21st Indian Institute of Geomorphologists (IGI) Conference

and

National Seminar

on

GEOMORPHIC HAZARDS : ISSUES AND CHALLENGES

(28th - 30th November, 2008)

Souvenir & Abstract Volume

organized by

Department of Geography and Disaster Management
Tripura University (A Central University)
Suryamaninagar - 799130, Tripura West

sponsored by

Department of Science & Technology (SERC Division), New Delhi ;
Indian Council of Social Science Research, NE Region;
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Geological Survey of India

YOUNG GEOMORPHOLOGISTS COMPTETTITION, 2008

21st Indian Institute of Geomorphologists' (IGI) Conference
Tripura University
28th - 30th November, 2008

THE BEST YOUNG GEOMORHOLOGIST AWARD

is sponsored by

Dr. Sudip Dey
Lecturer, Department of Geography and Disaster Management ,
Tripura University

in memory of his grandfather

Late Kalipada Dey

RAJ BHAVAN
AGARTALA – 799 001
☎ 0381-232 4091, 232 5756

October 18, 2008

GOVERNOR OF TRIPURA

MESSAGE

I am glad to know that the Department of Geography and Disaster Management, Tripura University, Agartala is organizing a seminar on “Geomorphic Hazards: Issues and Challenges” on the occasion of 21st Indian Institute of Geomorphologists’ from 28th to 30th November, 2008.

India is considered as hazard vulnerable and its 60% of landmass is prone to earthquakes, 229 districts in 29 states and U.Ts fall in seismic zones V (very high risk) and zone IV (high risk). Hilly regions are vulnerable to avalanches, landslides, hailstorms, cloudbursts and low and medium rainfall region which constitute 60% of the total area. Forty million hectares (8% of landmass) is prone to floods – the most vulnerable States to floods are Assam, Arunachal Pradesh, Bihar, Punjab, Sikkim, Uttar Pradesh, parts of Andhra Pradesh, Gujarat and Orissa. 8000 km long coast line is as well vulnerable. The North Eastern Region lies in high risk (seismic zone V) and high vulnerability to flood (Brahmaputra and Barak valley in particular) with 20% of the region affected. Landslides, flash flood could burst and cyclone takes in its fold 62% of the region.

Multiple and holistic disaster mitigation management strategies and formulations embracing management modules have to be put in place coupled with historical focus on disaster from relief and rehabilitation. The need of the hour is to chalk out multi-pronged strategy for a comprehensive and composite disaster management comprising prevention, preparedness, response, recovery and relief on the one hand and development strategies aimed at risk reduction and mitigation on the other. Only then we can look forward for a sustained disaster management.

Civil society ought to be incorporated into the dynamics of disaster management and preparedness. The community has to be the first responder to any disaster at the micro point and therefore, there is a greater need of community level people-centric initiatives in managing disasters. Civil society must be mobilized and sensitized to cope with disasters.

Time has now come to look at disasters from a developmental perspective and bring into play scientific and technological advances and psycho-social interventions towards the mitigation of human tragedy and economic losses from natural and man-made disasters. We must, therefore, demonstrate harmonized, synergized and integrated approach to disaster reduction and focus on research on disasters, pre-disaster planning, engineering preparedness, general preparedness and mass sensitization on disaster prevention coupled with sustained post-disaster relief capabilities.

I am sure that the seminar on disaster management will have productive deliberations and present cross fertilization of ideas to achieve the desired objectives.

(D.N.Sahaya)

Prof. A. Saha
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MESSAGE

I am happy to know that a National Seminar on Geomorphic Hazards: Issues and Challenges is going to be organised by the Department of Geography and Disaster Management, Tripura University on the occasion of 21st Indian Institute of Geomorphologists Annual Conference during 28th – 30th November, 2008. In order to commemorate the occasion, a Souvenir cum Abstract Volume is also being published.

With increasing pressure of population, overall environment of each and every corner of our country is at stake, which in turn results in severe natural calamities. The geomorphic hazards claim the highest percentage of destruction. Flood, landslide, tsunami, earthquake, river bank and coastal erosion, soil erosion are such hazards which often turn into major disasters. The theme of seminar is very much relevant to the present day situation of the country in general and North-East India in particular.

The deliberation of the Seminar will bring positive remedial measures to solve the aforesaid problems. The publication, I believe will be educative and informative. It will be immensely useful to the researchers in this frontier of studies.

I convey my best wishes to the Organisers and wish the National Seminar a grand success.

PROF. A. SAHA
Vice Chancellor

Preface

Occurrence of Geomorphic Hazards throughout the globle shows a sharp trend of increase in frequency and duration along with the increasing pressure of population on earth. Human beings try to impede the spontaneous rhythm of nature in view to resource utilization for making their life more hospitable. Lack of awareness among man often creates a disbalance and obstructs the natural ways of geomorphic processes thereby inducing hazard occurrences, e.g. improper construction of roads and buildings along vulnerable hill slopes generates the precondition for hazards like landslides; unscientific construction of dams and barrages, interlinking of rivers, often trigger devastating floods along the river basins and so on. Nature always tries to balance itself but in the process of man's interaction, it ends up in forming some process of hazards which comes as disasters to the human society.

To discuss on various issues related to such hazards by different academicians and scientists from different field, the Department of Geography and Disaster Management, Tripura University is hosting this particular Seminar on "Geomorphic Hazards: Issues and Challenges", on the occasion of 21st Annual Conference of the Indian Institute Geomorphologists (IGI) during 28th - 30th November, 2008. I, 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. …..abstracts have been included in ….subthemes. Some of the abstracts are so generalized that their subthemes could not be determined properly for which they have been placed in theie close subthems. A separate section has been made for the abstracts of the Young Geomorphologists competition which, I believe, is going to be a special attraction of the Conference.

This Souvenir and Abstract volume is the outcome of sincere efforts of all my colleagues, scholars and students. No word is enough to thank them all. I am also thankful to PCI Geomatics, Aimil India Ltd., Grantha Bharati, Tata Motors, Ruth & Co, B.S. Syndicate, Tyco electronics, Passion furnishings, Lucknath Bhander, Hotel Raj Palace, Little Heart, Berhampore Xerox and others, who have accorded their kind help both in cash and kind in bringing out this volume.

I gratefully acknowledge the financial support rendered by DST (SERC Division), ICSSR (North Eastern Region), Department of Revenue (Govt. of Tripura), NATMO and GSI to organize this Seminar and 21st IGI Meet.

Last but not the least, hats off to those personalities, who have encouraged, mentally accompanied and helped me from different dots of the country to materialize the event smoothly.

Dr. Sunil Kumar De
Convener
21st IGI Conference & National Seminar
Department of Geography & Disaster Management, Tripura University

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2. Dr. Kashi Nath Jena
3. Dr. Syed Arshad Hussain

LIST OF ABSTRACTS

Tripura University

(Pursuit of excellence)

(Compiled from University Website)

Tripura university epitomizes the aspirations of the state's people for academic excellence at the highest level and quest for knowledge. It is axiomatic that knowledge alone forms the basis of progress and development in the present internet-driven world. What, however, is of crucial importance is successful dissemination of knowledge and making it easily accessible to learners. With its cryptic motto 'pursuit of excellence' Tripura university has dedicated itself to this noble task ever since it had been launched on October 2 1987. The dream of the state's people had come true on the birth anniversary day of the 'Father of the Nation'. A flash-back to the historical background of the university sheds fascinating light on the series of developments that culminated in the setting up of the university. The state's first institution of higher education, MBB college, had commenced functioning from 1947 with affiliation from Calcutta University but in the immediate after-math of partition the population of the state registered a steep growth and so did the number of students aspiring for higher education.

The launching of the MBB college was soon followed by the setting up in 1950 of Ram Krishna college in Kailasahar , present headquarter of North Tripura district . The year 1964 saw the launching of Belonia college in South Tripura , followed within three years by the establishment of Ram Thakur college in 1967 at Agartala. The students of the state remained hamstrung by one crucial fact : all the colleges had to secure affiliation with Calcutta University and no scope for university education existed within Tripura. Since the late sixties of last century student movements within Tripura consistently focused on the demand for expansion of opportunities for higher education and setting of Tripura's own university. Responding to rising demands Calcutta University authority agreed to have post-graduate classes on History, Mathematics and Economics held in MBB college and in 1976 University Grants Commission (UGC) formally recognized this as Calcutta University Post Graduate Centre (CUPGC). This only further intensified the state's quest for higher educa-tion and demand for a separate university . It however took nine more years to initiate measures for setting up Tripura's own university. It was on the fateful day of May 18 1985 that the then education minister and legendary tribal leader Dasharath Deb laid the foundation for Tripura University on the sprawling 75 acres of land , donated by the state government , at Suryamaninagar , ten kms south of Agartala. The work on construction progressed rapidly and the state assembly passed the Tripura University Act in 1987 , extending legislative sanction to the process of launching the University. It was on October 2 , birth anniversary of Mahatma Gandhi , that Tripura University formally came into being as a towering embodiment of the hopes and aspirations of the people. The University has been converted to a Central University w.e.f. 2nd July, 2007.

At present Tripura University provides post-graduate courses on sixteen subjects while the various Depart-ments, Directorates and Centres within it provide 38 degree courses. All twenty four general and technical colleges within the state are affiliated with Tripura University which is now the veritable nerve centre of the state's higher education , enjoying the highest possible autonomy in all matters.

DEPARTMENT OF GEOGRAPHY & DISASTER MANAGEMENT, TRIPURA UNIVERSITY

A Brief Profile

Year of Establishment : 20th December, 2004
Faculty : Science

List of Faculty Members :

Name : **Dr. Nibedita Das (Pan)**
Designation : Reader & Head
Qualification : M.Sc., B.Ed., Ph.D.
Specialization : Fluvial Geomorphology
E- Mail address : nibeditadaspan@rediffmail.com
(mobile: +91 94361 34923)

Name : **Dr. Sunil Kumar De**
Designation : Lecturer (Senior Scale)
Qualification : M.Sc., B.Ed., Ph.D.
Specialization : Environmental Geomorphology, Landslide & Soil Erosion
E- Mail address : desunil@rediffmail.com / desunil@gmail.com
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Name : **Dr. Sudip Dey**
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Name : **Ms. Jimmi Debbarma**
Designation : Lecturer
Qualification : M.A.
Specialization : Environment and Resource Management
E- Mail address : jimmi_debbarma@yahoo.com
(mobile: +91 98620 89856)

Ongoing Research Project / s (apart from unassigned grant):

Principal Investigator	Title of the Project	Funding Agency	Amount Sanctioned	Number of research students engaged
Dr. Sunil Kumar De (Joint P.I.)	Innovative Research Methods and technologies for the multispatial / multitemporal analysis of landslides in mountain regions, the prevention and awareness of related natural hazards and risks	Ministry of University & Research, Govt. of Italy	******	1 (India) + 1 (Italy)

List of Publications

Dr. Nibedita Das (Pan):

i. Das (Pan), N (2007): Watershed Development Programme - Key to the sustainable development of Fatikcherra Micro Watershed under Bishalgarh R.D. Block, West Tripura District; The Indian Journal of Landscape Systems and Ecological Studies, Kolkata, Vol. 31 No.1
ii. Das (Pan), N, Bhattacharya, B. & Deb, M. (2007): "Geo-Environmental impact on Land Use : A Comparative Study in West Tripura", Indian Journal of Landscape Systems and Ecological Studies, Kolkata, Vol. 30 No. 2 p. 93-108.
iii. Das (Pan), N. & Deb, R. R. (2008): "Changing Course of the Khowai River of Tripura and related problems", Jharkhand Journal of Development and Management Studies (Special issue on Disaster Management), Vol. 6, No. 2 (XXIII), p. 2919 - 2928.

