes as well as nivational hollows in the alpine meadow areas above 4,000m in and around Dzongri, Bikbari and Thangsing area. Nivation hollows alone occupy about 18.47 hectares of land in this part. Besides, remnants of the rock glaciers, contact springs and landslide zones have also been identified and discussed. The distributional pattern of the relict and contemporary Quaternary slope deposits and their orientation has also been made. Furthermore, typology of the periglacial, nival and cryonival processes operating in this part of the Sikkim Himalaya has been prepared.
Keywords: Nival, periglacial, cryonival, slope deposits, Kanchenjunga Summit Complex

UNDERSTANDING GEOMORPHIC THRESHOLD THROUGH EMPIRICAL STUDIES

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Close observation, continuous monitoring and experiments reveal that geomorphic processes become active only after the major controlling factors attain their critical (Threshold) values. Study on debris slide for a duration of 6 years showed that slopes are not changing continuously but slides suddenly on certain dates after attaining threshold height (5m), steepness (21o) and critical rain (95mm). Experimental study on drainage development shows that Channelisation, Bifurcation and Branching started after some critical stress generated. Bank erosion is not also continuous but episodic in nature, related to some catastrophic events that generates threshold. Channel bed scouring also started after the critical shear stress has been achieved. Changes in landforms are not continuous but episodic. Lack of close monitoring lead us to believe in average rate of change in landform. Average rate of change is thus erroneous and misguiding rather it is required to rely on close monitoring, observation and experiment to identify the exact time, condition and mechanism of change in land form.
Keywords: Monitoring; Experiments; Threshold; Episodic Change

PROCESS-FORM RESPONSES OF ACTIVE DELTAIC PART OF SUNDARBANS: CASE STUDY ON MURIGANGA-SAPTAMUKHI INTERFLUVE

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Active delta of Sundarban is one of most dynamic geomorphic regions of the world which is dominated by large tidal river systems. Strong action of rivers and marine forces with unrest erosion and depositional activities is commonly noticeable which simultaneously shaped and reshaped this vast active tract. Adjustment of morphological form occurs as a result of process feedbacks that exist between channel form, flow, and sediment transport. In this present context spatio-temporal changing nature of bank line configuration, erosional and depositional extent and successive changing forms of different morphological units along with the existing ongoing processes within Muriganga- Saptamukhi interfluve region have taken into consideration. The study has done on the basis of old toposheets and recent satellite images along with field verification. Contrasting geomorphological characteristics of this region is very significant. The dissected coastal flat is dominated in the extreme south, the middle region is represented by low elevation with large meandering active tidal creeks, whereas the relief gradually increases towards north. Changes in morphological environment is directly related with nature of tidal flow pattern, bathymetric condition of channels, river bed configuration etc. Along with these natural processes man made processes are also responsible for changing the face of the land through alteration of different geomorphic units into economic units. Spatio-temporal variation denotes that though erosion and deposition both the processes are active side by side but the rate of erosion overtakes deposition rate as a result total area is in decreasing state. So proper knowledge about the ongoing processes, intense monitoring of the changing behavior of existing processes, structural and non-structural planning and management, integration between local demands and planning bodies etc are utmost necessary for the economic betterment of Sundarban and its dwellers in near future.

THE EFFECT OF RIVERINE SEDIMENTATION ON THE OPERATIONAL MECHANISM OF BRICK KILNS - CASE STUDIES FROM SOUTH 24 PARGANAS, WEST BENGAL

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In South 24 Parganas district a large number of brick kilns are located along the left bank of Hooghly. From Garden Reach to Kakdwip 189 kilns can be located, concentrated in certain zones viz. Kulpi, Diamond Harbour, Achhipur, Chittirgunj, Akra etc. In each zone about 10-15 kilns can be seen. These kilns use river bourne sediment or buy sediments excavated from agricultural fields or riverine bars. Thus the brick kilns act as indicators of riverine sedimentation as they trap river bourne sediment in their sedimentation tanks (paran). This paper is concerned with 2 zones - Kulpi and Diamond Harbour. The former is located more towards the estuarine mouth and the latter is situated 13 km upstream. In these two areas distinct operational pattern of brick kilns is noticed.

Questionnaire survey was done to enquire about the nature and rate of sedimentation in the sedimentation tanks. For determining the spatial pattern of suspended sediment concentration water samples were collected during high and low tide. Sediment samples were collected from the sedimentation tanks and river bank for textural analysis. Perception of the brick kiln workers indicates an overall lowering of sedimentation in the Hooghly. The study reveals spatial variation in the pattern of sedimentation in the studied stretch. Kilns of Kulpi produce bricks by utilising the suspended sediment deposited by the river in sedimentation tanks. Here the amount of sediment deposition is high and the sediment texture is clayey. Kilns of Diamond Harbour rely on purchased sediment as the amount of sediment deposited is very low with a sandy texture. The tide induced currents, position of riverine bars, dredging activities and passage of ships may act as causative factors for the sedimentary behavior of the river. Due to these factors operation of brick kilns in this stretch is highly varied.

IDENTIFICATION AND MAPPING OF MAJOR LANDFORM UNITS IN KUMARI RIVER BASIN, WEST BENGAL USING NEURAL NETWORK

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Automatic GIS techniques for quantification of terrain features are already available which include classification of morphometric parameters, fuzzy logic methods, ISODATA classification, multivariate statistics, landscape element analysis and so on. In geomorphology a common perspective of landform studies is to delineate homogeneous area from DEM data based on morphometric parameters. In such attempts the first order derivatives (slope and aspect) and the second order derivatives (cross sectional curvature, maximum curvature and minimum curvature that takes processes into account) of a DEM are commonly used as quantifiable parameters for landform and geomorphological processes. But generic land form elements like pit, peak channel, pass and plain can be extracted from DEM derivatives using an unsupervised neural network for mapping both landform elements and large landform features. This method has been used in case of the Kumari river basin in Purulia district of West Bengal. Four morphometric parameters are derived from DEM data by fitting a bivariate quadratic surface with a window size of 5×5, and then they are used as basic input for a semi-automatic Neural Network in which no specific classes are defined beforehand. This is a Self Organizing Map (SOM) designed as a rational model of the biological brain function. SOM comprises a regular two-dimensional grid of output map units connected via weights with input vectors, i.e. the four geomorphic parameters. Each input vector is presented to the network and Euclidean distances between it and all nodes in the network are computed. The node with the shortest Euclidean distance is and is selected as a winner (Best Matching Unit). This winner neuron becomes the centre of an updated neighborhood area within which nodes and their neighborhood weights will be updated simultaneously according to Kohonen rule. The procedure efficiently identified major landform units like dissected ridges, valleys, moderately slopping plain etc.

CYCLIC PATTERN OF SHIFTS IN VALVATI TIDAL INLET WITH RESPECT TO ITS HYDRAULIC STABILITY

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This paper attempts at charting down the cyclic nature of the Valvati tidal inlet along with its hydraulic stability. Valvati inlet has a shifting tendency and has exhibited its impact on the adjacent areas. The inlet shifted its position atleast four times from 2002 to 2015, ascertaining the fact that the inlet exhibits strong shifting tendency. Detailed plan mapping of the inlet shifts along with the collection of field parameters, required for computation of tidal prism and hydraulic stability was carried out for the period under consideration. A zone of 200 m was demarcated as the active zone of inlet shifts. The tidal prism decreased from 1.2*106m3 in 2002 to 0.11*106m3 in 2003, as a result of decreased critical cross sectional area (Ac) and excessive shoaling of the inlet. Consequently the tidal inlet was forced to shift its location northward which was attained by the inlet during a storm in the 2003 monsoon. In the subsequent years the increase in Ac must have instigated the shoaling due to siltation of the inlet throat width which further boosted the shift in the inlet position. By 2008 the 'P' recorded was 1.5*106m3. There was no change in the inlet position by 2010 however 2010 condition is noted by the highest velocities (Vm) (2.6 m/s). The Vm at the inlet may be attributed to the increased depth at the throat and decreased Ac, which are required for maintaining the inlet stability. By 2015 it was observed that the inlet once again had shifted due north however the inlet depth was considerably low (0.9m BMSL) with an Ac of 22.09 m2 and 'P' 0.26*106m3 only, indicating shoaling due to excessive siltation within the inlet. This also indicates that there is also all possibility of further closure and shifting of the inlet position.

EVOLUTION AND GEOMORPHIC CHARACTERISTICS OF NAYACHAR ISLAND, HUGLI ESTUARY, WEST BENGAL

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The Nayachar, the second largest island of macro-tidal Hugli estuary has evolved in a complex environmental setting in the Bengal deltaic system. Nayachar is a young estuarine island, developed out of accretional processes since 1945, presently covering an area of about 49.56 km2. Tides play an important role and they dominate the hydrodynamic behavior and extent of erosional and accretional processes in this part of the Hugli estuary . Colonization of pioneer mangrove species induce tidal sedimentation. Semi-diurnal tides with neap- spring variations ranging from 2.0 to 5.0m, inter-tidal variation, wave, current, wind, temperature and rainfall are the players behind evolution of Nayachar Island. Between 1971 & 2001 the island progressively enlarged, yielding an average accretion rate of 0.98 km2/ year. Multidated maps and images (Survey of India Topographical Sheet of 1971, Landsat MSS 1973, Landsat TM 1990, Landsat TM 2001, Landsat ETM 2008, Landsat ETM 2014) have been used to delineate erosion -accretion zones, land gain - land loss pattern of the island over a period of 43 years. The island boundaries digitized from multi temporal images using Geomatica V. 12.1 revealed the changing plan form of the island from elongated to near elliptical shape. The area of Nayachar increased from 15.94 km2 to 46.48 km2 in 2001. During 2001 - 2014, accretion occurred in the western- south-western -southeastern part while southern and eastern part of the island was eroded. Digital Image analysis revealed that coverage of vegetation and succession of mangrove species is one of the important factors behind island evolution. Field survey during December 2013 and March 2014 validated the signatures of erosion - accretion at selected points and observed development of meso and micro landform features viz. tidal marsh, salt marsh, tidal flats, mud flat, marsh creek, marsh cliff, mud ball, ripple marks, bio-turbation marks etc.

SPATIAL DISTRIBUTION AND VARIATION IN MUD BALL CHARACTER IN BAKKHALI COAST

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Mud balls consist of rounded, mostly encrusted masses of clay observed primarily in tidal setting. Mud ball shapes may vary from spherical to platy to elongated. The mud ball form due to the action of wave and tidal currents transporting eroded aggregates of clay. In the present work an attempt has been made to analyse the spatial variation and characteristics of mud ball in the eroding zones of Bakkhali beach. At these locations palaeomud has been exposed which is the source of the mud balls. Because of their common and conspicuous presence, detectable spatial differentiation in terms of size, orientation and density, mud balls have been selected in the present study as indicators of erosion structures. In the field detailed beach profiles were surveyed from high tide line to low tide line to determine the beach slope and all positions were taken by GPS. Mud ball frequency, measurement of long and short axis and orientation was measured by placing a 2ft × 2ft frame at regular interval.

The study indicates that mud ball distribution and orientation are partially dependent on the marine processes such as the wave and tide. The concentration of mud ball is depending on the slope and width of the beach. The mud ball orientations are influenced by the direction of wave approach. There is also a relation between the size of the mud ball and slope of the beach.

HYDRO-DYNAMICS RESPONSE TO CHANNEL CUT-OFF MECHANISM- A CASE STUDY OF MIDDLE JALANGI RIVER BASIN, WEST BENGAL

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Morphological attributes are better understood by its mechanism. In geomorphology of alluvial channel migration and its proportionate cut off mechanism can often an ample scope for better study of hydrological decay or evolution a channel. This paper deals with not only the evolutionary processes of channel cut off but emphasis has been given on the paradigm of wetted perimeter on the basis of both geometrical calculations and sedimentation related to multivariate analysis. The study area has been related with Ganga delta region where due to evolution of alluvial channel of Jalangi river, several channel cut off have been developed which is better known as oxbow lakes. Regarding the past study, importance had been given on the morphology of such cut offs or its evolution that how they have formed but this present study belongs to extracts some hydrological nature of main Jalangi channel. This hydrological analysis will be done not on the basis of main channel morphology but it will include a new look of study that how we can predict the present channel condition analysing the hydrological parameters of the cut off channels. This is the second objective of the study. Concerning all the mathematical analysis of sedimentation and hydrology, it has been observed that all the channel morphology parameters are well connected resulting the decay of both cut off and main channel in respect of time and space.

CHANGING OFF-TAKE POINT OF JALANGI RIVER IN MORIBUND DELTAIC PLAIN, WEST BENGAL: A HYDROMORPHOLOGICAL ANALYSIS

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River Jalangi is a branch of the Ganges river originating in Murshidabad district in the Indian state of West Bengal and meets the Bhagirathi in Nadia district after flowing in a south and south-west direction. The entire river flows over the Moribund delta of the Gangetic deltaic plain. On the basis of the evidences from old topographical sheets, literatures, and current satellite images the evolutionary history of the off take points of the river Jalangi have been identified and those are being presented through the maps of different periods. Since the origin of Jalangi river the off take point from river Padma was near Jalangi P.S. in the eastern part of Murshidabad district at the coordinates of 24º 05'39" N and 88º41'16" E. But the evidences of the mid 20th century shows that this source has been dried up and the rivers like Sialmari and Bhairab became the principal feeder for river Jalangi. But from the late 20th century until now only Bhairab supplies the discharge of Padma to Jalangi all round the year. So, technically the source of the river Jalangi has changed from the eastern part of Murshidabad district to northern part at the coordinates of 24º17'58" N and 88º26'45" E which is actually the present source of Bhairab river. The possible reason for these occurrences might be shifting of the meandering channel due to excessive discharge during monsoon period, channel avulsion due to excessive siltation and development of sand bar in the river bed etc. The consequences of this drying up of the river sources are the presence of paleo channel, formation of numerous marshes, ox-bow lakes of various size and shapes etc. So, continuous processes of transformation of geomorphological units are well observed over this stretch of study area.

CHARACTERIZATION OF GRANITIC PROFILES BY WEATHERING PROCESSES AS A GEOPHYSICAL AND GEOCHEMICAL ALTERATION OF ROCKS IN SOUTHERN PURULIA DISTRICT, WEST BENGAL

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Purulia district of West Bengal is geologically dominated mostly by Proterozic hard granite gneiss rocks including soft phyllite and mica schist of Singhbhum group. This study primarily aims to understand the nature of geophysical and geochemical weathering processes for characterization of granitic weathering crust and secondly, to determine the geochemical pathways of mineralogical alteration of parent rocks. During the field study 14 rocks and soils samples were collected from 3 sections of each weathering profile in 3 different blocks namely, Manbazar-I, Manbazar-II and Banduan. The samples were collected along road cuts, natural and other man-made exposures and restricted mostly within the exposed layers of the respective profiles. The samples were analysed in sieve for particle size distribution and in X-ray diffraction for mineralogical alteration. The thin section of selected samples were analysed under polarized optical microscope for understanding the nature of physical and chemical changes in parent rocks. From sieve analysis, the cumulative particle size distributions show that the size of weathered materials gradually reduces from saprolite to overlaying soils in every profile. Mineralogical analysis by XRD shows that feldspar, muscovite, quartz and biotite are the primary minerals which are intensely weathered and have undergone some geochemical processes except quartz, to form some secondary clay minerals like montmorillonite, kaolinite and illite in the overlaying soil. Optical microscopic analysis reveals that transformation of primary minerals to secondary clay minerals significantly reduced the rocks strength which leads the rocks disintegrate into smaller particles. The results show that there is an abundance of montmorillonite and altered primary minerals with gavel materials in the profiles are liable for further weathering to develop a mature soil.
Keywords: Granite gneiss, weathering, sieve analysis, x-ray diffraction, clay minerals

MORPHOLOGY AND SEDIMENTOLOGY OF TILLA-LUNGA TOPOGRAPHY IN WEST TRIPURA DISTRICT, TRIPURA

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The tilla and lunga (ridge and furrow) landform in West Tripura District are enigmatic, interesting but its origin is yet to be explored. The knowledge gap between the formations of the present landform with the geological history is one of the thrust areas. The term tilla and lunga are not gaining focus in terms of geomorphic features. The research problem is the identification of sequential paleo-geomorphic and sedimentological process for evolution of present landform.
The present form of Tilla-Lunga is identified from the Survey of India Topographical map (79M/1, 79M/5, 79M/6, 79M/9, 79M/10; year 1930-31, 1933; R.F 1:63,360) and elevation data of SRTM DEM (spatial resolution 90 m). The Agartala-Bishalghar Railway track is constructed over the different geomorphic features like tilla (upland), lunga (narrow valley), flood plain and rivers. The lithological assemblage, extension of sedimentological structure and primary bed formation are investigated in seven different places of West Tripura District. The paleo-current data of different sedimentary deposition cycle indicates the possible direction of sediment flow and origin. The soil samples are collected from the tilla top, tilla slope and lunga. The total number of 105 soil samples is collected from 30 specific areas of the District. The laboratory testing like grain size, soil pH, EC (Electrical Conductivity), concentration of Iron is studied for understanding the evolution of soil property in this region.
There is a significant change of drainage system in the recent period which bifurcate the tillas (terraced upland). The grain size of the facies indicates gravel deposit (Gms). There is a significant positive correlation between pH and EC. The Organic Carbone haphazardly deposited in different soil horizons. Overall, the analysis reveals that the periodical flood deposit, fluctuation of water level plays an important role in the deposition of sediments in West Tripura District.

BEDLOAD CHARACTERISTICS IN A SELECTED STRETCH OF PANCHNOI RIVER AND ITS RELATION TO CHANNEL MORPHOLOGY

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Panchnoi is a major right bank tributary of Mahananda river, flowing through the alluvium fan surface of Himalayan foothills in Darjeeling district. Total length of the channel is around 16 km of which around 8 km stretch of the middle course of the river has been surveyed. In this stretch, the Rongtong Khola, a major right bank tributary joins the Panchnoi. As the flow pattern of a river depends on the bed and bank morphology together with its competency and capacity, an attempt has been made in this study to correlate the hydraulic and geomorphic parameters of the river with its bed load character.
Geomorphic mapping of the surveyed stretch was done by theodolite tachometry. The long profile and 70 cross profiles were surveyed. 88 sediment samples were collected along this stretch and pebbles and cobbles were measured. The hydrological parameters were quantified based on empirical equations.
The bed load character reveals that the pebbles get more rounded with increasing distance downstream. A negative relationship can be observed between channel width and mean size of sediment. The relationship between channel width and kurtosis value shows negative relation in the upper and positive relation in the lower part of the surveyed stretch. This may be an effect of fluctuating energy condition of the depositing medium and also the effect of mixing of bed load contributed by the tributary streams. It is interestingly noticed that when the river course is straight the sediment shows an uni-modal distribution and the meandering pattern shows multi-modal grain size distribution where the pool-riffle sequence acts as an important factor. Various types of bank protection structures have been constructed along this stretch and acts as an important factor to modify the channel behaviour.

TIDAL BEHAVIOR OF JALDAH INLET, TAJPUR, WEST BENGAL

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Most of the coastal inlets have a meager fresh water flow and are principally flushed by flood and ebb tide. The mouth of these inlets frequently shifts to maintain a balance between the tide and the wave-induced littoral drift. The coastal tract of Purba Medinipur district of West Bengal includes four main inlet systems, namely, Pichhaboni, Jaldah, Sankarpur and Talsari. In this study only the Jaldah inlet has been taken into consideration to examine its tidal behavior. Though it has an inland source but due to lock gates the inflow of fresh water has been stopped. The tidal characteristics of the inlet viz. the flood and ebb tidal velocity, the hydraulic gradient, the tidal range and tidal prism were studied along with the geomorphic parameters like long profile and the cross sectional form of the inlet. The geomorphic and hydraulic properties together determine the sediment budget of the inlet.

Four monitoring stations were set up along the tidal inlet and tide monitoring was carried out for about 9 hrs. Water samples were collected every 45 minutes for determining the suspended sediment concentration in the inlet through the tidal cycle. Four cross sections were surveyed by theodolite and total station. The long profile of the inlet was measured by echosounder. These cross sections were used to calculate the hydraulic geometry of the inlet and compute the tidal prism.

The study revealed that the rising rate of the tide is greater than the falling rate. The hydraulic gradient also indicates a faster withdrawal of water at the mouth than the interior portions. The suspended sediment is getting sufficient time to get deposited away from the mouth.

CHANNEL DYNAMICS OF JIYA DHOL RIVER IN DHEMAJI DISTRICT OF ASSAM

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Jiya Dhol river system is one of the most dynamic rivers flowing out of the foothills of Himalaya in Arunachal Pradesh and joining mighty Brahmaputra in Assam. This river has created flood havoc in the District of Dhemaji due to frequent avulsion and other changes in its course, over the decades. The focus of this study is to understand the channel dynamics in the Jiya Dhol River in terms of pattern of channel avulsion and course changes. For the analysis the data on river planform are collected from the survey of India toposheets and a series of LANSAT imageries downloaded from USGS Earth Explorer (http://earthexplorer.usgs.gov) as well as from Google earth image and extensive ground truthing is done with the help of GPS. The time series of river planform is used to analyse the pattern of channel changes. The analysis shows that before 1993, the Jiya Dhol River had tendency to shift from east to west and the distance of avulsion was large near the foothills. While after 1993 till present time the channel avulsions are from west to east and the distance between the new and the old course has reduced. The course change in the lower reaches of the river during has a tendency toward straightening. This study is a significant contributed toward understanding the channel dynamics of Jiya Dhol river and it can be very helpful in management of floods caused due to channel dynamics.