Dr. Sunil Kumar De:

i. Basu, Subhashranjan & De, Sunil Kumar (2003);- "Causes and consequences of landslides in the Darjiling-Sikkim Himalayas, India" - Geographia Polonica, Vol. 76, No. 2, Autumn, 2003, pp. 37-52
ii. De, Sunil Kumar (2004): "Causes and consequences of landslides in the Balasan basin of Eastern Himalayas"- In Geomorphology and Environment, ed.by Singh, Sharma & De, acb publications, Kolkata, p. 406-414
iii. Basu, Subhashranjan, Ghosh, Anusuya & De, Sunil Kumar (2005) : Meandering and cut-off of the river Bhagirathi, in Geomorphology and Environmental Sustainability, ed by Kalwar and others, Concept Publishing Co., New Delhi, pp. 20-37
iv. De, Sunil Kumar (2004) : "Morphology of Braiding in the River Balasan" - "Indian Journal of Landscape Systems and Ecological Studies " No. 2, Vol. 27, 2004
v. Dey, S, De, S.K. & C Debbarma (2006): Natural Urban Lake Ecology of Agartala, North East India; Indian Journal of Geography and Environment; Vol-8, Pp-28-40.
vi. De, Sunil Kumar (2007): A Study of water resources of the Balasan basin of the Darjeeling Himalayas, India and its conservation; in Indian Journal of Power and River Valley Development, Vol. 57, Nos. 3 & 4, March-April, 2007, pp 122-129
vii. De, S. K. & Jamatia. M. (2007): Landslide Hazard Zonation in Relation to Some Physical Parameters: A Case Study on the Hilly Tract of the Balasan Basin of Darjiling Himalayas, India; Proceedings of the

XIX the IGI Conference (in press)
viii. De, S. K. Jamatia. M. & Bandyopadhyay. S. (2008): A Geo-technical investigation of Mirik Landslide, Darjiling Himalayas, in Geomorphology in India, Prayag Publication (in press).
ix. Basu, S. R. , De, S. K. & Bera, B.(2008) : Landslides in India; in Geomorphology in India, Prayag Publication (in press).

Dr. Sudip Dey:

i.Marfai, M.A, H. Almohammad, S. Dey, , B. Susanto, and L. King (2008): Coastal dynamic and shoreline mapping: multi-sources spatial data analysis in Semarang Indonesia; Environment Monitoring and Assessment; Springer Science; Vol-142; Pp-297-308.
ii.Dey, S (2008): Late Quaternary environmental changes and their impact upon coastal and paleo-coastal Bengal Basin in India: A climato-geomorphic study; Climatic change and food scarcity (etd by M. Dutta, N.P Singh and D. Daschaudhuri), New India Publishing Agency, New Delhi; Pp-229-241.
iii. Dey, S, C.Debbarma, P.Sarkar and D. Choudhuri (2008): Simple modeling for the analysis of level of geoecological changes and hazrds: An experimental study in Rudrasagar lake area, North-East India; Jh. Journal of Development and Mnagement Studies (Sp issue on Disaster Management), Vol-6 (2), Pp-2853-2864.
iv. Dey, S, C Debbarma and P. Sarkar (2008) Microgeomorphic assessment in "Grayscale Environment": An experimental study ; Indian Journal of Landform System and Ecology; Kolkata, Vol-31 (1) Pp-223-231
v. Dey, S et at: (2007): Micro-Environmental status of Tilla Lands of Agartala City, North-East India; Indonesian Journal of Geography; Yogyakarta, INDONESIA; Vol-39, No-2 Pp-22-27
vi. Dey, S (2007): Marine-Coastal Micro-features and their Importance in Geomorphic Assessment: An Analytical Study along East Medinipur Coastal Tract, India; Issues of Geomorphology and Environment, (Etd by Dr. S.K.De); ACB Publications, Calcutta;
vii. Dey, S and D. Choudhuri (2007): Dynamics of Natural Environment and its Impact upon Rudrasagar Lake of Tripura, North-East India; Water Resource Sustainability in the Context of Global Change (Etd by Dr. R.B. Singh), Rawat Publishers, Jaipur; (In Press)
viii.Dey, S, J. Debbarma, R. Dadebbarma, S Paul and B Roy (2007): Nature of Plant Diversity on Tropical-Monsoon Highland Slopes: A Micro-Environmental Study In Suryamaninagar Of Tripura, North-East India; Biogeography and Biodiversity; (Etd by Dr. R.B. Singh), Rawat Publishers, Jaipur; (In Press)
ix. Dey, S (2006), Holocene Sea Level Change and Impact upon Geomorphology of Digha-Shankarpur Coastal Tract, West Bengal.; Natural Hazards and Disasters Management-Vulnerability and Mitigation (Etd by Dr. R.B. Singh), Rawat Publishers, Jaipur, Pp-289-297

Ms. Jimmi Debbarma:

i. Dey, S, and J. Debbarma (2007): Nature of Plant Diversity on Tropical-Monsoon Highland Slopes: A Micro-Environmental Study in Suryamaninagar of Tripura, North-East India; Biodiversity and Biogeography (Etd by Dr. R.B. Singh), Rawat Publishers, New Delhi; (In Press).

List of Books Published

Sl. No.	Name of Teacher	Name of Book	Publisher
1	Savindra Singh, H.S. Sharma & **Sunil Kumar De (2004)**:	Geomorphology & Environment,	acb Publications, Kolkata
2.	S.R. Basu & **Sunil Kumar De (2008)**	Issues of Geomorphology and Environment	acb Publications, Kolkata
3.	**Dr. Nibedita Das(Pan)** & Parimal Debnath	Madhyamik Bhugol Bichitra (Text Book for Class X)	Bani Bitan, Lenin Sarani, Agartala, Tripura (W)-799001

Major Thrust Areas of Research

1. FLUVIAL GEOMORPHOLOGY GROUP:

The Fluvial Geomorphology Research Group concerns with the fluvial hazards and disaster management, particularly within Tripura State.

Being a state of North-East India, Tripura lies in the neo tectonic zone and different hazards related to river action are very much frequent and turn into disaster. There is paucity of hydrological data in this border state and official records on different aspects are also lacking. Keeping in view of these constraints the Fluvial Geomorphology Research Group is working on different drainage basins of Tripura. The team is pursuing intensive field survey for collection of hydrological data through various measurements and thus preparing a data bank on 10 major river basins of Tripura. Fields of fluvial hazards already considered include sedimentation and bar formation, bank erosion and shifting of channel, flood, landslide etc. In each field Frequency Mapping and Hazard Zonation Mapping are in progress with the application of RS and GIS technique. Fluvial dynamics and their impact on land use in different river basins are also in progress.

Thrust Areas

Fluvial Dynamics

Fluvial Hazards & Disaster Management

Members of the Group:

Dr. Nibedita Das (Pan)

Mrs. Bijoya Bhattacharyya (Research Scholar)

Sri Bajrang Lal Meena (Research Scholar)

Ms. Mugdha Chakraborty

2.EENVIRONMENTAL GEOMORHOLOGY RESEARCH GROUP:

The Environmental Geomorphology research group concentrates mainly on Landslide Hazard Zonation, Geotechnical Investigation of individual landslides, soil erosion and Water quality assessment.

Landslide Hazard Zonation mapping and risk assessment is being prepared by the research group at Meso scale based on the BIS rating scheme as well as the Buffer method on the Kurseong subdivision of Darjiling Himalayas as a whole at meso scale (1:50,000) under the bi-lateral project funded by the Ministry of University and Research, Govt. of Italy. As till now the department does not have any well equipped laboratory that is why for geo-technical investigation of individual landslides very few tests like texture, moisture , pH etc are done by the group themselves with the existing equipments but other tests like Atterberg Limits and Shear Parameters are done on higher basis from other laboratories. Generation of data base for landslides in Tripura is in progress.

Assessment of Soil Erosion on Meso-scale is being practiced on the basis of RUSLE method. Till today two such works have been produced to determine the amount of annual soil loss and its distrution in the Tripura University Campus. Some manual experimental works are also going on to estimate the amount of annual soil loss generated from different slope categories in the University campus itself.

Thrust Areas

Landslide and Soil Erosion
Climatic Geomorphology

Members of the group:

Dr. Sunil Kumar De (Senior Scale Lecturer)
Ms. Mili Jamatia (Research scholar)
Mr. Goutam Ghosh (Research scholar)
Ms. Samayita Bandyopadhyay
Ms. Sushmita Saha

3. QUATERNARY RESEARCH GROUP:

The researches by QLRG focus on last two million years landform evolution in the tropical coastal and paleo-coastal areas. Geological, geomorphic and ecological evidences of coastal changes are the major interest of study this group. The members of this research team are engaged in studies of Quaternary period depositions especially microstructure and microfabric of the sedimentary rooks in the western and eastern geo-tectonic provinces of Bengal basin. Experiments on petrographic image analysis (PIA) and microstructure mapping are going on by using digital technology. Small units of geomorphology or microgeomorphic features of coastal and tectonic areas are studied by QLRG as one of the important evidences for the assessment of recent landform changes and their influencing geo-climatic factors.

Rudrasagar Lake of Tripura is studied for last five years by this research group. The QLRG concentrates on the history of landform evolution and present geo-ecological status of this lake of international importance. The paleo-environmental condition of this area is another field of interest. The geo-tectonic signatures on the geomorphology of Baromura hill, Tripura also attracts the researching members of QLRG.

This research group is engaged in the experiments of mathematical modeling and their application for scientific assessment of short term and long term landform dynamics. The group members are also using remote sensing and GIS techniques for detecting shoreline changes, changes of wetlands, signatures of tectonism etc. A recent interest of this research group is the experiments on analysis of various spectral resolutions for geo-spatial data analysis. Attempts are going on to study the changes of geo-physical characteristics of the earth surface through the spectral and spatial resolutions. In the Digital Analysis Laboratory the QLRG uses very simple software like ILWIS, ET Pro, TNTmimps and some microstructure analyzing software.

Thrust Areas:

Dynamics of Coastal Geomorphology
Microgeomorphology and Cenozoic Microstructure
Lacustrine and Tectonic Geomorphology

Members of the group:

Dr. Sudip Dey (Lecturer)
Ms. Chandrani Debbarma (Research scholar)
Ms. Prasamita Sarkar (Research scholar)
Mr. Suvendu Ghosh (Research scholar)
Mrs. Susmita Paul

4. Environmental Research Group:

Environment & Resource Management
Urbanisation & Tourism of Tripura

Number of Ph. D Scholars at present: 8 (Applied for)
Total number of Scholars awarded Ph. D. Degree since inception: NIL

A Brief Outline of Tripura

Location

Tripura, one of the seven States in the north eastern part of India, is a land-locked state touching both national and international boundaries. It covers an area of 10,477 sq. kms. The territorial shape of the state is irregular measuring about 113kms from east to west, and 184 km from south to north. The length of its international boundary with Bangladesh measures 839 km. Among the Indian states it has common boundaries with Assam and Mizoram.