NEO-TECTONIC IMPRINTS ON LANDFORM MORPHOLOGY- A CASE STUDY OF NEORA - JALDHAKA INTER VALLEY,WEST BENGAL

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The ongoing paper is concerned about the sensitive issue like neotectonism impact on the landscape development. It is a detail and micro level study of North Bengal Himalayan foothills where the effect of tectonism is precisely observed. The term 'neotctonism' was introduced by Obruchen (1948) to summarize the active tectonic processes including the last major tectonic configuration change and establishment of modern stress. It is the one of the active unstable area of NE India where faults/thrusts and presence of synformal axis are predominantly controlling the geomorphological landscape development. This frontal region of an active orogenic belt like the NE Himalaya is characterized by complex terrace morphology with fluvial aggradation, degradation and strath terraces. Concerning the fault zone area of Matiali scarp, it is very clearly observed the extended part of Garubathan thrust (MBT) under the Matiali formation near the upper part of Kurti river. But, in the middle part of the river , where the synformal axis is present, river terraces are magnificently developed over two sides of R. Kurti. Here, two terraces are well virtualized but the upper most flat terrain is designated as fan surface which is made of mainly by the sediments of Matiali formation. In this region, slope of the fan surface is southerly 2.1?. In south of the Matiali scarp on the banks of R. Neora, Kurti, Murti raised terraces are distinctly observed as T1 and T2. The last surface rupture with a recorded displacement of 14m of Chalsa fault related to the historical earthquake in Nepal around 1100 AD (Kumar et.al. 2011). It is a positive feedback system where neotectonism and geomorphological landscape are well related and in a classical model of fault propagation; geomorphic evolution through the structure/process is present in respect of time and space.

TEMPORAL CHANGE AND SEDIMENT CHARACTER OF SHRIVARDHAN BAY MOUTH SPIT, KONKAN COAST, MAHARASHTRA

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Central Konkan coast of Maharashtra exhibits an alternating sequence of bay and headland. Shrivardhan is a small bay of 7 km2 area which shows the development of a prominent bay-mouth spit, which extends from north to south for about 2.5 km. The western part of the spit acts as the present beach with an average width of 300 m. The spit has extended in a north-south direction aligning itself with the longshore drift, which has almost closed the main inlet mouth in the south. The southern tip of the spit is not stabilised and it gets exposed only during the low tide.

Methodology

To detect the change of the high tide line (HTL) GPS survey was done along the HTL. About 2 km stretch of the beach was represented by 7cross sections. To understand the sediment character of the beach 35 sediment samples were collected from these transects. Granulometric analysis was carried out by standard dry sieving method.

Findings

The position of the HTL shows that during the last 90 years the HTL has moved inland from 1968 to 2003 and subsequently again shifted towards the sea. The same trend of cyclicity is noticed in case of development of the southern end of the spit. The analysis of the sediments reveals that along the beach, the sediment becomes well sorted towards the HTL. The mean grain size becomes relatively coarser from north to south and the kurtosis value also increases towards south.

RIVERINE MORPHOLOGY IN THE SOUTHERN PART OF NADIA DISTRICT, WEST BENGAL: A SPATIO-TEMPORAL ANALYSIS

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The Southern Part of Nadia District of West Bengal comprises the areas of six Community Development Blocks, viz., Santipur, Ranaghat - I & II, Chakdah, Kalyani and Haringhata having a total area of 1132.30 km2. The entire study area lies within the moribund sector of the Ganga Delta where all the rivers viz. Hooghly, Churni, Ichamati, Anjana, Jamuna etc. are stagnated. The main objective of the present study has been to make an effort to discuss and analyse the nature and character of the rivers and the changes that have occurred in the riverine morphology in the area within the last hundred years. The present work is based on detailed analysis of topographical maps and satellite images of the last hundred years as well as intensive field study. The study reveals that the rivers have erratic water flow causing floods over large tracts spilling over the banks during torrential rains, but remaining practically flowless (even dry in stretches) during dry season. The changing courses of the rivers in this moribund deltaic tract form numerous interesting fluviomorphic features since the last hundred years. Therefore, the study area possesses a variety of morphological features like bils, ox-bow lakes, cut-offs, palaeochannels etc. and floodplain features like meander scrolls, natural levees, point bars, mid channel bars, crevasse splays etc. Not only natural but several anthropogenic factors have led to the changes in riverine morphology of the area. Besides this, the semi-consolidated to unconsolidated alluvium in the study area forms a rich store of ground water which is under threat for over-exploitation. On the basis of comparison, discussion and analysis, the striking features in terms of changes that have occurred in riverine characteristics in the study area have been identified.
Keywords: moribund, bils, palaeochannels, fluviomorphic, alluvium

QUANTITATIVE MORPHOMETRIC ANALYSIS OF A WATERSHED OF MOREL BASIN, RAJASTHAN USING SRTM DATA AND GIS

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Basin morphometry is a means of numerically analysing or mathematically quantifying different aspects of a drainage basin. In the present paper, an attempt has been made to study the detail morphometric characteristics of Dhund watershed in Morel river basin, which itself is part of the Banas basin in eastern Rajasthan. For detailed study, we used SRTM data for digital elevation model (DEM), and geographical information system (GIS) was used in evaluation of linear, areal and relief aspects of morphometric parameters. Watershed boundary, flow accumulation, flow direction, flow length, stream ordering have been prepared using ArcHydro Tool; and contour, slope-aspect, hillshade have been prepared using Surface Tool in ArcGIS 10.22 software. Different thematic maps i.e. drainage density, slope, relief, superimposed profile, and longitudinal profiles have been prepared by using ArcGIS software. Author has computed more than 70 morphometric parameter of all aspects. Based on all morphometric parameters analysis; that the erosional development of the area by the streams has progressed well beyond maturity and that lithology has had an influence in the drainage development. These studies are very useful for planning rainwater harvesting and watershed management. The Dhund watershed covers an area of 995.70 km2 and has 4th order drainage with mainly obsequent drainage having dendritic patches of drainage pattern. The mean bifurcation ratio is 5.12 indicating the watershed is largely controlled by structure. The study has strengthened in understanding the hydrological, geological and geomorphological characteristics of the Dhund watershed.
Keywords: Morphometry, Dhund watershed, SRTM, geographical information system

SEDIMENTARY FACIES CHARACTERIZATION AND COMPARISON FROM THE SANDY DEPOSITS OF THE RIVER TEESTA

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The river planform dynamics from new deposition and erosion helps to study the facies characteristics from old depositional structures as well as new depositional structures. To establish the comparative facies characteristics of the old and new depositional structures are important to know about long period change in the process. Again satellite images have empowered the research with the synoptic view of the spatial change and long period archive of the records enabled to establish the temporal change of the river geomorphic features. Again the study of the sedimentary structures and the lithology are very important to determine the past depositional environment which is also supported by the grain size and facies characterization. The present work focused on the study of the sedimentary facies of the river Teesta in different parts of the river reach. For the detail analysis of the depositional environment several sedimentary profiles have been observed and documented from different reaches of the river. Not only the vertical section of the facies recorded but also more or less 40 m long horizontal profiles have been drawn to establish the depositional differences of the different section of the river. The profile sections are predetermined by the satellite images to access to the location for drawing the record of the respective facies sections. The basis of the selection of the profile is the age or the temporal scale that satellite images enable us to determine the landforms (old islands, new islands, modern sandy bars) to identify and study.The study foundlarge difference between old depositional structures and facies associations in comparison to the new depositional structures indicating the change in process while there are not much difference between moderately age depositions in comparison to the new depositional features.
Keywords: geomorphic features, spatio-temporal change, sandy deposits, grain size, facies

SEDIMENT TRANSPORT PROCESSES IN RIFFLE -POOL SEQUENCES AND THE EFFECTS OF RIVER REGULATION FOR HYDRO-ELECTRIC-POWER WITHIN THE TONS RIVER OF CENTRAL INDIA

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This study examines the effects of 10 years of river regulation on the sediments and the sediment transport processes within the gravel-bedded part of the River Tons of Central India. The Tons River was regulated following the closure of the dam on Tons, since then the releases from Tons reservoir have been dominated by the generation of hydro-electric power.

Direct measurements of sediment transport using a range of techniques identifies a sediment flux divergence between riffles and pools. Riffles sustain significantly accentuated sediment transport rates and competence over associated pools during hydro-power releases. This removes non-structured and finer particles from the riffle surface and compacts the layers. The stabilisation process takes approximately 2-3 months under normal operational conditions.

Pools experience little sediment transport during hydro-power regulation nor up to discharges of 36% bank full. During rising discharges, sediments are selectively restrained by bed structure on riffles whilst pool sediments become competent in the order pool-head, mid-pool and pool-tail. The downstream trend in competence through the pools generates a queuing system for sediments, culminating at high discharges by evacuation of the pool-tail to the downstream riffle. The presence of accentuated bed structure on riffles presents a surface of higher particle entrapment probability. This is sustained during sediment transport by a process of dynamic particle exchange. The net result of which is lower particle velocities over riffles than in pools, and a subsequent choking of riffles with pool sediments.

The effect of river regulation is to reduce and attenuate flood peaks leading to riffle degradation and the aggradation of pool tail regions. Rates of aggradations and degradation are, however, lower than those experienced on a neighboring regulated river without hydropower. Hydro-electric power releases are therefore retarding the rates of aggradational channel change caused by regulation of flood peaks.

SOIL EROSION AND SEDIMENT YIELD IN THE LOWER TONS BASIN, INDIA

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Soil erosion and sedimentation are key environmental problems in the Lower Tons basin because of the ongoing large hydro-power project on the Tons River near by Chachai waterfall (Sirmaur, M.P.). The study aims to examine controls on the spatial and temporal distributions of sediment transfer within the Lower Tons River and the hydrological consequences of land use changes, using varied approaches at different catchment scales.
First soil erosion and sedimentation are examined within the reservoir catchment of the hydro-power project. The results indicates that soil erosion on sloping arable land and the rates of reservoir sedimentation have been severe during the past 20 years, mainly due to cultivation on steep slopes. Changes in reservoir sedimentation rates are mainly attributed to land use changes. It is necessary to point out here that the use of technique for erosion investigation may have limitations due to the abundance of coarse soil textures, uncertainty about fallout deposition rates and the high incidence of human disturbance, but the technique shows promising perspectives for sedimentation investigation.
Second, sediment and runoff measurement data for around 20 years from various available hydrological stations within the Lower Tons have been examined within a GIS framework. The analysis of the sediment load data has permitted identification of the most important locations of sediment sources, the shifting pattern of source areas in relation to land use change and sub-catchments exhibiting trending sediment yields corrected for hydrological variability.
The study demonstrates the importance of scale dependency of sediment yield in both the identification of temporal change and the modelling of relationships between sediment yield and environmental variables, suggesting that the treatment of the scale problem is crucial for temporal-spatial studies of soil erosion and sediment yield regarding the reservoirs of the hydro-power projects.