Brief Historical Background

The history of Tripura as an administrative unit goes back to the days of Maharajas. The former princely state of Tripura was ruled by Maharajas of the Manikya dynasty. From Maha Manikya (1400-30) to Bir Bikram Manikya (1923-47), the Manikya dynasty ruled over the kingdom for over 500 years. After independence, an agreement of merger of Tripura with the Indian Union was signed by the Regent Maharani in September 1947. However, its final integration with India was given effect from October 15, 1949, and then Tripura became 'C' state administered by a chief Commissioner as its administrative head. Tripura became a Union Territory without legislature with effect from November 1, 1956, and it attained statehood on 21 January 1972.

There are many opinions on the origin of the name of the state. According to one version the name of the state had been derived from the name of an ancient king Tripura, the grandson of Yayati, of Mahabharata. prior to this the state was known as Kiratadesha--the land of the kiratas. However, according to modern historians the kingdom was founded by Maha Manikya in early part of the fifteenth century. There is not enough tangible evidence to reconstruct the ancient history of Tripura prior to the rule of the Manikya dynasty. 'Sri Rajmala' is the only source book of the princely regimes of Tripura. This may be compared with the Raj Tarangini and Assam Buranji of Kashmir and Assam respectively. The first part of Sri Rajmala was compiled during the reign of Dharma Manikya in the 15th century. The second part was compiled during the reign of Amar Manikya in the 16th century and the third part during the reign of Govinda Manikya in the 17th century. Some believe that the name of the state has come from `Tripura Sundari' -- the presiding deity of the land. According to yet another version the name of the state originated from two Tripuri words (Kakbarak) viz., Tui and Pra meaning a land adjoining the water. Tui means water and pra means meeting point. It is assumed that `Tuipra' gradually transformed into Tripura (Tuipra_Tipra_Tripura).

Agartala is the Capital of the State. It was established about one hundred and fifty years ago by Krishna Kishore Manikya. Prior to this the capital was at old Agartala. The state is divided into four districts - West, North, South and Dhalai. As per 2001 census the state's population was 3,191,168 . Out of this 84.7% was rural and 15.3% was urban population. The state has a population density of 262 per sq km. Its literacy rate was 60.44 percent. The population of Tripura is heterogenous. Besides the Bengalees and the Manipuris it has 19 major tribal groups viz., Tripuris, Noatias, Jamatias, Reangs, Kukis, Garos, Halams, Santals, Moghs, Chakmas, Oraons, Mundas, Lushais, Khasias, Bhils, Uchais, Lepchas, Bhutias and Chaimals. The Tripuris constitute the bulk of the tribal population.

Physical Background

Besides several smaller hill ranges there are six prominent hill ranges, namely Jampui, Sakhantang, Longthorai, Atharamura and Baramura. Betling Sib (979 MSL) is the highest peak of Tripura.

The main rivers of Tripura are: Burima, Dhalai, Deo, Gumti, Howrah, Juri, Khowai, Longai, Muhuri and Manu. River Gumti is the largest and longest in the State of Tripura. It is about 176 kms long and 118 metres wide. The rivers are rain-fed and many of them are draining into the rivers of Bangladesh. Besides rivers the

State has many streams and rivulets.

The climate of the state is generally hot and humid. The average maximum temperature is 35oC in May-June and the average minimum temperature is 10.5oC in December-January. The average rainfall is around 230cm/annum. The monsoon starts generally in April and continues upto September. Summer starts in March and continues upto May and is followed by rainy season extending over about three-four months (May-August). The pleasant season lasts only for about two months (September and October). Then follows winter which continues up to February.

The State has a fascinating variety of flora and fauna. There are four sanctuaries in the state viz. Rowa Wild-life Sanctuary in North Tripura, Sepahijala Wildlife Sanctuary in West Tripura, Tripura Wildlife Sanctuary and Gumti Wildlife Sanctuary, in South Tripura. The forests are rich with a large number of economic plants such as medicinal & aromatic, treat fodders, fruit producing trees, oil-seed producing trees, spices & orchids and other ornamental plants. The dense forests of the State are infested with a wide variety of wild beasts and birds. Phayre's leaf monkey (local name `Chasma Banar' that is spectacled monkey) is found only in Tripura and nowhere else in the country.

Cultural Background

Its major languages are Bengali and Kakbarak. The economy of the state is primarily agrarian - agriculture contributing 42% of total employment and 64% of GDP. Some 90% of the farmers are small and marginal. A variety of horticultural/plantation crops like pineapple, oranges, cashewnut, jackfruit, coconut, tea, rubber etc., are produced in the State.

The state has rich cultural heritage. The main folk dances of Tripura are: Hozagiri dance of Reang community; Garia, Jhum, Maimita, Masak Sumani and Lebang boomani dances of Tripuri community; Cheraw and Welcome dances of Lusai Communities; Wangala dance of Garo community, Sangraiaka, Chimithang, Padisha and Abhangma dances of Mogh community; Garia dances of Kalai and Jamatia communities; Gajan, Dhamail, Sari and Rabindra of Bengalees, and Basanta Rash and Pung chalam dances of Manipuris. Some of the important musical instruments, are Khamb, Bamboo flute, Lebang, Sarinda, Do-Tara and Khengrong etc. Kumar Sachin Dev Barman (popularly known as S.D. Barman) and his son Rahul Dev Barman (R.D. Barman), the famous musicians, hail from the State.

Rabindranath Tagore had a long association with Tripura. He wrote a novel named `Rajarshi' based on the history of the royal family of Tripura mainly on the life of Govinda Manikya. He also wrote a drama titled `Mukut' (Crown) on the events of the reign of Amar Manikya (1577-86). Tagore persuaded Maharaja Radhakishore Manikya to extend financial help to Jagadish Chandra Bose when he was working in London. The Maharaja also donated a handsome amount at the time of setting up of the Bose Institute in Calcutta. Tagore visited Agartala seven times during 1900 and 1926.

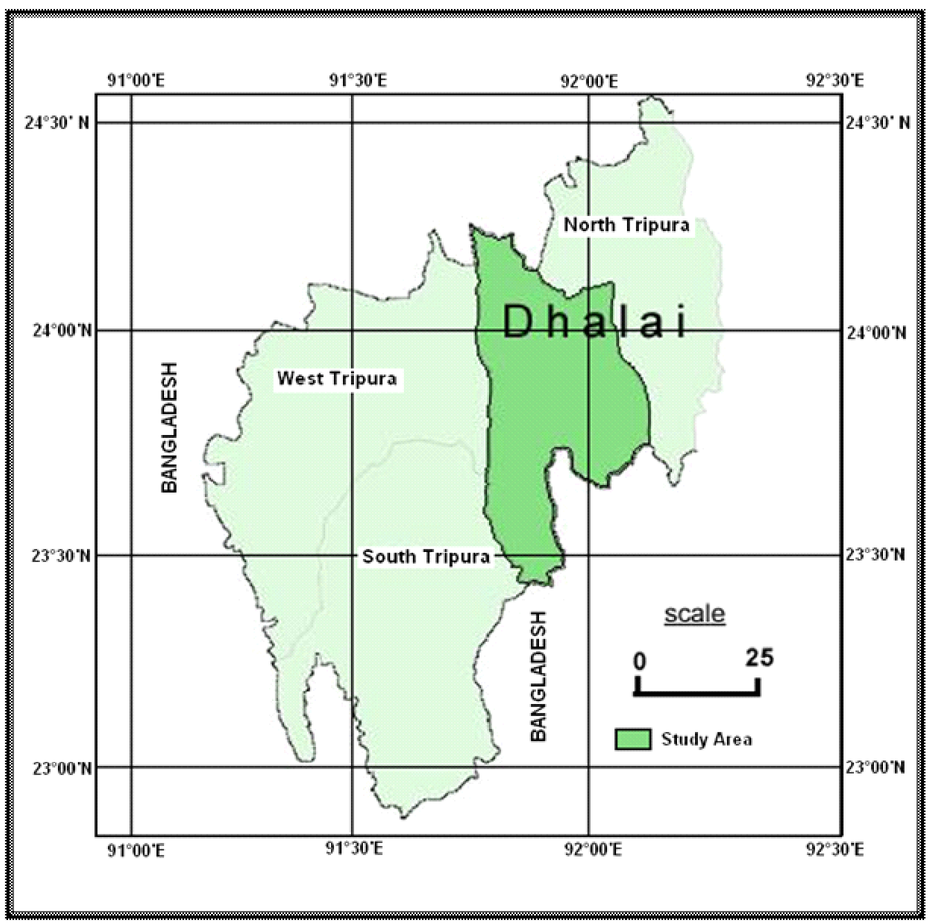
Bamboo occupies an important place in the whole gamut of living of the people in Tripura, particularly of tribals. Bamboo is used to construct huts, all types of baskets for keeping domestic articles and for carrying loads, special type of cage for rearing fowls, decorated wedding platform, musical instruments, ornaments, images of deities, hair-pins and hair combs, bridges and so on.

The state has excellent opportunity for tourism. Some of the important places/sites of tourists' interests are: Unokoti Tirth, Pilak Pathar, Devatamura, Tirthamukh, Agartala, Old Agartala, Vijayanta Palace, Brahma Kunda, Malanchanibas, Kunjaban Palace, Nirmahal in the Rudra Sagar (or Rudi Jala), Government Museum at Agartala and Udaypur. Besides it has many enchanting hills.

Compiled By:
Sunil Kumar De
Department of Geography and disaster Management, Tripura University

Tripura State - At a glance

Coordinates	23°50'N 91°17'E
Time zone	IST (UTC+5:30)
Area	10,453 km² (4,036 sq mi)
Capital	Agartala
Largest City	Agartala
Districts	4 (Four)
Population	3,191,168 (21st)
Density	305 /km² (790 /sq mi)
Language(s)	Bengali, Kokborok (Tripuri)
Governor	D. N. Sahay
Chief Minister	Manik Sarkar
Established	1972-01-21
Legislature (seats)	Unicameral (60)
ISO abbreviation	IN-TR



TRIPURA : Daughter of the Eastern Himalayas

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Tripura, the third smallest state in India (after Goa and Sikkim), extends from 22° 56' N. to 24° 32' N. latitude and 91°10' E. to 92° 22' E. longitude covering an area of 10,491 sq.km. with a population of 31.91 lakhs (2001 Census). It is bounded on the north by the Sylhet district of Bangladesh; on the south by the districts of Noakhali and Chittagong of Bangladesh; on the east by the Cachar district of Assam and Mizoram; and on the west by the districts of Comilla and Noakhali. The state has an international boundary of 856 km and national boundary with Assam and Mizoram of 53 km and 109 km respectively. The length and breadth of the state are 183.50 km and 112.70 km respectively.

Tripura has four districts namely (1) North Tripura District with three sub-divisions like (i) Kailasahar, (ii) Dharmanagar, (iii) Kanchanpur; (2) South Tripura District with five sub-divisions like (iv) Sabroom, (v) Amarpur, (vi) Udaipur, (vii) Belonia, (viii) Santir Bazar; (3) West Tripura District with five sub-divisions like (ix) Sadar, (x) Khowai, (xi) Sonamura, (xii) Bishalgarh, (xiii) Teliamura; and (4) Dhalai District with four sub-divisions like (xiv) Ambasa, (xv) Kamalpur, (xvi) Longtarai Valley and (xvii) Gondacherra.

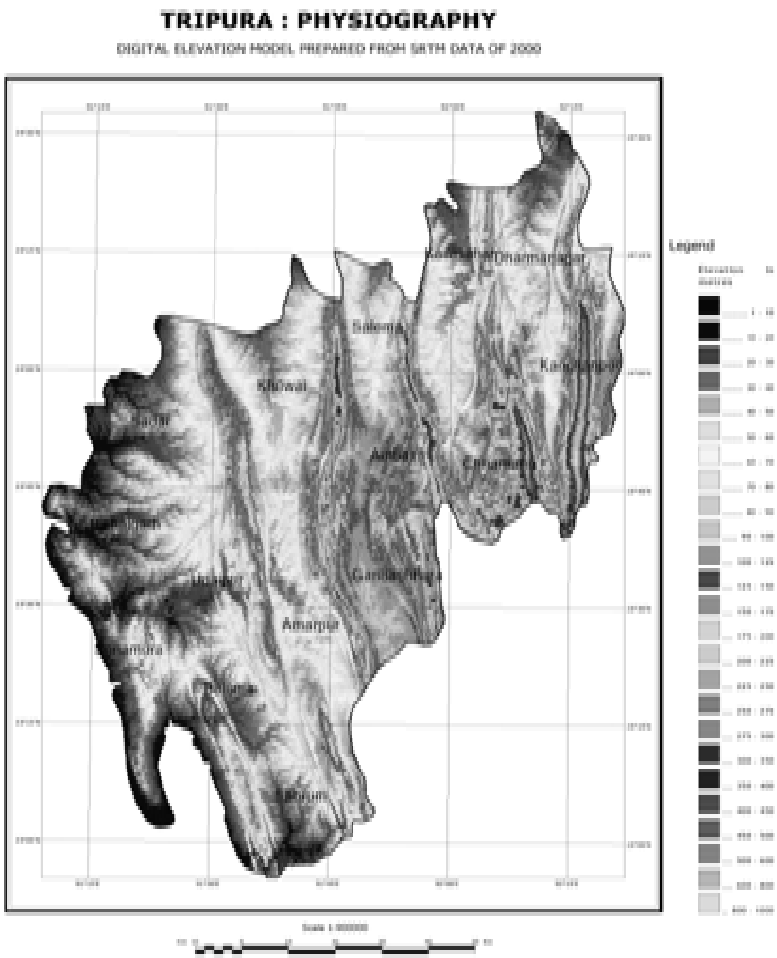
GEOLOGY: Tripura is predominantly a hilly state. About 60% of s land is hilly. Geologically, this hill tract appears to consist of a sub-stratum of tertiary rocks which were covered to a considerable extent by later alluvial deposits. The sub-stratum was exposed to a warping movement, contemporaneous with the main Himalayan uplift in Eocene times. The stress caused it to buckle up into a number of parallel anticlinal ridges, running from northwest to southeast. Three series of sedimentary rocks namely, Barail, Surma and Tipam are found one over the other in Tripura. The Barail series consists of fairly hard fine grained and yellow to pink sandstones. The Surma series consists of massive sandstomedium to coarse grained and bluish in colour. The Tipam series consists of soft coarse-grained sandstones of yellow colour. The entire region falls under the earthquake zone V, which indicates instability in arrangements rock stratum.

PHYSIOGRAPHY: Tripura can be divided into three broad physiographic regions namely, (A) Hilly Region, (B) Rolling Upland with adjacent Narrow Valley Region and (C) Plain Region.

(A) Hilly Region: Whole North Tripura and Dhalai Districts and parts of West and South Tripura District fall under this division. There are five important hill ranges run parallel to each other extending from northwest to southeast direction and gradually disappear in the Sylhet plain of Bangladesh. In between the two successive ranges lies a river valley of approximately 20 km width that expresses a "Ridge and Valley Topography" like USA. Elevation of the hill ranges rises gradually from west to east and from north to south. From west to east the hill ranges are Baramura-Deotamura, Atharamura, Longtarai, Sakhantang and Jampui.

Baramura-Deotamura: Baramura (Bara means big and Mura means hill) hill range runs for 47 km over common boundary between Sadar and Khowai sub-divisions. Saisunmura (269m) is the highest peak of this range. Other important peaks are Baramura (175m), Champamura (154m) etc. The Haora River originates from this range and flows westwards until it merges with the Titas River in Bangladesh. Deotamura is the extended part of Baramura. Deotamura (Deota means god and Mura means hill) runs for 85 km over the boundary between Udaipur and Amarpur sub-division. Important peaks are Deotamura (247m) and Sahalemura (150m). The Burigang River originates from this range and flows in a southwest direction. The Gumti River cuts across it near Radhakishorepur town and flows westward and enters into Bangladesh.

Atharamura: Atharamura (Athara means eighteen and Mura means hill) runs for 106 km and forms the boundary between Khowai and Kamalpur Sub-Division. Jarimura (481m) is the highest peak. Other important peaks are Atharamura (436m), Tulamura (244m). The River Khowai starts its journey from the southern



part of this range and flows towards north until it reaches the Sylhet plain of Bangladesh.

Longtarai: This hill range runs for 48 km over the boundary between Kamalpur and Kailasahar Sub-Divisions. Phengpui (482m) is the highest peak. The River Dhalai rises from Dolajari peak and runs towards north. Deeply cut ravines characterize the southern part of the range.

Sakhantang: This range runs for 75 km towards south from Kumarghat and merges with the Langten Range of Chittagong to the extreme south. Sakhan 786m) is the highest peak. Other important peaks are Thanrimaman (410m), Cobel (384m) and Kamunta (239m). The eastern portion of this range is characterized by faults and fractures. The River Manu takes its rise under the Kohosib peak of the Sakhantang Range and flows towards north.

Jampui: The Jampui Range is the highest range of Tripura. It runs for 74 km between the river valleysof Longai and Deo. To the north it merges with a low ridge that runs into Sylhet and to the south with the Langten range of Chittagong. Betling Sib (939m) is the highest peak located in the extreme south. Other important peaks are Banghurun (616m), Jampui (567m) etc. All hill ranges are forest covered and dotted with the patches of shifting cultivation (locally known as jhum) practiced by the tribal people of the state.
important peaks are Banghurun (616m), Jampui (567m) etc. All hill ranges are forest covered and dotted

(B) Rolling Upland with adjacent Narrow Valley Region: Most part of West and South Tripura fall under this region. Here the undulating uplands are characterized by flat tops like the plateaus and gradual slopes towards the adjacent narrow valleys. In Tripura this type of landscape is known as Tilla- Lunga Landscape. The tillas are 30 - 60 m in elevation and covered by degraded forests and the lungas are used for cultivation, mainly, rice cultivation.

(C) Plain Region: The plain regions are extensive in the West and South Districts and in synclinal river valleys of the North and Dhalai Districts. It is a piedmont plain, lying at the foot of the north-south trending hill ranges extended from Mizoram and merges with the greater Bangladesh plain. The slope of the plain covering West and South Tripura Districts slopes down west and southwards. The areas are drained by the rivers Haora, Burigang, Gumti and Khowai in the west and Gumti, Muhuri, Fenny in the south district. Synclinal valleys are occupied by the river Manu, Deo, Dhalai, Juri, Longai, Khowai and slope towards north. As any other piedmont plain, Tripura plain is the product of both degradational and aggradational activities.

Brief Note on Some Evidences of Environmental Dynamism and Landform Evolution in Tripura

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Pre-tertiary Tectonic background:
Tectonically north-eastern India as well as Tripura remained very dynamic through Tertiary-Quaternary period. It is well accepted by the geoscientists that the evolution of hilly landform in this area is related to the movement of Indian plate during the geological past. The early researchers (McKenzie and Sclater, 1971; Curray and Moore, 1974; Sclater and Fisher 1974) attributed that the intensity and pattern of plate-to-plate interaction between the Indian, Tibetan (Eurasian) and Burma Plates remained very dynamic through the geological past which plays an important role in geophysical changes of the north-eastern part of Indian subcontinent and the Bengal Basin. Some authors like Smith and Hallam (1970), Curray et al. (1982), Falvey, (1974) and Varga, (1997), Lee and Lawver (1995) and Acharyya (1998) accorded that there are ample evidences to prove that the Indian landmass was once a part of Gondwanaland. In the Early Cretaceous, this landmass was detached from part of Gondwanaland and started to move initially northwestward and then northward. Three large continental masses were closely joined with 'Greater Indian landmass' extending for an unknown distance into the Tethys Sea. Indian subcontinent separated about 100 million Years BP (Valdiya, 1984) and with the break-up, a continuous zone of subduction was established along the southern margin of the Asian and Tibetan Plates. The initial alignment of these subduction zones is speculative, but was probably about east-west or southeast-northwest. A continuous zone of subduction also lay off the southwest side of the Burma Block (IBA), again at an unknown alignment. Authors like Hutchison (1989) and Acharyya (1998) agree that the India-Asia collision occurred for the first time during the Mid-Paleocene. Sahasrabudhe (1963) assumed that the Indian subcontinent drifted northward at a very faster rate of 18-20 cm / year in the early Tertiary period, but the speed decreases by 10 cm / year in the later part of Tertiary period. Anti-clock wise rotation of the Indian landmass occurred about 60-44 Ma (Klootwijk et al., 1992) after several India-Asia collisions (soft collision during Paleocene and hard continent-continent collision during Eocene), which was responsible for the closing of the under compressed sutures and then the Himalayan orogeny commenced. Since then India passed obliquely into and/or under Asia the northern Bay of Bengal became a remnant ocean basin at the beginning of Miocene because of the continuing oblique subduction of India beneath and southeast extrusion of Burma (West Burma Block).

Tertiary-Quaternary landform evolution of Tripura:
During the Miocene period the sediment deposition in Bengal basin from east, west and north started. Sedimentary evidences strongly support that the present study area Tripura covers, the Eastern geo-tectonic province of the Bengal Basin or Chittagong-Tripura fold Belt which was under domination of marine environment during pre-Tertiary period. Sediment deposition in the Bengal basin started during mid-Miocene period and the coast line shifted southwards (Dey, 2005a). The present coastline of the Bengal basin formed with in last 6000 years during late Holocene period (Dey et al, 2002; Dey 2002). Evidences of marine coastal sediments and depleted marine-coastal roots preserve the 25 million years geological history of Tripura since Miocene period. During 17th and 18th century this area was known to the European surveyors as "Hilly Tripura" (Menon, 1975) due to its undulating hilly topographic character. The succession of rock type is shown in the table-1:

Table-1 Geological succession of Tripura (West)

Geological period	Epoch	Time	Group	Lithology
Quaternary	Holocene	10000 years	Alluvium	River born clayey silt, clay with silt, sands etc.
	Pleistocene	1.6 million years		
Tertiary	Pliocene	5.3 million years	Dupi Tilla	Estuarine brown clay sand, mettled silty clay, white to gray sandrock with silt band, white clay.
			Tipam	Marine-coastal and estuarine sand rocks with shale and fossil wood.
	Miocene	23.3 million years	Bokabil	Marine-coastal Shale with minor sandstone
			Bhuban	Marine-coastal sandstone with minor clay shale and calcareous

Courtesy: Unpublished report of Geological Survey of India, Agartala, 2004

This area exhibits sedimentary rocks of marine-mixed-fluvial type origin ranging age from Tertiary to middle Quaternary (Dey, 2005). Evidences of early marine coastal depositions like Bokabil shale (Miocene deposition) and Tipam (Early Pliocene deposition characterised by Marine-coastal and estuarine sand rocks with shale and fossil woods) strongly support the dramatic environmental change (from marine to inland) in this area. Apart from these it has been observed during the field survey that in the basins of R. Haora and R. Gumti very thin layers of recent alluvial depositions are found. In Tripura several structural evidences displayed in the formation which are evidences of changes of geomorphic processes during geological past. Ripple marks, ripple drift cross lamination, current bedding etc are some of the examples. Lithological composition of Tipam group is mainly yellowish brown felspathic sand rock with clay band. Fine to medium grained sandstones of this Tipam group is found mainly in and around Brigudasbari, Sonai Gang Dondra Chara, Belphang of Baromura Hill range area. In western flank of Baromura, clay balls elongated with their long axis parallel to bedding. Interestingly Tipam rocks on the eastern flank do not have clay bands.