RECENT CHANGES IN THE BRAIDED PLANFORM OF THE TISTA RIVER IN THE EASTERN LOBE OF THE TISTA MEGAFAN, INDIA

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The study has taken the opportunity of Landsat (1990-2010) satellite images, SRTM digital elevation model data and water discharge data to understand the temporal dynamics of the Tista River in the last two decades. Along with the enormous impact of flash floods the construction of Gjoldoba Barrage has played the key to change the braided planform of the river. The river upstream of Gajoldoba Barrage is characterized by eastward shifting (upper portion), westward shifting (immediate upper portion of the barrage), decreasing sinuosity, increasing braid-channel ratio, an increase in the number of sub-channels and a reduction in the size of channel bars etc. The river downstream of the barrage is characterized by westward migration, decreasing sinuosity, increasing braid-channel ratio, an increase in the number of sub-channels, and a reduction in the size of channel bars etc. Moreover, the study reflects a significant comparison of the morphological dynamics between the up and downstream of the river. Some stable ground points exist in the study reach viz. the barrage, immediate downstream of the barrage, near Jalpaiguri and the west bank line in the upstream that help to shape the channel planform into the present form. The river flows the eastern boundary of the Tista Megafan and a number of tributaries are flow in the south-west direction and meet the Tista on the left bank floodplain. But there is no such tributaries from the right side and the existence of a large forest belt continue the stability of the right bank of the river in the proximal part of the Tista Megafan (the eastern lobe).

SEDIMENT BUDGET OF THE MORA DHANSIRI RIVER, ASSAM, INDIA

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This study is an attempt to estimate the sediment budget of the Mora Dhansiri River in Assam. The Mora Dhansiri River is a tributary of the Jia Dhansiri River in Assam. In fact, it is a bifurcated channel of the Jia Dhansiri River. However, no surface flow is evident from the mainstream except during rainy season. It has three gullies which contributes sediment to the mainstream. This study adopts sediment estimation budget method suggested by Goswami (1985) using the data on contribution of suspended sediment from tributaries/gullies to the mainstream and estimation of the same in different reaches of the mainstream. Sediment removed/stored in three different reaches of the channel is estimated. The estimation of removal/storage of sediment in the three different reaches of the channel is made for the period 2009-2015. It is found that 6761 tons, and 5111 tons of sediment was removed from the upper and middle reaches of the channel during 2009-2015. Lower reach evident storage of 3430 tons of sediment in the channel during 2009-2015. Examination of bank line migration and field observatio reveal that there is very little bank erosion in the river. This infers that due to equilibrium condition in erosion-deposition system the river bank erosion is not evident. It is concluded that the bed of the Mora Dhansiri River is degrading during the study period.

WAVE CLIMATE, WIND AND BEACH MORPHOLOGY AT GUHAGAR, MAHARASHTRA

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The effect of wave action acts as the most important agent shaping coastal landforms. Many field observations show the close relationship that exists between wave type and beach profile gradient. Shepord and LeFond (1940), Boscom (1954) demonstrated that the low flat swell waves during the summer period built up the berm (the beach face), forming seaward steep profile. During winter high steep storm waves erode the beach face and transport these materials of sediment towards sea, where it forms a longshore bar. The beach profile is widened and its overall gradient is reduced. Flat beaches in Konkan are usually associated with low and spilling breakers of fair-weather and as plunging breakers with steep beaches. Sedimentary characteristics and morpho-dynamics of sandy beaches of Konkan are controlled mainly by specific waves and tide environment related to season and tidal range (Karlekar, 1997).

To study the morphological characteristics of beach- dune at Guhagar in association with wave climate and wind, twelve sites were selected for Profiling from north to south along beach, perpendicular to shoreline. Beach profiles were surveyed throughout the year with collection wave climate data like wave height, wave length, wave period, wave velocity and direction of drift by taking actual measurements in the breaker and surf zone.

The beach at Guhagar is located in Ratnagiri District of Maharashtra, India. The length of this sandy pocket beach is 6.44 km. Guhagar is located at the 17º28' N Latitude and 73º11' E Longitude. Effect of wave environment and wind on Guhagar beach is used to understand the spatial and temporal morphological changes occur on the beach.

Keywords: Beach, Guhagar, slope, dune, beach profile.

CHANGING RIVER COURSES AND FLUVIO GEOMORPHOLOGICAL EVOLUTION OF THE MORIBUND DELTAIC TRACT OF NABADWIP, NADIA, WEST BENGAL: SOME OBSERVATIONS OVER A PERIOD OF 1921 -2014

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Land building process in the moribund deltaic tract of Nabadwip have particularly ceased and the rivers have become functionally inoperative. The river Bhagirathi, flowing over centuries through this deltaic tract of Nabadwip has undergone great metamorphosis in flow pattern. Detail study of changing bank line of river Bhagirathi has been done for a period of 93 years based on Police station maps of 1921, Survey of India Topographical maps (79A/7) of 1950 & 1967, Landsat MSS of 1977; Landsat TM of 1990 & 2000, Landsat ETM 2009 & 2014. The study gives clear evidence that the river oscillation and channel shifting gradually towards east at Prachin Mayapur, Par Media and between Gadkhali - Maniknagar area. Places of oscillation and increasing sinuosity could be traced at Banker Dhopadi, erosion along the river bank in Rudrapara area, ox-bow lake formation in Idrakpur -Purbasthali - Chupir Char area. Such shifting of Bhagirathi has left also behind numerous cutoffs, abandoned channels (Chara Ganga), decayed stretches of Bhagirathi (Maraganga), subterranean flow (Chora ganga), meander scrolls, meander scars, chutes, back swamps etc. The oxbow lakes (bils) once a rich zone of biodiversity are in decaying condition and their percentage of decay is quite alarming. viz. Ranipur bil(76%,) , Chander bil(74%) , Bara bil(74%) , Basader bil(45%), Bachamari bil(61%), Pakhir char (70%), Mora ganga (93%), Alokananda bil (68%), Hansadanga bil (61%), etc. as they are delinked from the main river course. Siltation, eutrophication, human colonization, agricultural practice, road construction, increasing domestic sewage, lack of government monitoring has led this surface water reserves gradually shrinking and they have began to lost their natural functionability. Field survey (December 2013, May 2014, April 2015) using Current Meter, GPS (Oregon 550) and Garmin Ecosounder, over different segments of Bhagirathi and in the important bils validate signatures of decay in the area.

AVULSIVE NATURE OF THE BHAGIRATHI-HUGLI RIVER BETWEEN AJAY AND JALANGI RIVER CONFLUENCES IN LOWER GANGA PLAIN, INDIA

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The emergence of fluvial geomorphology as the field of fluvial dynamics of the alluvial monsoon rivers especially in India has enriched in recent time for the application of remote sensing and GIS techniques. To study fluvial dynamics over time, channel avulsion no doubt is one of the most considerable phenomenon. Avulsion of the Bhagirathi-Hugli River in Lower Gangetic Plain is spontaneous in nature. The study section (~75 km) in between the two confluences of the Bhagirathi River i.e. Ajay (Katwa) and Jalangi River (Nabadwip) confluence in Lower Ganga Plain of West Bengal is highly oscillatory in nature. Several satellite images and toposheets of different time periods (1955, 1973, 1990 and 2011) have been used in order to analyse the avulsive nature in this section of the river. These fluvial features (cut offs, ox-bow lakes, point bars etc.) form as a result of channel avulsion and have been identified with the help of Landsat satellite images. High avulsion or channel migration is associated with the meander cutoffs. The decadal differences in sinuosity ratio in different parts of the studied section and channel migration rate zonation explain the dynamic nature of the channel in the mentioned time period. For both the reaches, meander loop cut offs are dominant rather than lateral avulsion in the context of aggregate channel migration. The palaeochannels and the analysis of 56 years channel shifting indicate that the channel is high avulsive in the study reaches. It can be pointed out that these reaches are the most avulsive section in comparision to the other portions of the river.

DEVELOPMENT OF CHANNEL CHARACTERISTICS AND INTERFLUVE - A CASE STUDY ON A PART OF TORSA BASIN, WEST BENGAL

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Avulsion in any river course is the change of a system in a complex manner where river has to readjust it through different behavioral responses. Channel shifting in recent time on piedmont part of Sub-Himalayan West Bengal is high flood discharge induced while river captures an old course and neo- tectonic reasons are underneath. In the last decade one of the biggest changes in river course in West Bengal occurred when Torsa River left its actual course and captured on of its old course called Bura Torsa or Sil Torsa (eastern branch) below Hasimara Railway Bridge in Jalpaiguri district (now Alipurduar district). Abandonment of former course, readjustment into the new course and development of new floodplain as well as the interfluvial part are the consequent actions. Development of present channel, plan form characteristics, drainage characteristics over the interfluvial area and bank configuration are controlled by few natural factors like vegetation, physiography as well as anthropogenic utilization of land surface and river banks. Geomorphic characteristics of Torsa River are accompanied with development of gravel, sand bars and formation of swamps, marshy areas within the braid plain while high discharge induced by intensive rainfall associated with high suspended load are the major hydrological characteristics. In recent time braiding intensity as well as average width of the floodplains and width of the active corridor of Sil Torsa has increased. Anthropogenic utilization of inter fluvial lands as well as paleo-courses through intensive agricultural practices, embankment of certain parts of the river to protect their lands and increase in areal extensions due to recent migration of bank lines are characteristics features of the interfluve.

DEGENERATION OF THE ICHHAMATI, GANGA DELTA, WEST BENGAL

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The Ichhamati forms a part of the distributary system of the Ganga. It emanates near the Majdia (23 24?16? N, 88 42?37? E) as the Mathabhanga bifurcates into two: the Churni and the Ichhamati. With a length of 284 km, the Ichhamati flows south-southeast and reaches the Bay of Bengal as the Jhilla-Raimangal. Of this, the lower 159 km is maintained by the tides. Currently, the Ichhamati remains severed from freshwater sources in its upstream course barring a few weeks during the monsoons. The phenomenon of time velocity asymmetry is seen in the tidal stretch of the river whereby differences occur between the velocities of the flood tide and the ebb tide. The amount of sediments carried landward by the flood-dominated Ichhamati is more than the material it transports seaward. The sediments thus get trapped in the upstream reaches of the river and channel gets degenerated. The process is aided by anthropogenic encroachments.
A study is done on the Ichhamati between Swarupnagar and Basirhat (18.8 km) in 2011 and 2015. Eight cross-profiles obtained through hydrographic surveys of similar locations indicate that the depth of the thalweg has increased at constricted channel bends. In the intervening straight reaches, development of bars and reduction of depth - e.g., from 5.88 m (2011) to 4.64 m (2015) at Sangrampur (22 39?50? N, 88 52?08? E) - is evident. Velocity ranges at the Sangrampur section observed during flood and ebb tides are 0.68-0.84-m s-1 and 0.62-0.74 m s-1 respectively, conforming flood dominance. Sinuosity indices of the surveyed stretch in 2002 and 2015 denote little change at 2.01 (ETM+ data) and 1.95 (OLI data) respectively.