Seismic status:

North-east India is seismically one of the six most active regions of the world along with Mexico, Taiwan, California, Japan and Turkey. Tripura, a small peripheral state of north-east India also falls in Zone V in seismic hazard map of India updated in 2000 by the Bureau of Indian Standards (BIS). Most of the catastrophic earthquakes in north-east India are detected as tectonic in origin (Gupta, and Singh, 1982; Guha, and Bhattacharya, 1984; Agarwal,1986; Kayal,1987; Gupta, and Singh, 1986; Gupta, and Singh, 1989; Gupta, 1993; Kayal, 1997 Kayal,1998; Bhattacharjee,1998;).According to available data it can be stated that earth quake activity in Tripura is mainly shallow. Some recent earthquake experiences of Tripura are shown in table-2.

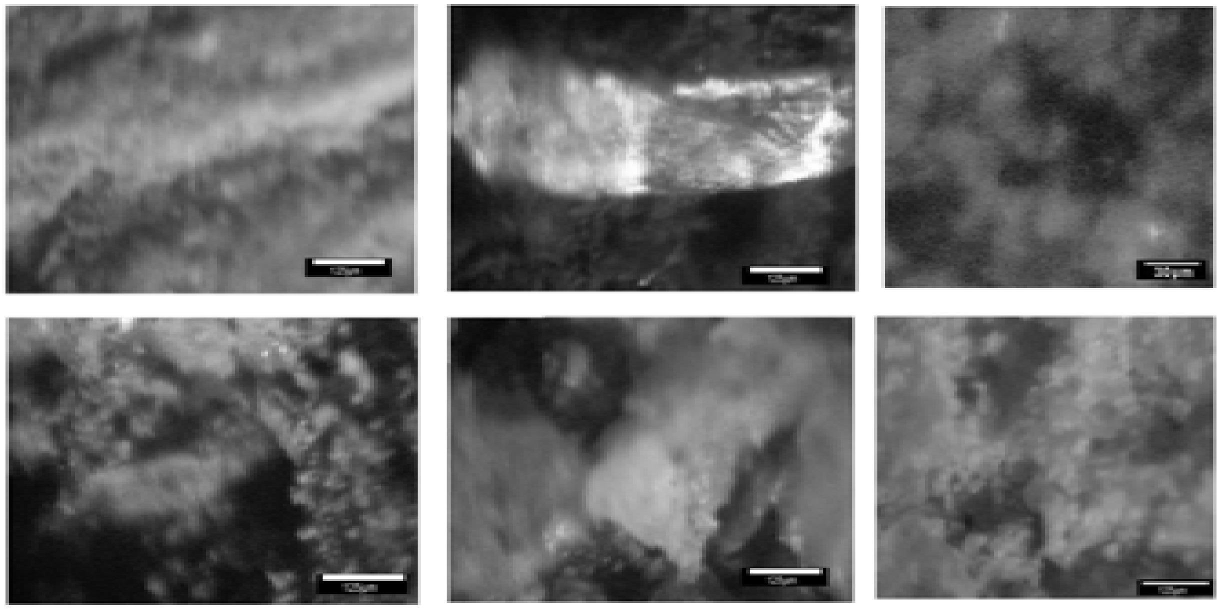

Plate-1: Some microscopic evidences Tertiary-Quaternary sediment depositions under different geo-environment conditions (Courtesy: Digital Micro Analysis Laboratory, Quaternary Landform Research Group, Department of Geography and Disaster Management, Tripura University

Table-2: Some recent earthquakes in Tripura

Location	Date	Magnitude	Depth	Severity
India-Bangladesh border region (North Baromura Hill)	06 September, 1967	5	18 km	Moderate earthquake
India-Bangladesh border region	14November, 1967	5.1	33 km	Moderate earthquake
, region ( )	02 February, 1971	5.4	48 km	Moderate earthquake
India-Bangladesh border region	27December, 1968	5.2	26 km	Moderate earthquake
North of Agartala Tripura	30October, 1980	5	33 km	Moderate earthquake
region (	21May, 1984	5.3	33 km	Moderate earthquake

Extracted from unpublished report of Geological Survey of India, Agartala, 1989
Courtesy: Department of Geography and Disaster Management, Tripura University

End remark:

The landform evolution of Tripura is still not much explored scientifically. Recently it draws attractions of the scholars due to its geophysical, geological and geomorphic characters. Unfortunately before the year 2004 there was no university department in Tripura for higher level earth science training. The practical importance of landform science started to be developed among the students after the establishment of the Department of Geography and Disaster Management in Tripura University. Now different research groups like Fluvial Geomorphology Group, Environmental Geomorphology Group and Quaternary Landform Research Group (QLRG) of this university department are taking the challenges to explore the unknown story of landform development in this area. The QLRG is taking the special interest on environmental dynamics and its impact upon geomorphic processes during the Quaternary period. Though the task is not always easy because of many reasons, still we are hopeful to reach the scientific goal.

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Presidential Address

21st Indian Institute of Geomorphologists Conference
&
National Seminar on Geomorphological Hazards

Tripura University, Agartala, 28-30 Nov., 2008

Geomorphplogical Hazards and Their Management with special reference to Northeast India

Esteemed Fellow Geomorphologists and Friends

I am beholden to you for the honour you have done me by electing President of this august body of the Indian Institute of Geomorphologists. I feel humbled at your gracious gesture. Today, on the occasion of 21st Indian Institute of Geomorphologists Conference and National Seminar being organized at Tripura University in the historic city of Agartala, I stand before you to share a few thoughts related to the theme of the seminar.

A Precursor

The study of natural hazards forms a core area in Geomorphological science and you all are dedicated and many of you highly acknowledged teachers and researchers on the subject. Being conscious of these facts, no doubt I feel some strain building up inside me. Two reasons prod me to gravitate towards this decision when I was in the hunt for a suitable theme to speak on. First, although the term geomorphological hazard is increasingly being used in recent times by authors, teachers and researchers, geomorphologists and many others from related fields, there seems to be certain amount of incongruity and laxity in the application of the term and in its differentiation from certain other types hazards like geological hazard, environmental hazard or natural hazard. There is therefore a need to examine the issue in historical-theoretical perspective and to establish the required clarity and precision of the term so that its meaning and scope , distinctiveness and expediency enjoy improved sharpness and characterization. Second, the Northeastern region as a distinct and unique natural entity is so acutely prone to major natural hazards like flood, erosion, earthquake, landslide and rainstorm affecting life and livelihood of population and often causing damage and loss of property and infrastructure that a discussion on it in the context of the region appears to be exceedingly pertinent and rewarding, more so when the IGI is being held for the first time in this region.

Geomorphological hazards , as defined by Professor C. Embleton of London University (1988) - a pioneer researcher in this field, denote those events or processes, natural or man-induced, that cause a change in earth-surface characteristics detrimental to Man and his activities. It covers a wide spectrum of physical phenomena and processes. A major impetus in the development of the study of geomorphological hazard was achieved in the year 1988 when the International Geogragraphical Union(IGU) set up a Study Group on Rapid Geomorphological Hazards under the Chairmanship of Professor C. Embleton. The group comprised mainly of the members of three previous working Groups of the IGU ,namely, geomorphological survey and mapping, geomorphology of river and coastal plains and morphotectonics. A joint meeting of the three groups was held in Italy (Firenze-Modena-Padova) from May 28 to June 4, 1988 sponsored by the IGU and the International Council for Scientific Unions . A good number of papers on a variety of geomophological hazards pertaining to study areas in Europe, SE Asia, Africa, the Soviet Union and the Middle East were included in the volume that came out of this pioneering effort. In the decades that follow, there had been a multitude of works on the subject covering study areas spread across the globe including our country. However, in case of many of the current works in geomorphological hazard studies, there seems to be a general lack of focus in respect of the earth processes and forms that are responsible for the hazards and the consequences that follow. Thus, the use of the qualifying term ' geomorphological' in the case of many of those hazards in preference to natural , geological , environmental or something else appears to be rather subjective than rational.

Profiling the 'Hazardous' Northeast

The North Eastern Region of India comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya , Mizoram , Nagaland, Tripura and Sikkim covers a total area of 2,62,179 sq km which accounts for 7.97% of the country's total geographical area. The region is characterized by a unique geo-environmental and socio-cultural setting vis-à-vis the eastern Himalayas dominated by extremely dynamic earth processes, intensely potent monsoon rainfall regime, active seismicity and a fabulously rich biological and cultural diversity.

The region represents a distinctive geophysical unit marked by variable topographic relief and geologic framework. The major physiographic units comprising it are : (i) mountainous region of Greater and Lesser Himalayas covering most of Arunachal Pradesh and Sikkim with elevations ranging from 800m to 7000m above msl, (ii) hilly region covering eastern parts of Arunachal Pradesh, almost all the hill areas of Manipur, Nagaland, Mizoram, Tripura, and North cachar district of Assam with elevations from 300m to 5000m (iii) plateau region comprising the Meghalaya plateau (200m-1357m) and the Karbi plateau (80m-1400m), (iv) the Brahmaputra plain(valley) in Assam covering 56,480 sq km with elevations ranging from 34m to 130 m and (v) the intermontane and piedmont plains comprising Manipur basin (1843 sq km),the Barak valley (6962 sq km) and the Tripura plains (3500 sq km) with mean elevations of 700m, 75m and 20m respectively. The Northeastern region constitutes the northern part of a Geological province called Assam-Arakan basin that extends over a vast area covering Assam, Meghalaya, Nagaland, Arunachal Pradesh, Manipur, Tripura and Mizoram in India, Myanmar(Burma) and Bangladesh. Geologically, the region is comparatively young which evolved during the Upper Tertiary and Quarternary times. The region had undergone a series of geological and tectonic upheavelments that resulted in the development of a diverse geological structure with an associated assembly of surficial morphological features. The region extending from Assam to the Arakans including Tripura is traversed by a series of folds running north-south that has given rise to parallel hill ranges separated by broad synclinal valleys. The Tripura region was covered by sea during the Tertiary period with its shore running from Garo to Mikir hills. Towards the end of the Miocene period, intense earth movements resulted in the formation of the hill ranges that are seen today on the eastern part of the state. During the Late Miocene to Early Pliocene times most parts of the Assam-Arakan basin started gradually to come under fluvio-depositional environment due to the retreat of the sea towards south and southwest. Subsequently, sedimentation in the basin had taken place under continental conditions after establishment of the fluvial system on the emerging landforms, interrupted occasionally by neotectonic activity. Thus the present topography of this region is largely shaped by weathering and fluvial erosion by small tributary rivers that rise in the western hills and flow east to merge into the rivers such as Padma or Ganga in the plains of Bangladesh.

The Northeastern region of India and adjoining parts of Myanmar, China, Bhutan, and Bangladesh comprise one of the most active seismic regions of the world. High seismicity of this region is mainly due to the collision tectonics in the north(Himalayan arc) and subduction tectonics in the east(Burmese arc) and presence of numerous structural lineaments. The area is characterized by very complex tectonic domains due to juxtapositioning of different tectonic elements, namely, the Himalayan tectonic zone in the north, Indo-Burman orogenic belt in the south and the northeastern prolongation of the indian shield. The Main Central Thrust (MCT) and the Main Boundary Thrust(MBT) are the two major structural discontinuities in the Himalayan arc of the northeastern region. The seismic activity frequently observed in this area reflects the interaction of the Indian and Eurasian plates. The intense continental convergence at the rate of 5 cm/yr of the Indian plate northward continues to produce earthquakes of magnitude larger than 8.0 in the Richter scale every few 100 years. The earthquakes of 1897 and 1950 each of Richter magnitude 8.7 that occured in this region are among the largest in the world. Besides causing widespread damage and destruction of public property and loss of life, these mega earthquakes wrought large scale geoenvironmental impacts including extensive landslides and rockfalls on the hill slopes, subsidence and fissuring in the valley, and changes in the course and configuration of several tributary rivers as well as the main stem of the Brahmaputra together with other water bodies (e.g. wetlands) strewn over the floodplains. In fact the region's active seismicity has a significant impact on the hydro-geomorphic regime of the Brahmaputra system of rivers, occasionally causing landslides that result in the natural damming of rivers, flash floods due to bursting of landslide induced temporary dams, raising of river beds due to siltation, fissuring and sand-venting, elevation of existing river bottoms and margins, creation of new water bodies and waterfalls due to faulting. The great Assam earthquake of 1950 that occurred on 15th August at 19:39 IST was epicentered at the tri-junction of India-China-Myanmar border near Rima in Arunachal Pradesh and was felt over a vast area in eastern India, Bangladesh, Bhutan and Myanmar covering a region of about 4.5 million sq.km. The area that suffered maximum damage to life and property, namely, upper Assam, Abor and Mishmi Hills of Arunachal Pradesh covered about 15,000 sq km. Immediately after the shock, several major tributaries of the Brahmaputra river ,especially the Subansiri, Dihang, Dibang and Lohit were blocked by landslides caused by the violent earthquake. The Subansiri river dried up after the shock wave due to damming. The dam had burst on the night of 19th August, 1950 inundating an of about 500 sq km and killing more than 400 people. The Siang and Dibang rivers were also blocked for a couple of hours. The earthquake raised the bed-level of the Brahmaputra at Dibrugarh by at least three meters leading to increased flood and erosion hazard potential in the river. In the case of the 1897 Shillong earthquake that occurred on 12th June at 17:11 IST causing devastation to an area of 220,000 sq km, R.D Oldham(1899) stated that the ground acceleration recoded was so high that loose stones lying on the roads of Shillong were tossed into the air and at places bouncing like peas in an empty drum, while at Guwahati the water level of the Brahmaputra was raised 2.3 m by 6 p.m. on the fateful day. Post earthquake surveys mapped large fault scarps on the western edge of the Shillong plateau, most importantly the Chedrang and Samin scarps. Recent studies indicate that the earthquake originated in a south-southwest dipping fault, named the Oldham Fault, situated at the boundary of the northwestern part of the Shillong plateau. Microseismic activity is also a common feature of the seismicity of Northeast region.

The Brahmaputra, a major river of the world that drains a large part of the NE region, not only carries an immense water resources potential and its vast watershed endowed with fabulously rich biodiversity, but it also symbolizes extreme manifestation of nature's fury in the form of devastating flood and erosion hazards that create annual mayhem of death and destruction for millions living in its valley in India and Bangladesh. Originating in a great glacial mass near the Kailas range of southern Tibet at an elevation of 5300 m, the Brahmaputra, known there as Tsangpo, flows eastward for 1625 km over the Tibetan plateau before continuing southwards across the east-west trending ranges of the Himalayas and debouching onto the Assam plain near Pasighat. The different geo-ecological zones traversed by the Brahmaputra have distinctive assemblages of topographical, geological, climatological and biotic characteristics. The gradient of the Brahmaputra river is as steep as 4.3 to 16.8 m/km in the gorge section upstream of Pasighat, but near Guwahati it is as flat as 0.1m/km. The dramatic reduction in slope suffered by the Brahmaputra as it cascades through one of the world's deepest gorges in the Himalayas before abruptly debouching on to the Assam plain explains the sudden dissipation of immense energy locked in it and the resulting unloading of large amounts of sediments in the valley downstream. Two rivers, the Dibang and the Lohit, join the upper course of the Brahmaputra, known as the Dihang (or Siang) river, a little south of Pasighat and the combined flow, hereafter called the Brahmaputra, traverses westward through Assam for about 640 km until near Dhubri, where it abruptly turns south and enters Bangladesh with a new name Jamuna before meeting the Ganga and ultimately flowing into the Bay of Bengal through a joint channel.

The Brahmaputra basin is underlain, for the most part, by very young and unweathered sedimentary formations with the result that the river carries mainly fine sand and silt with very little clay. The sub-Himalayan ranges bordering the Brahmaputra valley on the north consist mainly of Tertiary sandstones and are marked by the presence of several raised, relatively young terraces. The middle Himalayas are underlain by lower Gondwana deposits comprising shales, slates and phyllites, while the greater Himalayas consist primarily of granites and gneisses. Further to the north, the Trans Himalayas of Tibet (average elevation 4500m) are made up of sedimentary rocks of Palaeozoic to Eocene age. The Patkai-Naga ranges bordering the Brahmaputra valley on the east and the south east (average elevation 1000m) consist of Tertiary formation riddled with numerous active faults. The highlands to the south comprising Meghalaya plateau and Mikir Hills (elevation 600-1800m) are made up of gneisses and schists of Precambrian age. The Brahmaputra valley in Assam is a tectono-sedimentary basin, 720 Km long and 80-90 Km wide, underlain by recent alluvium approximately 200-300m thick. The channel of the river is characterized by rapid aggradation, dramatic channel shifts and excessive bankline recession.

The North East region receives an average annual rainfall of 2500 mm with variability ranging from 1200mm in parts of Nagaland to 2125mm in Kamrup district (Assam) to 4142 mm in Tirap district (Arunachal Pradesh) to 11000 mm in Cherrapunji (Meghalaya).The monsoon rains from June to September account for more than 70% of the annual rainfall. The Himalayas exercise a dominating influence on the prevailing weather of the NE region due to their location in the path of the southwest monsoon. The rainfall in the Himalayan sector averages 5000 mm per year with the lower ranges receiving more than the higher ranges. The summer rains are primarily controlled by the position of a belt of depressions called the monsoon trough extending from northwest India to the head of the Bay of Bengal. In the course of its north-south oscillations in summer when this axis moves closer to the foothills of the Himalayas, heavy precipitation is caused in Assam and adjoining highlands. Intense rainfall activities triggered by cloud burst occasionally cause devastating flash floods and landslides in the region. The orographic effect on rainfall is a significant feature of the NE region's climate which is marked by significant variability in the spatial distribution of rainfall. Snowfall in the NE Himalayas occurs at the elevation of 1500 meters and above. There are altogether 612 glaciers in the Brahmaputra basin of which 450 glaciers are located in the Tista subbasin of Sikkim while the remaining 162 are in the Kameng river (upper Jia Bharali) subbasin of Arunachal Pradesh.

The impact of climate change as a result of global warming is likely to be very harsh on the land-water system of the Northeastern region. It is feared that the intensity and frequency of natural hazards may significantly increase in this region especially in regard to weather-related hazards like floods, cyclones, landslides and droughts that are intimately linked with depleting snow cover of the Himalayas and the increasing perturbations in the monsoon system. Indications obtained so far from scenarios developed based on the Hadley Centre model simulations and other GCM model projections point towards drastic changes in the flood and drought hazard situations in the Brahmaputra basin by several orders of magnitude during the first half of this century although there seems to be certain amount of divergence in the current assessments. A key adaptation measure in this regard can be to incorporate climate change in long-term planning in different sectors of development and management including hazard management. Good governance, quality construction and maintenance operations, heightened knowledgebase, sustainable life style and increased public awareness may be considered as indications of good preparation for dealing with the impending challenge of climate change. The potential implications of these changes on the natural as well as built-up environment are causes of serious concern for citizens, scientific workers, public decision makers and leaders in the government.

In Assam, the Brahmaputra flows in a highly braided channel marked by the presence of numerous mid-channel and lateral bars and islands. An extremely dominant monsoon interacting with a unique physiographic setting, fragile geological base and active seismo-tectonic instability together with anthropogenic factors have molded the Brahmaputra into one of the world's most dynamic and complex fluvial system .

The hydrologic regime of the Brahmaputra that responds to the seasonal rhythm of the monsoon and freeze-thaw cycle of the Himalayan snow is characterized by an extremely large and variable flow, enormous rates of sediment discharge, rapid channel aggradation, accelerated rates of basin denudation and unique patterns of river morphology. With an average annual discharge of 19,830 m3s-1(cumec) at its mouth, the Brahmaputra ranks fourth among the large rivers of the world. High monsoon rainfall in the upper catchments and steep gradients are considered to be the major factors responsible for the high rates of unit discharge which in turn help generate the high sediment yield from the basin and contribute significantly towards causing drainage congestion in the valley. The highest recorded daily discharge in the Brahmaputra at Pandu was 72,726 cumec with a return period of 133 years that occurred on August 1962, while the lowest was 1757 cumec in February 1968. The discharge in the river between summer high flows and winter low flows fluctuates, on an average, by 12 times although in certain years it has been as high as 20 times. The enormously large variation in the river's daily discharge over different seasons is a remarkable feature of its flow regime. The river carries more water per unit area of its watershed compared to any other river in the world. This together with the steep gradient in the hill section and restricted valley width in the plains help create the extreme conditions of acute drainage congestion leading to flood inundation in the valley. However, the hazard potential is greatly accentuated by wrongful human interventions. Besides, the Brahmaputra is also one of the major sediment transporting large rivers of the world, second only to the Yellow river (Hwang Ho) in China in terms of amount of sediment transported per unit drainage area. At Pandu (Assam), the river carries an average annual suspended sediment load of 402 million metric tons with an average daily rate of about 2 million metric tons during the monsoon months, May through September.

The river Barak with its network of tributaries is the second largest river system in the NE region and is a part of the Ganga-Brahmaputra-Meghna system. It rises in the Manipur hills , traverses through its valley in Assam and ultimately joins the Meghna river in Bangladesh. Its valley in Assam is acutely prone to flood hazard. Out of its total basin area of 42,455 km2, about 62% lie within India(NE India) while the rest is in Bangladesh. The flood discharge in the river rises upto 7764 cumec during the flood season. Among the other notable river systems of the NER are the Chimtuipui (7000km2) and Karnaphuli (4000 km2) in Mizoram and the Gumti (2500 km2) and the Feni (1500 km2) in Tripura.

The Brahmaputra and Barak basins, particularly the portions in Assam, have earned notoriety for the awesome hazards of annual flood and erosion that create mayhem every year, bringing misery to the people and shattering the fragile agro-economic base of the region. The valleys of the Brahmaputra and the Barak, which together account for 24.9 % of the surface area of NER and 80.8% of Assam, are two worst flood ravaged regions of India receiving, on the average, 3-4 waves of flood every year. These floods cause extensive damage to agriculture, environment, human life and property, thereby affecting severely the economy of the state. With over 40 % of its land surface (3.2 million ha) susceptible to flood damage, which is 9.4% of the country's total flood prone area, the Brahmaputra valley in Assam represents one of the most acutely hazard-prone regions in the country. Several other states in the region like Arunachal Pradesh, Manipur and Tripura and Sikkim are also faced with flood hazard in certain areas within their state territory.