MID-CHANNEL BARS OF THE HUGLI RIVER, NADIA AND HUGLI DISTRICTS, WEST BENGAL: EVOLUTION AND UTILISATION

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In the tidal lower course of the Hugli river, mid-channel bars are formed due to the dynamic processes of erosion and sedimentation. Bed composition, river profile and geometry of mid-channel bars are changed frequently due to the dynamic nature of the river. For the present work, two mid-channel bars (23 07'55''N 88 28'15''E, 23 06'00''N 88 30'51''E) are selected from Balagarh and Ranaghat blocks of West Bengal to study geomorphic and environmental aspects like sedimentation, formation, evolution, and vegetation. Human interference and environmental management of the bars are also evaluated. Among these, the physical characteristics are analysed by RS and GIS. Social properties are analysed through the help of quantitative methods based on primary and secondary data. The study reveals that erosion and sedimentation lead to formation of the point bars in the Hugli river. The mid-channel bars, on the other hand, develop due to the separation of the point bars. The mid-channel bars are utilised for different purpose by the local people that modify their natural characteristics. Uncontrolled and unplanned utilisation of these bars calls for proper management.

LATERITIC BADLANDS OF SINHATI, BANKURA, WEST BENGAL: A GEOMORPHIC INVESTIGATION

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Located 4 km NW of Bishnupur town at Sinhati area of Bankura district, a localized badlands area is developed in a N-S orientation over the Pleistocene lateritic sediments on the left bank of River Birai, a tributary of Dwarakeshwar River. Climatic condition of this region is ideal for development of lateritic badlands by water erosion. Three gully networks are identified over this 50.8 ha area with dominance of lower order streams indicating high erosional rates by overland flow and surface runoff. Mean bifurcation ratio is 4.1. A four facet slope profile is developed here with lateritic duricrust and mottled layer clearly representing deep weathering. The western section of the badland is more erosive than eastern section. Typical micro and meso-scale landforms are recognized such as escarpment, cliff, duricrust, rills and gullies, gully fans etc. Traditional fish breeding practice by embanking gullies makes this badland most revenue earning site of the area which marks it an exception against the general perception of non-productive badlands. Indigenous technique of fish breeding also acts as an effective measure of restricting soil erosion which can be followed elsewhere. But increasing numbers of commercial fish-breeding farms resulting from growing market demand, posing threat of accelerated soil erosion at Sinhati.

NAYACHAR ISLAND OF HUGLI ESTUARY: A GEOMORPHIC APPRAISAL

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Situated at the upper reaches of the Hugli estuary, Nayachar is a small estuarine island formed by natural delta building bio-tidal processes during the last six decades. Now largely reclaimed for aquaculture, the island (21°54'41"-22°01'30"N, 88°03"-88°08'52"E) presently covers an area of 47.8 km2. To study its supratidal evolution, images pertaining to 2009 (L3) and 2014 (OLI / Google Earth) were used for georeferencing and extraction of High Water Line. The 2014 image was also digitised to show the reclamation of the island by the aquaculture ponds. Surface sediments were collected from 11 different points and tested for textural analysis. The same samples were also tested for soil pH. The surface sediments were then tried to relate with the vegetation zones of the island using a 1989 TM image that showed the island in non-reclaimed condition.

The results show that that the island has increased in its area by 1.21 km2 between 2009 and 2014. The accretion has mainly taken place in the northwestern corner of the island. Out of the total areca of 47.8 km2, 45.1 percent has been reclaimed by the aquaculture ponds which are destroying the natural diversity of the island. No significant pattern emerged out from the samples tested and this could be attributed to the increasing reclamation.

GEOMORPHIC AND SEDIMENTOLOGICAL CONTROL ON THE CRAB POPULATIONS: A NEOICHNOLOGICAL APPROACH IN PARTS OF SUNDARBAN DELTA

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Organism-environment interaction has been studied based on spatially differentiated crab burrows, their ichnofabric and characteristic distribution along a number of land-shore transects in Sagar island and Bakkhali coast of Sundarban Delta. Correlation and regression were studied for competing factors - geomorphic (relief, distance from strandline and slope of terrain) and sedimentary (sediment mean size and hydrodynamic structures used as proxies for energy of deposition) vis-à-vis response of benthic crab populations as reflected in their burrow diameter, frequency and long axes orientations. Dispersal of crab burrows appear to reveal a significant control of cumulative distance from strandline and lesser controls of relief and slope. Nature of sediment substrates, mean grain size in particular, appears to have a subtle control on size distribution of burrows. However, it does not directly relate to energy of deposition, since crab populations indulge into their surface activities, thus making varied ichnofabrics-burrows, scratch/scrape marks, tracks etc. only during the ebbs. Reducing nutrient supply landwards from the strandline perhaps acts as a preponderant determinant controlling the frequency of burrows.

IMPACT OF DEVELOPMENT ON TOPOGRAPHY: CASES FROM NORTH-EAST INDIA

ANTHROPOGENIC ACTIVITIES AND ITS IMPACT ON ENVIRONMENT IN MEGHALAYA

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In the history of human civilization the mining activities have played a very significant economic role all over the world. Mining operations are second only to agriculture as the world's oldest and important economic activity. In a sense history of mining is the history of human civilization. Soon after independence our country witnessed spurt in the growth of heavy industries that needed large amount of coal for energy. Natural resources have been over exploited without any concern for the environment. This has resulted in the disfiguring of landscapes, reduction of forest areas, greater soil erosion, air, water and land pollution and damage of biodiversity.

The state of Meghalaya is one of the seven states of North-Eastern Region of India. Geologically the Meghalaya Plateau is the north eastern extension of the Indian Peninsular Shield. The state has nearly 700 million tons of coal reserves belonging to group of rocks of Eocene age. By and large the coal mining is privately controlled by local tribal people. Because of peculiar landholdings system and the area falls under the 6th schedule of Indian constitution, very little governmental control can be exercised on landholdings. Mining is considered as cottage industry. No environmental acts and rules can be enforced in these areas. Thus in most part of state coal is being indiscriminately mined in most unscientific manner causing large scale damage to landscape, soil, water, air and vegetation. The present paper has tried to analyse the impact of coal mining in Meghalaya and suggests some possible environmental conservation measures in the mining areas.

URBANIZATION AND ITS IMPACT ON ARABLE LAND: A CASE STUDY OF SOME SELECTED MUNICIPALITIES OF UPPER ASSAM

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Urbanization, the conversion of other types of land to uses associated with growth of populations and economy, is a main type of land use and land cover change in human history (Weng 2001). The urbanization takes place either in radial direction around a well-established city or linearly along the highways (Ramchandran and Jagadish 2003). The integration of remote sensing and geographic information systems (GIS) has been widely applied and been recognized as a powerful and effective tool in detecting urban land use and land cover change (Ehlers et al. 1990, Treitz et al. 1992, Harris and Ventura 1995). Dibrugarh, Jorhat , Sibsagar and Tinsukia municipal areas of Assam depicts eventually the urban growth with regard to the landuse change most dominate being the built up area which have shown a substantial increase i.e. 208 hectare for Dibrugarh, 309 hectare for Jorhat, 261 hectare for Tinsukia and 155 hectare for Sivasagar. The changed detection through image difference between 1971 to 2014 for Dibrugarh, 1975 to 2014 for Jorhat, Sibsagar 1972 to 2014 and 1975 to 2014 for Tinsukia. Therefore, the present study is an attempt to analyze the impact of urban areas over agricultural land of the selected municipalities of Upper Assam and thereby produce Land use Land cover Map of the selected Municipality areas. It is an attempt to derive useful information for the analysis of land use / land cover mapping in the study area on a time scale.

Keyword: Landuse change, landcover change, Municipality, GIS

IMPACT OF AGRICULTURAL PRACTICES AND THE CHANGING ECOLOGY OF KAPLA BEEL OF BARPETA DISTRICT, ASSAM

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Wetlands, locally called Beel in Assam are important geomorphic unit which have great role in the ecology and economy of a particular area. The Barpeta district of Assam has about 97 Beels out of which Kapla Beel has the largest areal extension. This Wetland has been considered as valuable source from the for food and fodder production. Besides being habitat for numerous valuable plants and animals the wetland has also been used for aqua culture, grazing etc. The ever increasing population and higher food grain requirement have created tremendous pressure on available agricultural lands, as a result of which the wetland have been reclaimed for agriculture and in this way the natural ecosystems have lost much of their original character. The study has been carried out both using primary and secondary data. Primary data are collected through interview using structured schedule and questionnaire in the study area. Spatial land use and land cover change is at different temporal scale is studied using Satellite imagery of LISS III (IRS 1C), Landsat TM, and Toposheet numbering 78 N/ 3 is done. Collected data are processed and tabulated with meaningful statistical and cartographic techniques. The present paper studies the changing ecology of Kapla beel due to agricultural practices, and it is found that due to active human interference the wetland is being encroachment and the biodiversity is under serious threat. Finally, the paper suggests some workable measures and steps for protection of the wetland ecology.
Keywords: Wetland, Biodiversity, Ecology, Agriculture, Economy

LANDFORM PATTERN AND URBAN GROWTH IN GOALPARA URBAN AREA, GOALPARA, ASSAM

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The landform characteristics offer an effective way of analysing urban environment-landform relationships in small areas of urban delimit. Landforms as a type of resource and environment have always been playing essential roles on urban development.

Evaluation and analysis of landform characteristics is a fundamental requirement of landform study in any area. The Goalpara urban area (Goalpara Master Plan) covers an area of 7203 hectares (72.03 km2) between 2606/48//N and 26011/58// N latitudes and 90032/40// E and 90039/13// E longitudes and supports 97,562 urbanites (2011). The Goalpara urban area though covers a small area it exhibits a mosaic of landform features. This area experiences an average annual rainfall of 2322.5 mm. with much concentration in the summer months. This paper is a modest attempt to analyse the landform pattern and highlight the urban growth based on landform characteristics within the Goalpara Urban delimit.
Keywords: absolute relief, relative relief, average slope, dissection pattern, urban growth

THE DEEPOR BEEL OF KAMRUP DISTRICT, ASSAM: PRESENT STATUS AND CHANGE

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The Deepor beel in Kamrup district of Assam occupies an important position in the wetland environment of the state because of its unique geo-ecological characteristics. Deepor beel recognize as a Ramsar Site and in 2004 declared as an important bird area. Now a days, this wetland is increasingly facing several anthropogenic pressure. The rapidly expanding human settlement and large scale development of industrial activities have created tremendous threat to wetland environment. And in this way the geo-ecological characteristics of the beel have been deteriorating day by day. The present study, therefore, is an attempt to analyse the recent status of the beel and its changing geo-ecological characteristics over time caused by natural and anthropogenic factors. The study is based on personal field observation and investigation with the help of primary and secondary data collected from the field and from different secondary sources.
Keywords: Deepor Beel, geo-ecological characteristics, changing environmental conditions

AGRICULTURAL PRACTICES AND THEIR IMPACT ON SAMAGURI AND KACHUPIT WETLAND OF NAGAON DISTRICT, ASSAM

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Nagaon district of Assam is endowed with rich wetland resources and within Assam highest numbers of wetlands are found in this district. Most of the wetlands are located in agricultural environment and these wetlands have been recognized as valuable resource for food and fodder production. Ever increasing population and higher foodgrain requirement have created tremendous pressure on available agricultural land, the wetlands have been reclaimed for agricultural purpose. The alarming human dependency upon wetlands and several developmental activities have created threat to geo-ecological characteristic of the beels and in this way the natural ecosystems have lost much of their original character, leading to reduce biodiversity and reduce performance and productivity. Hence, the present paper is an attempt to identify what changes have been took place under the influence of agricultural activity within wetland environment and to suggest conservative plan. The changes have been identified based on the comparison of topographical map, different period of remote sensing data, google earth image and field data collected from Samaguri and Kachupit beel.
Keywords: wetland environment, agricultural effect, estimating change, conservative plan.