In the NE region floods are caused by a combination of natural and anthropogenic factors. The unique geo-environmental setting of the region vis-à-vis the eastern Himalayas, the highly potent monsoon regime, weak geological formation, active seismicity, accelerated erosion, rapid channel aggradation, massive deforestation, intense landuse pressure and high population growth ,especially in the floodplain belt, and ad hoc type temporary flood control measures are some of the dominant factors that cause and/or intensify the flood hazard leading to disasters. The scenario is further exacerbated by a myriad of social, environmental and economic factors that make riverine populations increasingly vulnerable.

Assam, the most flood prone and flood ravaged state of the region, has experienced major floods in the years 1954, 1962, 1966, 1972, 1977, 1984, 1986, 1988,1998,2000,2002 , 2004, 2007 and lately in 2008. In the aftermath of the Great Earthquake of 1950, the damage potential, intensity and frequency of floods have increased significantly mainly due to aggradation of the river bed . The floods of 1988 and 1998 and 2004 were the worst ones in recent history. However, the flood hazard of 2004 broke all previous records of flood damage, affecting 28.5 million ha of land, 12.3 million people, 12.57 million ha of cropland, and 10,560 villages besides claiming 251 human lives and innumerable cattle and wildlife. All the 27 districts were affected by the flood and the total damage was estimated at Rs.6500 crore. As many as 336 breaches had occurred in the embankments which aggravated the flood, erosion and sedimentation problems. Several tributaries of the Brahmaputra had undergone drastic channel avulsion, thereby causing heavy erosion, extensive sedimentation and severe flooding. Exceedingly heavy, persistent, and concentrated rainfall in the upper catchments of flashy rivers like Pagladiya, Puthimari, Pohumara, Beki-Manas-Aie etc., synchronization of flood peaks in the tributaries and the main stream, breach of a natural dam upstream of Kurichu Hydel Project in Bhutan and release of excessive amount of water by the Kopili Hydel project together with long-continued human depredations in the watersheds are cited as the major causative factors of the flood havoc.

Powerful atmospheric systems called cloudbursts that trigger intense rainfall in limited areas causing flash floods of great fury and destruction are being experienced in greater frequency in the Northeastern region especially along the foot hill region and in the immediate downstream areas in the Brahmaputra plain. The situation aggravates further if such extreme climatic events trigger landslide and slope failure in the upper watersheds or temporarily block river courses creating dams that subsequently break sending surging flood waves downstream. During the 1950 Assam earthquake a massive landslide in Arunachal Himalayas blocked the Subansiri river - a major tributary of the Brahmaputra for days together creating a dam which was eventually released in a deluging flood that greatly devastated the downstream areas in Dhemaji and Lakhimpur districts of Assam. On 10th June 2000, a massive flood occurred in Arunachal Pradesh reportedly as a result of a sudden failure of a landslide-induced dam in the neighbouring uplands of Tibet. Cloudburst and landslide related flash floods occurred in 2004 in the Manas and Beki rivers of Assam due to failure of a landslide dam upstream of Kurichu hydel project in Bhutan that caused highly destructive flood and channel avulsion. On October 7 of the same year i.e. 2004, a flash flood in the Jinari river of Assam was triggered by a cloudburst over Meghalaya that caused great havoc in the downstream areas in Assam. Lately, in the extremely powerful monsoon season this year (2008), there have been several waves of flash flood in the Lakhimpur district of Assam reportedly due to sudden release of excess water from the Ranganadi hydel project that received excessive rainfall in the upper catchment. The ravage done by the sudden deluge was too widespread and persistent in the impact zone.

Breaching of embankments has been a major cause of intensification of the flood hazard in recent times. The undesirable consequence of embankments, especially in aiding channel aggradation and overbank flooding, is clearly visible in Assam. Structural measures, mainly embankments, have been used so far as the sole answer to tackling of floods. Out of a total length of 15,675 km of embankments built so far in the country, Assam alone accounts for as much as 5027 km, i.e. about 32% of the country's total. Erosion hazard posed by the Brahmaputra is also extremely severe in several vulnerable reaches like Majuli , Palasbari, Rohmoria , Matmara, Bhuragaon etc. Majuli, the world's largest inhabited freshwater island and legendary nerve centre of Neo-Vaishnavite cultural heritage of Assam, has already lost as much as 371 sq km of its landmass to the river in the last 50 years with a reduction in area from 1246 sq km in 1950 to 875 sq km in 1998.

Sedimentation caused as a result of flooding and erosion has become a serious hazard in many riverine areas in the Northeast especially in the Brahmaputra valley in Assam. Deposition of coarse sediments have damaged large tracts of productive cropland, human habitats and infrastructural facilities causing enormous loss and misery to the public, and huge cost to the exchequer.

Landslide is also a dominant hazard in the NE region, especially in the populated hill slopes in and around the urban centers and along hill sections of highways. Landslides are complicated processes generated by a multitude of factors like lithology, geologic structure, tectonic activity and geomorphological features such as slope, relief, land use, climate, ground water and seismology. The principal factors that are responsible for triggering a landslide in the Northeastern region are heavy and prolonged rainfall, destabilization of hillslopes by removal of soil and vegetation cover for settlement and infrastructure development or due to deforestation, impact of earthquake tremors, and increased landuse pressure. Due the presence of active lineaments, intense rainfall activity - cloudburst, landuse pressure and development activities, most of the states in the region experience landslide hazard during the monsoon season. The increased frequency of massive cloudbursts accompanied by deluging flood surges and devastating slope failure and landslides has become a serious hazard in the region. Excessive deforestation and urbanization are major factors that cause landslides. Guwahati -the premier city of the northeast faces a multiple hazard syndrome where annual flooding and landslide-related hazards together with high earthquake risk factor vis-à-vis the mushrooming growth of high-rise buildings , destabilization of hill slopes through encroachment and improper landuse, congested thoroughfares, cramped commercial centers, stressed out public utility systems , improperly planned urban sprawl and its bourgeoning population have become a cause of perpetual anxiety and agony to the city dwellers. There has been an ominous rise in the incidence of landslide hazard in the region in recent years especially in urban centers and capital cities like Guwahati.

Towards a Safer Northeast

Management of geomorphological hazards in an acutely vulnerable region like the Northeast with its exceedingly dynamic and sensitive geo-physical, eco-biological, socio-economic and ethno-cultural disposition is no doubt a daunting challenge. The problem becomes more intricate and intriguing in view of the multi-hazard character of the region where in most cases communities are exposed to hazards that are interacting and cascading in nature. Preponderance of socially vulnerable groups and marginalized communities, slow pace of economic growth, underutilization of natural resources endowments, institutional and systemic inadequacies in the background of an immensely fragile geological framework, extremely potent geodynamic and hydrometeorologic regime , hypersensitive location in regard to its dominant Himalayan interface and complex transboundary implications are some of the aspects that mold the hazard scenario in the region. In spite of the inherent complexities and challenges involved, there needs to be a sustained effort towards bringing the Northeastern region to an accepted level of disaster risk so that a reasonable measure of safety and security can be provided to the people and the diverse physical , natural ,socio-economic and cultural systems that support them. In order to accomplish this onerous task, a holistic and integrated approach in the management of hazards with a shift in paradigm from the traditional relief-driven to a more desirable preparedness-driven approach where gainful use of recent scientific knowledge and technology along with the traditional and local knowledge base, generation of awareness, participation and capacity building of various stake holders ,and data and information sharing at a regional transboundary level should be among the essential core components. In regard to flood hazard management in the region, there appears to be a strong case in favour of watershed level integrated regional strategy based on the principles of water and soil conservation and sustainable development as against the adhoc type, piece-meal, short term structural measures adopted so far. It is high time to go beyond the confines of techno-centric management to a broader notion of resource utilization and hazard management. Proper assessment and reduction of vulnerability, empowering local populations, strengthening existing institutions and appropriate reorientation of policies are essential for this. Especially in case of the Brahmaputra and Barak basins with their diverse background of natural and human heritage and vast resource base, such a plan may contribute immensely towards ensuring food, health and ecological security of the region besides providing safeguard against damaging impact of hazards. As a long term strategy for hazard management and resource utilization, a judicious mix of structural and non-structural measures with a greater emphasis on the latter should form the core of the watershed based regional plan aimed at optimizing resource use, hazard risk reduction and welfare maximization. In case of these international rivers, adequate networking of hydrometeorological data centres for real time transmission and analysis of disaster-related data and exchange of technology and expertise across state as well as national boundaries, will play a significant role in creating an effective response mechanism against the hazard of flood and erosion. Being an international river of immense size, huge resource base and high hazard potential, only effective cooperation and coordination among the basin countries together with persistent efforts at the national and regional levels will be able to create an effective response mechanism to the problems of flood and erosion and usher in an era of progress and prosperity to the region.

Use of more sophisticated recent technologies like geoinformatics, computer-based modeling and simulations, radar estimation of rainfall etc together with more focused, analytical field based studies of vulnerability at the societal and ecolological levels backed by rigorous regimes of field based observation and monitoring should be able to significantly improve the existing knowledge base on the hazard-prone river systems of the NE region. There seems to be a need for greater emphasis on the practice of flood hazard zonation in the case of vulnerable watersheds on a priority basis in this region. The application potential and efficacy of non-structural methods of flood hazard management deserve more elaborate enquiry and analysis both at the analytical and theoretical levels to justify their adoption as viable alternative or supplement to the structural measures. In the case of the mega dams that are currently in various stages of planning and development in the lower Himalayan sector of NE region, basically for hydropower development, there is growing concern about the possible negative impact of such large structural interventions in terms of their viability and sustainability vis-à-vis the delicately poised geo-environmental base, ecological balance, ethno-cultural heritage and extreme dynamism of geophysical processes in the region. In view of the inadequate knowledge base, lack of systematic data over an adequate time span and across diverse terrains and considering the intense dynamism and immense scale of the geodynamic processes of the Himalayas, the wisdom behind constructing series of big dams in the Himalayas raises more questions than can possibly be answered at the present stage of our knowledge and development. Besides, given the raging controversies over issues like inappropriate assessment of environmental and social impacts, lack of transparency and public participation in the decision-making processes and displacement of local communities, loss of their lands and livelihoods, the question assumes further complexity.

It will therefore be apt and proper for us to first fully explore the potential of using time-tested, well-regarded and environmentally more benign methods of water resources management such as watershed management and rainwater harvesting which fit well into the newer paradigm of water development. Otherwise, the stakes seem to be too high and risks too great in case of interventions of immense dimensions having far reaching consequences to call for any hasty decision. Therefore under the existing circumstances, modest interventions with minimum impact on the environment appear to be the safest option for this region. Any deviation from this is fraught with uncertainties that may lead to grave consequences.

In regard to earthquake hazard management in the Northeast, comprehensive and long-term initiatives for mitigation and preparedness need to be further strengthened along with heightened activities towards enhancing the scientific and technological knowledge base on the seismicity of the region and level of public awareness. However, in recent years considerable progress has been made in instrumental monitoring of seismicity using broad band seismographs and accelometers, seismic microzonation for obtaining information on location-specific response to seismic events, active fault studies, palaeoseismology for estimation of recurrence history of earthquakes and radar interferometry-based seismic studies. Along with creation of better scientific understanding of the nature, causes, frequencies, magnitude and areas of influence of earth-quakes , reduction of structural, locational, institutional and social vulnerability of the various elements at risk need to be ensured to move the region to a relatively safer level of risk.