LANDSCAPES OF A FLOODPLAIN VILLAGE OF THE BRAHMAPUTRA VALLEY, ASSAM: CHANGES AND SUSTAINABILITY

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The Brahmaputra valley of Assam is basically dominated by village landscapes. The village landscapes of the valley reflect the long and continued process of adoptation of lands by the rural people for various productive purposes. The landscapes which evolved from different ecological settings of the valley are very diverse because of the varied cultural and natural factors. Very recently the culturally adopted landscapes in the rural areas of the valley have been witnessing changes in many respects because of the influence of some external factors. The changes in village landscapes have made the rural live and livelihood difficult to sustain. The present paper is an attempt to investigate the changes of landscape of a floodplain village of Brahmaputra valley and the problems arising from these changes. The study is based on both primary and secondary data/information, landuse maps prepared at the field and PRA methods.

Keywords: village landscape, Brahmaputra valley, changes, external factors, rural live and livelihood.

HYDRODYNAMIC MODELLING OF RIVER CHUNGTHANG"- A CASE STUDY OF HYDROLOGICAL VARIABILITY USING REMOTE SENSING & GIS

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A hydrodynamic model is a tool able to describe or represent in some way the motion of water. River Chungthang is a tributary of Teesta River, formed by joining two streams Lachen and Lachung, located in the Sikkim Himalayan region. The topography of the study area is characterised by mountain terrain and very steep slope. The tectonic condition and geology the area indicates high susceptibility to hazards like land slide or earth quake. Moreover the study site is selected for Teesta III hydro power project. Due to these natural and anthropogenic factors the fluvial dynamic character of the river also changing. The study aims to analysis the hydrological characteristics of the river Chungthang and examines the river in response to the Teesta III hydro power project by using a hydrodynamic model based on relationships resulting from law of conservation of mass and momentum. The process is simplified and presented in a form based on two levels namely Geodetic measurements i.e., spatial localization of positional location and altitude & Graphical processing which deals with the process modelling and visualization of results obtained. GIS techniques have been used for the first level i.e., documentation of spatial location, elevation, boundaries and other structural parameters over the stream to create a geometric profile for hydrodynamic modelling while the graphical processing have been done using Hydrologic Engineering Centers River Analysis System (HEC-RAS). The resulting model is able to describe the behavior and impact of different hydrological parameters of the river with respect to each other as well as on the surrounding area. The model is also able to develop simulation of flow and the volume elevation information curve regarding the site selection of Teesta III hydro power project.
Keywords: Hydrodynamic modeling, Teesta III, HEC-RAS, Chungthang.

IMPACT ON TOPOGRAPHY ON THE DEVELOPMENT OF RURAL WOMEN IN KAMRUP DISTRICT, ASSAM; A CASE STUDY

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Kamrup (Rural) District lies in the northern fringe area of the Meghalaya Plateau with the isolated hills and alluvial plain. Agriculture is the main occupation does not provide security to support the growing population. Alternative sources are also limited due to natural constraint like flood, drought, and poor quality of land. With a view to improve the economic conditions of the rural poor, the government of India has introduced the Swarnajayanti Gram Swarozgar Yajana (SGSY) in 1999 to organize the rural poor into Self-Help-Groups (SHGs) ensuring financial aid through Micro Credit. The performance of credit agencies for the economic development of the block depends on the effective exploitation of locally available natural and human resources to the optimum level. The financial institutions play a prominent role in credit disbursement to the SHGs in need.

Here an attempt has been made to see the rural women and their steps to fulfill their daily needs promoting the Self Help Groups through micro-credit of the Hajo Community Development Block which is identified to represent the Char Community in Assam. In order to materialize the objectives data from both primary and secondary sources have been used. Data have been interpreted with the help of tables, Statistical techniques like percentage, Mean, Standard Deviation, Coefficient of Variance, Z-scores, graphs and maps. The study reveals that among the women Self- Help-Groups micro credit increases their income level by adopting different types of economic activities which change their economic standard of life a quite. Performance of recovery rate of loan from the Government and within the women Self- Help-Groups is found to be satisfactory.

Keywords: topography, rural women, development.

GEOMORPHOLOGICAL IMPLICATIONS OF HABITAT DESTRUCTIONS OF VEGETATION IN SHILLONG: A CASE STUDY ON INULA (ASTERACEAE)

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Habitat destruction and loss of vegetation is a sad story in India at present. The fragile ecosystems are particularly facing this threat. Our mountain ecosystems are the worst sufferers of indiscriminate developmental and associated activities. In the wake of drastic population change and rapid urbanisation the issue becomes more complex. A field survey of Inula and allied genera has shown that several species of genus Inula and Duhaldea which were earlier reported to be common have now become rare, threatened and endangered. I. kalapani is facing habitat loss and during herbaria visits, it has been noted that no fresh collections of these species have been done. Duhaldea cappa, D. cuspidata, D. eupatorioides, D. nervosa and D. rubricaulis show a wide range of distribution but it is noted that their habitat is shrinking and most of the population is shifting towards the higher altitude. Thus, extensive field surveys are needed in order to conserve threatened and endangered species. This paper ultimately aims at indicating the loss and probable threat to our environment and its geomorphological implications today.
Keywords: Inula, habitat loss, rare, threatened

IMPACT OF TRANS - ARUNACHAL HIGHWAY ON THE SLOPE DEGRADATION: A CASE STUDY BETWEEN PAPU - YUPIA ROAD, ITANAGAR, ARUNACHAL PRADESH

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The study area is a 2 laning of Papu - Yupia road from 0 to 10 Km stretch in Arunachal Pradesh. The road alignment passes through mountainous (85% length) and steep terrain (15% length). The rugged topography with slope instability, variability in climatic condition and high seismicity that is combined with human disturbances, have made the capital region environmentally very fragile and generates geomorphic hazards at different parts of the region. The environmental hazards which includes the active gully erosion, bank erosion, landslides and flash floods. The most recent human interference in the name of regional development is the construction of Trans - Arunachal Highway in the study area. The Trans-Arunachal Highway is a planned mega two-lane highway project in the Indian state of Arunachal Pradesh. The highway extends from Tawang in the western part of the state to Kanubari in the east covering 1,559 km. This paper analyzes the impact of the construction of highway on the degradation of slope as well as in geomorphic processes. The work is carried out by measuring the debris flows (extensions, sediment size, and surface coverage) and its effect on the human habitation as well. The strength of the land was also verified through field study. The region shows weak, soft sandstone and sand pebble alternations of the Siwalik group of Himalaya that are very prone to slope instability. The study also shows that within a short stretch of road i.e 10 Km, approximately 29 nos. of landslide activities of both small to large scale within a distance of 5 mtrs to 1 Km were observed.
Keywords: slope instability, hazards, strength

ENVIRONMENTAL CHANGE AND GEOMORPHOLOGICAL PERSPECTIVE

EVALUATION OF RIVER BANK-LINE SHIFT AND ASSOCIATED EROSIONAL AND DEPOSITIONAL PHENOMENA IN DHEMAJI DISTRICT, ASSAM

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River bank-line shifting is an important characteristic feature for the tropical rivers of Assam. The eight major rivers of Dhemaji district, which are also tropical in nature, are identified and selected for evaluation of bank-line shift. The erosional and depositional phenomena associated with this bank-line shift have been also observed in this study. Major river bank-lines of the study area are mapped for two time periods (1991 and 2013) from Landsat data following vector-based approach. The bank-line shifting of the rivers has been measured for both the right and left banks using linear cross-sections. Erosional and depositional statistics have been generated for each river of the study area under GIS environment using overlay analysis. From this study, it has been observed that the average shift of right bank-line of Brahmaputra river (northern one) within Dhemaji district is 1,717 meters during the year 1991 - 2013. Similarly, two largest rivers of the study area, Jiadhal and Simen have recorded an average right bank-line shift of 2,143 meters and 2,263 meters, and left bank-line shift of 1,954 meters and 1,555 meters respectively. The mean estimated areas of erosion and deposition along the north bank of the Brahmaputra river in Dhemaji district, as computed from overlay of bank-lines are found to be 22 km2 and 42 km2 respectively. The entire study has provided much useful information on the nature of bank-line shift and associated environmental change in the valley region which will be helpful for sustainable river management.
Keywords: Bank-line shift, erosion, deposition, cross-section, Dhemaji district.

THE GEO-ECOLOGICAL CHARACTERISTICS OF THE KIRAKARA CHAR ISLAND OF THE BRAHMAPUTRA RIVER, ASSAM

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The Brahmaputra river of Assam, exhibiting intense braiding pattern is dotted with numerous sand bars and river islands. These sandbars and river islands are characterized by some peculiar geo-ecological conditions which are different from the built-up areas of the state. The char landscape of the Brahmaputra river are physiographically very sensitive and vulnerable and ecologically poor. Very recently these marginal landscapes have been dominantly inhabited by the people of immigrant origin and they have transformed these naturally developed landscapes into cultural landscapes. The present study is an attempt to examine the geo-ecological characteristics of the Kirakara Char Island of of the Brahmaputra River reach in Darrang district of Assam. The study carried out with the help of both primary data obtained from field survey and secondary data procured from different Government and non-govt. sources.
Keywords: Sand bars and river islands, geo-ecological conditions, braiding pattern, cultural landscape.

HYDRO-GEOMORPHIC CONSTRAINTS OF AGRICULTURAL PRODUCTIVITY IN WEST BENGAL - A DISTRICT LEVEL ANALYSIS

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Present study reveals that hydrological and geomorphological constraints are dominantly influencing the agricultural productivity in West Bengal. Many districts of West Bengal like Burdwan, Hooghly, Howrah, Murshidabad, Nadia, Purba Medinipur, Purulia, S 24 Paragana, Coochbehar have been recorded a negative rate of growth in agricultural productivity during 2001-2011. Net cropped area of these districts has been decreased steadily during this period due to water scarcity, salinity and floods that in turn also play dominant role in reducing productivity.
Keywords: Agricultural productivity, Net cropped area, Water scarcity.

CHANGES IN WATER QUALITY OF BASNA DRAIN IN PHAPHAMAU ENVIRONS, ALLAHABAD, UTTAR PRADESH

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Basna drain is the tributary of holy river Ganga. It flows in Phaphamau Environs of Allahabad district. The study area extends from 25°30? N to 25°40? N latitude and 81°45? E to 81°55? E longitude in Holagarh and Soraon block of Soraon Tehsil. It originates from a big pond near Holagarh. It has three major sources of channel flow; minor of Sharada canal, rain water and waste water of villages/towns. These water sources of Basna drain bring pollutant from different places of the region. The bring pollutant to Basna drain decrease the quality of the drain's water.
The Biological Oxygen Demand (B.O.D.), Dissolved Oxygen (D.O.), Chemical Oxygen Demand (C.O.D.) and pH value are important element of water. The normal quantity of B.O.D. should not more than 3.0 mg/liter. The B.O.D. of Basna drain is 7.3 mg/liter. It is about two times of normal B.O.D. of the drain. This is dangerous for living organism of the drain. The D.O. should not be less than 5 mg/liter. But in Basna drain it is only 2.97 mg/liter. It indicates the decreasing quality of Basna drain. The C.O.D. should be less than 6.0 mg/liter. But now it is 37.03 mg/liter. Like this the pH value should be between 6.5 to 8.5 pH. But it is only 5.9 pH.
The above data of water quality in Basna drain is imbalance from balance condition. Hence there is a problem for living organism of the drain. Now they are suffering from their existence. The polluted water of the drain impacts on internal and external atmosphere of the region. People and government should be aware about the imbalance in the drain's water. For maintenance in water quality of the drain government should bring an appropriate plan.
Keywords- Basna, imbalance, quality, pollutant, organism.

LAND USE LAND COVER CHANGES IN RANI-GARBHANGA FOREST AND FRINGE AREAS, KAMRUP, ASSAM

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The biodiversity and stability of forest ecosystem is increasing threatened by heavily impacted population pressure on forest and fringe areas are leading to unprecedented land use change. In turn, unsustainable land use is driving land degradation. The result is a loss of land productivity with impacts on livelihoods and the economy. This study intended to characterize and quantify land use changes and characterize the livelihood change over the last two or three decades. Times series Landsat MSS images (1977) and LISS III (2010) of the Rani-Garbhanga Reserve Forest were interpreted and classified to establish the pattern in land use changes. The livelihood change was assessed using semi- structured questionnaire, focus groups and household analysis tools. The destruction of the forest for firewood and cultivation has reduced the forest cover. . The result of the study shows that land use changes in the study area are primarily responsible for the decrease of forest area and wild habitats in and around the reserve. This study addresses relevant issues on land use and land cover changes, change detection analysis etc.
Keywords: Reserve forest, land degradation, biodiversity, forest ecosystem

TREES: DIVERSITY, PATTERNS AND PLANTATION IN BANARAS HINDU UNIVERSITY CAMPUS AND ITS IMPACT ON LANDSURFACE

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Abstract:
Banaras Hindu University (BHU) campus is rich in greenery and has broad trees diversity. There are more than 16317 thousands trees (not included saplings) in BHU campus. The major trees in campus are Mango, Peepal, Sheesam, Palm, Tamarind, Banyan, Neem, Black-berry (Jamun), Teak, Mahua, and Saraca indica (Ashok). These above tree's plantation are scattered all over the campus along the road side and within building compounds. There are huge number of trees like 4298 trees of Ashok, 1698 trees of Mangos, 443 tree of Teak, 254 trees of Mahua, 224 trees of Black-berry (Jamun), 200 trees of Neem, 202 trees of Peepal, 180 trees of palm and many other miscellaneous trees. All planted trees (16317) have marked on map with their location. Except this there are 716 saplings marked on map for new plantation. BHU campus area is in a semi circle shape and it designs a straight major roads and semi circle roads. So the plantation of trees is follow up by road side from one or two cross road to another cross road with a double plantation line like Mango tree road, Teak tree road and others. It seems like a tunnel on road of trees. Most of the two cross roads, four Peepal trees are found. Some forest covered area in campus are occupying about 208953.07m2 and two major botanical & ayurvedic garden occupying about 130766.58 sq km area which is also covered with trees. These patterns impacts on lands and prevent soil erosion due to less runoff (0.15) in comparison of other land area. It helps to reduce water logging problems, increase fertility and balanced rain fall and temperature within campus.
Keywords: Trees Plantations, Diversity, Patterns, Number of trees, Impact on Land

VARIABILITY AND TREND ANALYSIS IN TEMPERATURE AND RAINFALL AND DISCHARGE OF THE RIVER MUHURI, TRIPURA, NORTH-EAST INDIA

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High population pressure, poor water and land management, and climate change are inducing a pressure on agricultural productivity and vulnerability in Tripura. In order to manage poverty and food insecurity, it is widely recognized to utilize water resources. So, assessment of the impact of temperature and rainfall on water resource may provide substantial information to the areas where maximum agricultural land depends entirely on rain-fed agriculture. The Muhuri River is rain fed and therefore, flow discharge also fluctuates with the fluctuation of rainfall. In this paper, annual rainfall and discharge of the Muhuri River, which is situated in the southern part of Tripura, have been analyzed to get an observed rainfall and flow trend characteristics respectively through time. The annual fluctuation of rainfall, temperature and discharge is high. However, it might be for the impact of climate change in this region. The work has been done with the help of secondary data and statistical analysis. Significant fluctuations of average annual and seasonal discharge in the Muhuri River have been observed in this paper.
Keywords: Rain-fed agriculture, Muhuri River, temperature, rainfall, discharge.

WATER MANAGEMENT IN DROUGHT PRONE DISTRICT OF BANKURA, WEST BENGAL - A SUB-WATERSHED SCALE STUDY

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The watershed running across the boundary between Purulia and Bankura district of West Bengal experience acute water scarcity inspite of having 1470mm of average annual rainfall. 20-30% of this annual total concentrates to a single storm of few days' duration. On an average, a continuous duration of 3 months of no rain occurs in this area. Again winter temperature increases steadily for past 100 years leading to more evaporation and thus, more requirement of irrigation water for double cropping. Water budget has been calculated based on surface water supply through runoff and demand of water for domestic and agricultural purposes. Domestic demand may be satisfactorily met by roof top water harvesting. Study shows that 60-83% of the roofs are made of tin, asbestos, cement or tiles that can yield as much as 90% of rain water. From a roof of 10m x 5m size, average rain can yield sufficient water to meet year long demand of a family of four members. A reserve of 5000L of water may effectively manage the worst drought of 5 years' recurrence considering the trend of average rainfall. Runoff and Evaporation analysis with mass curve shows that if 5-8% of available runoff is stored at the mouth of four sub-watersheds, agricultural demand for double cropping at the respective catchment may be fulfilled.
Keywords: Watershed; Water Budget; Water Harvesting; Reservoir.

ENVIRONMENTAL IMPACT OF URBAN LAND USE AND LAND COVER CHANGE IN MOUNTAINOUS URBAN TRACT: THE CASE OF GANGTOK TOWN, SIKKIM

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Rapid urban expansion and related built up growth in Gangtok, Sikkim urban area has brought sever losses of natural forest, waste land, agricultural land and open forest. Long continued urbanization and tourism activities have been responsible for fragmentation of habitats and deterioration of the original land due to land use and land cover change. The present study deals with the classification and changing pattern of urban land use and land cover in Gangtok municipal area of Sikkim Himalaya. This study also tries to identify the factors, in particular, responsible for changing nature of land use in the study area. Satellite imageries (LANDSAT TM and ETM) of 1991, 2000 and 2011 are used to assess urbanization by measuring land use and land cover change for whole of the municipality. Change analysis and spatial trend analysis have been carried out using land change modeller to find the gain and loss of land under each use categories and conversion of land from one category to others. It has also been tried to determine the responsible factors for land use change. From change analysis, it is found that, lands under settlement, open forest and agricultural have increased by 0.09, 0.57 and 1.79 sq km respectively, during the period from 1990 to 2011. On the other hand, net losses of dense forest and waste land have been 0.04 and 2.40 sq km, respectively between 1990 and 2011. From spatial trend analysis, it reveals that most of the dense forests have disappeared from the central part of the study area for expansion of built-up area while in the outer parts they have been converted into waste lands (0.57 sq km). During 1990 - 2011 agricultural land and settlement areas have tremendously increased at the lost of dense and open forests. Therefore, the woodland and grass land habitats are gradually losing their existence and are being converted to residential habitats. On the other hand, crop land habitats are gradually increasing in the western part of the study area due to the continuous losses of natural forest.
Keywords: Land use/Land cover, change analysis, spatial trend, habitat change

THE POLLUTION HISTORY OF NAINA LAKE OF NAINITAL CITY, UTTARAKHAND, INDIA

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Few long -term studies of hydrological change prove that sediments are useful for reconstructing the pollution history of lakes due to being sensitive to change within the catchment. This study related to Naina lake of Nainital City of Uttarakhand, uses the properties of urban lake sediments in order to reconstruct environmental pollution history. The two principal objectives of this study were the reconstruction of historical atmospheric, point source and diffuse heavy metal pollution in the urban environment of Nainital and the evaluation of the lake- sediment record as a source of proxy hydrological data over the last 100-150 years.

Naina lake is a closed lake which is situated in the centre of the city of Nainital (Uttarakhand) where the main source of pollution is atmospheric. But trends indicate that catchment sources contributed upto 5 times more than the atmosphere. Heavy metals budgets were calculated, and these showed that loadings of metals have increased by up to 7.5 times between 1950 A.D. and the present day. Sequential digestion of the Naina lake sediments showed that the important fractions containing heavy metals were Fe and Mn oxides and organic matter. The heavy metals associated with these fractions could be remobilised with changing environmental conditions, but an analysis of contemporary water quality indicated that, at present, suitable Eh and PH conditions for remobilisation did not occur.

It was concluded that urban Naina lake of Nainital City of Uttarakhand do preserve the heavy metals records and can provide surrogate data on medium term environmental change. This lake also appears to provide a much-neglected opportunity for palaeolimnological reconstruction over a period when little directly monitored data exists.

POPULATION GROWTH AND RESOURCE UTILIZATION CREATE ENVIRONMENTAL PROBLEMS: A CASE STUDY IN GUWAHATI CITY

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The plentiful growth of population and increasing rate of exploitation and utilization of resource in Guwahati city leads the devastating change of the environment which takes sustainable development for coming generation. The human society developed through exploitation and utilization of natural resources. Sustainable development concern the man's interaction with the environment and environment change is caused by human influence which can be defined as the disturbance of the environment by deforestation, earth cutting and engineering construction activities caused reduce biodiversity, manufacturing and processing of raw materials create waste materials. The industries using fossil fuels emit a huge amount of gasses which pollute ambient air and change atmospheric chemistry in the city and also increase green house effect and resultant global warming leading to climate change. When the population increases there must be increase in the use of resources and change the natural environmental system. The study attempts to examine the impact of growing population pressure and abundance use of resource and degradation of environment in Guwahati.
Keywords: population growth, sustainable development, greenhouse effect, global warming.

EVALUATION OF DRINKING WATER QUALITY AND ITS IMPACT ON HEALTH IN URBAN SLUMS: A CASE STUDY OF ALLAHABAD CITY

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An increase in urbanization, industrialization, agriculture activity and various human activities has increased the pollution of surface water & ground water. The direct impacts of water on health are derived from the quality of water consumed by the population. The general observation of the international agencies is that the impact on health caused by the poor water supply is felt the most by the 'urban- poor' which generally dwell in the 'slum areas' of the cities. The areas under study are the slum areas located within the rising city of Allahabad, Uttar Pradesh. They typically use water supplies of lower quality. The low-income communities are supposed to be at the greatest risk from water-related diseases.

The main aim of this research is to assess the Drinking Water Quality Assessment of the Slum Areas of Allahabad City. It's been observed that the water used by the population in slums contain undesirable amounts of disease-causing microorganisms (pathogens) or chemicals that are toxic. Such contaminants cause a number of diseases, often affecting very large number of people over a short period of time. Many of these diseases such as cholera, typhoid and dysentery may cause severe symptoms in patients and in some cases are fatal as reflected by the high mortality and morbidity rates in many developing countries.

The quality of safe drinking water provided, indirectly reflects the prosperity of a nation therefore it is necessary to have information about the drinking water supply in cities / towns in India. The investigator has attempted to present the current scenario to ascertain the present status of drinking water quality being supplied in urban areas and to evolve a suitable strategy for future planning.

UNDERSTANDING THE RELATIONSHIPS BETWEEN GEOMORPHIC UNITS AND LAND USE PATTERNS FROM LANDSCAPE ECOLOGICAL PERSPECTIVE: A STUDY IN SALI RIVER BASIN, BANKURA DISTRICT, WEST BENGAL

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Land use/land cover (LULC) is the prominent ecological symbol within the surface of the earth which has strong ties with geomorphological characteristics. In the present work an attempt has been made to investigate the spatial configuration of LULC within the Sali river basin and examined how spatial pattern of different land uses categories (agricultural, forest, built-upland, wasteland and water bodies) are related to geomorphic landscape from landscape ecological perspectives. The types of land use/ landcover features are controlled by geomorphic units, which are further altered by human modifications. The result indicates that different geomorphic processes and human disturbance produces forest fragmentation as a result habitat of keystone species have been modified and landscape setting has been change. Species generally needs different types of habitat along their life cycle and often, this is not provided enough in reserves (Protected forest), also because reserves are bounded by artificial, human-transformed landscapes. Water bodies and built-up lands have high patch and edge densities, and agricultural land use as the largest patch, were also associated with difference in geomorphic landscape of this region. So, the scientific contributions of landscape ecology are essential for land-management and land-use planning. Understanding the relationships between land use patterns and geomorphic units from a landscape ecological perspective is important for landscape planning and management and healthy ecological functioning in a riverine landscape.

ASSESSMENT OF THE RELATIVE CONTRIBUTION OF TRIBUTARY BASINS TO GANGA RIVER - CASE STUDIES ON KOSI AND GANDAK

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The water availability at Farakka creates serious limitations in lean season sharing of Ganga water between India and Bangladesh. Annual rainfall as well as pre-monsoon rain over the basin shows a negative trend during past 100 years. In this context, analysis of relative contribution of tributary basins is made. The result shows that Kosi and Gandak together contribute to 26% of annual discharge of river Ganga at Farakka. Rainfall, soil types, landuse and terrain data collected from IMD, FAO, satellite images and SRTM respectively are used as input to SCS CN model to quantify the discharge. With the change in rainfall and construction of reservoirs, the contribution from these tributary basins has been substantially reduced.
Keywords: Water availability, Negative trend, SCS CN model.

MODIFICATION OF DIGHA-TALASARI COASTAL LANDSCAPE, WEST BENGAL AND ODISHA: CHALLENGES, OPPORTUNITIES AND MANAGEMENT

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The coastal landscape of India as well as Digha-Talasari coast is facing challenges by natural processes and anthropogenic activities. The result is that the shape and size of the coastal area is changed in respect of shoreline, dune field and beach area although there is potential opportunities of coastal landscape development. The present work is in the aim of quantification of morphological changes and to identify the responsible factors for changes and its impacts on landscape development in the Digha-Talasari coast of West Bengal and Odisha. The typical coastal hydrodynamics and frequent landfall of cyclonic storms and over burden tourism in the study area are the major responsible factors for the challenges. Coastal erosion and accretion are both noticed along the coastal tract. The objective of the study is also to predict the coastal erosion and its mitigation as well as identification of potential opportunities in the coastal area. Temporal study of beach profiles, shorelines and sand dunes shows the morphological changes in the area. Modern techniques and methods like remote sensing and geographical information system are incorporated to study the changes and to develop a management plan for the coastal landscape.
Keywords: Coastal landscape, Morphological changes, shoreline, beach profile, sand dune.

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IMPACT OF RIVER CHANNEL MIGRATION ON LAND USES IN THE INTER-FLUVIAL ZONES IN MIDDLE GANGA PLAIN

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The land use pattern of any area is a reflection not only of the immediate and current requirements of the community but rather of the cumulative needs or the pressure exerted on the space over a period of years. This fact is applied on three districts of the state of Bihar in the inter-fluvial alluvial tracts of four important rivers, i.e the district of Saran coinciding to the inter-fluvial area of Ghaghara and Gandak rivers joining Ganga from north, and districts of Buxar and Bhojpur in the inter-fluvial area of Karamnasa and Son rivers joining Ganga from south, wherein the channel migration of the rivers, changes in occurrences of floods, due to physical variability is evident. This should have an impact on the land uses, in particular on the agrarian land use pattern.

The flood occurs in the low lying area along the rivers in the month of August to November, that effect the kharif crops and sometime also effect the rabi crops. Soil erosion is high due to the steep slope and the shifting characteristics of major rivers like the Ghaghara, Gandak, Ganga and the Son. In addition to all this, the cumulative impact of various other social and economic needs of the growing population over the years too have exerted pressure on the limited space and is reflected on the pattern of land uses.

The study examines the relationship between land use changes, indicators of environmental sensitivity; environmental outcomes stemming from land-use conversion caused due to physical variability, in particular the channel dynamism leading to change in land configuration that potentially have important influences on land uses and environmental quality in the region.

ISSUES AND CONCERNS OF ENVIRONMENTAL CHANGE IN KARLI CREEK, SINDHUDURG DISTRICT, COASTAL MAHARASHTRA, INDIA

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Estuaries and Creeks are coastal aquatic ecosystems which provide various natural resources and services to the community surrounding it. People along the west coast of India and villages along the coast of Sindhudurg district of Maharashtra, particularly, have sensed how to use the potential of aesthetics of creeks and estuaries in the region to integrate for tourism activity. Tarkarli- Devbag spit bar is bordered by Karli Creek (15057' to 16003' North Latitude 730 29' to 73031'East Longitude) For the last decade Karli creek has been increasingly utilized for tourism by the people in villages of Devbag and Tarkarli in addition to traditional fishing practices. From recent field visits, discussions with local people of Devbag and Tarkarli it is almost certain that due to natural factors and anthropogenic activities, there is a change in the morphology of Karli creek in recent years. The paper tries to bring forward morphological changes of Karli creek in the last decade with the help of the Naval Hydrographic chart of the Karli creek procured from harbor and port division Khar office Mumbai, Government of India. The authors also try to bring forward what are the critical issues and concern of the study area along with remedies for Integrated Coastal Zone Management (ICZM) for creek management of Karli keeping in mind sustainable development of the region.

Keywords: Spit, Morphology, Creek management, Integrated Coastal Zone Management (ICZM), Sustainable Development.

CHANGES IN AREA AND SURROUNDING LANDUSE OF THE RUDRASAGAR LAKE, MELAGHAR RD BLOCK, WEST TRIPURA

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The Rudrasagar, situated in Melaghar RD Block of West Tripura, is one of India's National Lakes and also an important Ramsar Site. The 154.8 ha (2015) water body is well-known for its rich biodiversity, pisciculture and forms a major tourist destination. The lake occupies a detention sub-basin (trough) located in the Gumti river basin, contributed by channels like Noa Cherra, Durlavnarayan Cherra and Kemtali Cherra. It is connected with the Gumti through the Kacchi Gang, a controlled link channel which has a bi-directional flow depending on the water levels in the river and the lake. By analysing maps (SoI) and images (MSS, ETM+, LISS-3, OLI) of six different years between 1931-33 and 2015, it is found that the lake area varies with the fluctuating discharge of its catchment. Maximum increase (107%) of the lake area is observed between 1931-33 and 1967-69; between 1967-69 and 1977 maximum shrinkage (48%) is seen. A 20% increase in lake area is observed between 1977 and 2001. Subsequently, the lake again shrank by 18.37% during 2001-2009. Finally, an increase of 45.37% of its area is detected between 2009 and 2015. Changes in the area of Rudrasagar noticeably affect the landuse of the surrounding region. Encroachment of shrunken parts of the lake and its conversion into agricultural land and other landuse is a major threat to the biodiversity and traditional economic practices that depend on lake waters.

AN ASSESSMENT STUDY ON THE DRYING OF THE LOCAL WATER SOURCES ENHANCING WATER SCARCITY IN AND AROUND DARJEELING TOWN, WEST BENGAL

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The Darjeeling hills has about 1303 sq km of forest area which is about 41.3% of the total district area (3149 sq km) along with 21.82 sq km of degraded notified forest land. Needless and reckless obliteration of forests mainly due to grazing, forest fire, illicit cutting, lopping, coupled with natural calamities such as landslides, changing pattern of rainfall and natural mortality of the forest resources have largely affected the available water resources of the region. Though water is abundantly available in the form of surface as well as ground water, lack of scientific and sustainable management of available water resources of the region is enhancing only its depletion. The pathetic situation of drinking water in the urban areas is evident from the ever increasing deficit up to 13,32,500 gallons/day in Darjeeling town, 5,02,750 gallons/day in Kurseong town and 3,00,000 gallons/day in kalimpong town. Under such conditions, the local springs are the only alternative and dependable sources of drinking water and have huge significance and potential in meeting drinking water demand of the areas. But many of such sources that are still in existence have been exploited as private property thereby localizing its use and due to rampant deforestation and unscientific and unplanned urbanization; such springs have been gradually diminishing threatening the local hydrology.

In this paper, an attempt has been made to assess the causes of drying and seasonal variability of local springs in and around Darjeeling town. From the field survey, it is evident that decrease in forests and open areas has induced insufficient surface infiltration resulting into decrease in spring flow and many perennial springs of the region has gradually transformed into seasonal springs which dries for lean months. Besides, the construction of concrete structure along with unplanned sewerage and septic tanks above the springs with rapid urban expansion especially along ridge tops has been largely responsible for contamination of spring water.

Keywords: Natural Springs, Urbanization, Deforestation, Water scarcity, Darjeeling Town