In regard to landslide hazard in the region which appears to be rising in recent years especially in urbanized hill slopes and along highways across hilly terrain, there is an urgent need to increase the scientific knowledge base through site specific studies and extensive field monitoring ,and to intensify the landslide hazard zonation activities covering all the active as well as hazard prone sites. Since sliding is not generally a very sudden phenomenon but involves a series of precursory signals that can be monitored using specific instruments at appropriate locations on a right time, intensive investigation on selected highly vulnerable sites can be taken up on priority basis deploying different sophisticated instruments such as automatic target recognition system, inclinometers, tiltmeters, differential GPS, microseismic recorders, geophones, piezometers, automatic rain gauge etc, together with mapping components like high resolution satellite data and GIS. Data generated with the help of these instruments will not only help understand the nature and mechanism of landsliding events but can provide necessary inputs for developing a suitable warning system. Preparation of a comprehensive landslide inventory is also a matter of priority for the NE region. Adequate public awareness on matters related to the physical, structural, legal, administrative, and social aspects of landslides needs to be created and appropriate institutional capacity-building and policy changes made to help minimize the level of risk in the vulnerable locations.

Esteemed friends, I would not seek your indulgence to stretch this discussion further. Let me conclude with a word of thankful appreciation to you for your kind presence.

Yours Sincerely

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28.11.2008

FLUVIAL GEOMORPHOLOGY AND HAZARDS

Special Lecture

Geomorphological understanding of flood hazard: The Indian Context

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India is one of the most disaster-prone countries in the world. Flood hazard is one of the three most destructive natural hazards in India. The enormous risk posed by monsoon floods was brought to the forefront following the devastation from an extraordinary flood on the Kosi River in the last week of August 2008 that tragically inundated much of the area in Bihar and changed the course of the river. In order to implement measures to mitigate the disastrous effects of such floods, the flood hazard needs to be well assessed and understood. Geomorphic and hydrologic understanding of the flood hazards is the first step in minimizing their impacts. Great floods, though primarily the result of heavy monsoon rainfall in catchment, involve other elements of the hydro-geomorphic system as well. The intensity, duration and areal coverage of the flood-generating monsoon systems are the most critical factors. Longer duration and basinwide events produce broad hydrographs with large volumes. Drainage basin size and shape, basin slopes and relief, channel and valley morphology, etc. determine the peak discharge, duration and the travel time of flood wave. The combination of meteorological and geomorphic factors determines the spatial variation in peak flood discharge as well as its volume and duration. In this paper, these aspects of the Himalayan and Peninsular rivers have been discussed with examples.

Another aspect that is critical for the improved understanding of the flood hazards in India is the occurrence, frequency and spatial distribution of geomorphologically effective floods. In terms of the geomorphic impact of floods, the frequency of large magnitude events, the ratio between mean monsoon discharge and the peak discharge and the flood power are more important than absolute magnitude of large floods. The Flash-Flood Magnitude Index (FFMI) is another widely used measure of the variability of flood frequency. In this present paper, some data on the mean-to-peak ratio, FFMI, flood power and geomorphic effectiveness for some large Indian rivers are presented and interpreted. The long-term trends in the annual peak discharges for some large Indian rivers are also discussed. The trend analysis indicates significant spatial variations.

Regional envelope curves encompassing the highest floods on record have been used by flood hydrologists and geomorphologists to evaluate the tendency of rivers in a region to produce large-magnitude floods. For ungauged rivers, regional envelope curves have been used to approximately estimate the magnitude of extreme floods. In the present paper, an attempt has been made to present such an envelope curve for Indian rivers.

Streamflow records in India are generally short for some rivers and non-existent for others. Extreme monsoon floods, with a recurrence interval of over 50 or 100 years, are not generally represented in the short-term river gauging station data. Therefore, conventional flood-frequency analysis alone cannot predict the occurrence of extreme and geomorphologically effective flood events. As a result, hydrologists and geomorphologists have turned to other sources of information, such as historical records and palaeoflood records. Palaeoflood hydrology, as discussed in this paper, has been used to quantitatively reconstruct hydrologic variability for about the last 500-2000 years in some Peninsular rivers. Another advantage of the palaeoflood data is that it provides information on the tendency of a river to produce large-magnitude floods over a long timescale under given hydro-geomorphic conditions.

The present study demonstrates that flood hazard management in India is extremely challenging due to large spatial and temporal variability in the monsoon rainfall, profound regional differences in the drainage basin and channel characteristics, and short-term hydrological records. Therefore, there is an urgent need to generate more hydrological and geomorphological data on floods and improve the scientific understanding of the flood hazards to mitigate the disastrous effects of extreme floods.

Adjustment to Riverbank Erosion Hazard: A Case Study of Chalyar, Swat Valley, Pakistan

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Erosion due to river channel trenching is a severe problem that has threatened vast tract of agricultural land all over the world. It leads to destruction of valuable land particularly in the fertile river basins. In Pakistan, this problem exists both in plain as well as mountainous areas. In district Swat, riverbank erosion is much severe and causes damages to the already scarce agricultural land and other properties. In Swat valley, riverbank erosion is common, down stream Khawaza Khela. However, at certain localities, it is very disastrous to the life and property of inhabitants of the area. Chalyar, on which the present study is based, is one of the worst river eroded sites.

This paper describes and explains human adjustments to riverbank erosion hazard in Swat valley. In the study area, major causes of river erosion include both natural and anthropogenic ones. The river erosion has affected the inhabitants to a greater extent. Therefore, this study is an attempt to evaluate the menace of river erosion in Swat valley and suggest policy recommendations for reducing its adverse consequences.

Key Words: Riverbank; Erosion; Hazard; Causes; Damages; Mitigation

Bank Instability and Erosion Hazards of the Brahmaputra River near Goalpara Town of Assam

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River bank instability leading to erosion and bank line migration is one of the important fluvio-geomorphic processes by which a river tends to adjust itself with varying conditions of the fluvial regime. Bank erosion and bank line migration triggered by the intensive braiding process is very much active in the Brahmaputra River. The erosion hazard posed by the Brahmaputra is more serious in several vulnerable sites along the Assam-section of the river. Goalpara town of Assam flanked by the unstable channel of the Brahmaputra is such a most erosion-prone site on the south bank of the river. The problem of bank erosion has assumed serious dimension in recent years posing threat to this township. Besides examining the nature and pattern of bank line migration of the Brahmaputra near Goalpara town, this study attempts to analyse the magnitude of bank erosion and its impact on the study area using the techniques of remote sensing, GIS and GPS. This study further tries to highlight the management issues relating to the on going bank erosion problem of the study area.

Impact of Fluvial Processes on Channel Morphology of the Ganga River at Manikpur-Karaghat Point: Some Micro Level Observations and Analysis

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Fluvial Processes generally involve 'Overland Flow' and 'Stream Flow'. The overland flow picks-up particles of mineral matter ranging in size from fine clay to coarse sand or gravel depending on the speed of the flow and the degree to which the particles are bound by plant root lets or held down by a mat of leaves. The stream flow depends on the nature of channel morphology, the channel materials and tools with which the current is armed. Channel morphology includes the consideration of channel length, channel width, channel width, wetted perimeter, channel slope, channel bends etc. (channel cross-sectional characteristics), discharge, velocity etc.(channel fluid dynamics), hydraulic geometry, channel types, channel bed configuration and channel patterns etc.

The present paper deals with such morphological nature of the Ganga channel which after taking its primary sources from the great Himalayan ranges, flows over the great planis stretched between the Himalayas and northern foreland of Peninsular India. Between Manikpur and Karaghat point (Location 25 48 30 N and 81 22 E) the Ganga channel flows over the pure alluvial tract and is affected and controlled by various physical factors which have exercised their demonstrable influence up to considerable extent over the rate of river-bed erosion , channel bank erosion, types of river load, development of longitudinal and transverse profiles and the channel pattern etc. These influences have generated a number of alluvial landforms ranging from pools and riffles bars, meanders and ox-bows, river bluffs, miner rills and gullies, levees dead arms of the channel, sandy pot-holes, sandy ripple marks and vertical cut-banks etc. Micro-level observations reveal the fact that these micro alluvial landforms begin to appear generally after the month of October and take shape up to the end of May and begin to disappear when the monsoon rains start. The regular micro-level observation also makes the point clear that the shape of these micro alluvial landforms vary from year to year, month to month, days to days and even sometimes hours to hours depending on the seasonal variation in flow of water in the channel, slope and flow characteristics, velocity and sediment load, land cover changes, subsurface piping and resultant collapse of top layer of the soil, meander wave length, the nature of soil and channel bank slope etc. The role of anthropogenic factors is also responsible for such variations also.

Episodic Flood Hazard Modeling In Unstable Channel At The Apex Of Inner Delta And Mega-Fans

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An unstable channel, in a strict sense, is where all particles along the wetted perimeter are moving in random simulating equally random and quicker transport of bed materials causing swinging movement of the channel developing multiple defunct channels and causing severe flooding. This paper deliberate on a Mobile Channel model for better prediction of flood hazards.

Architecture of the paper is dealt in three signatures and they are identified by separate portfolio structures.

1. The first signature identifies the various probable spatial identities and two space codes are selected. These are the inner delta of the Damodar and mega- fan of the Tista system. Basic aspects of these two domains are noted in this signature.
2. The second signature encompasses the hydraulic similitude of these systems and detailed channel shift patterns. Two comparisons are made at this level. The inner delta of the Damodar is compared with that of the Ajoy-its northerly neighbor and the mega-fan structure of the Tista is compared with its westerly system of the Kosi.
3. The third signature is about a Mobile Belt Channel model to thwart any episodic flood hazard which these systems are capable of.

Hydro- Geomorphological Study of the Ghat Gad Watershed (Lesser Himalaya), Uttarakhand

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The Ghat Gad watershed is the 4th order tributary of the Bino River (A tributary of the Ramganga) between the fringe of Garhwal and Kumaun region in the lesser Himalaya (Uttarakhand). It covers an area of 2.05km2 between the height of 1120m and 1860m. The main purpose of the study is investigation of hydrological behavior in relation to geomorphologic setting of the highly populated and cultivated catchments in the Lesser Himalaya.

The analysis of the study area is carried out by revenue maps, topographical sheet(530/1), areal photographs, monitoring of data, field observations and personal inquiry methods. Hydrology of the catchment is influenced by the tectonic settling of the region. Kelani formation of rocks plays a significant role in the hydrological behavior of the catchment. Most of the perennial springs are sinking out along the normal faulting and reverse faulting and minor fractures. Four types of aquifers are classified in the study area. Diminishing water discharge of the springs is the serious problem of the catchment.

The water discharge and sediment load of 4 years are also monitored. The average rate of water discharge was 305.37 l/sec/km/y. The average of sediment rate was calculated 514.47 t/km/y.

Structurally, the area has under gone repeated phases of folding and faulting. The different tectonics impulses, varying in the magnitude and directions have left their imprints in the tectonics of the study area. It is noticed that earlier phases of tectonism, have been superimposed by those of the later phases of deformation. The geomorphic imprints of tectonism in the catchment include up hill facing scarps, triangular facets, fault scarps, faulting, folding, slumping, landslide etc. Morphological features are associated either with successive neotectonic uplift of reserve faults. Several episodes of erosion in the forms of mass movement and drying of springs caused by successive neo-tectonic phases that change the morphology of the area. Configuration of the topographic level of these features, height of the hill tops and recharge of springs and turning of stream course suggest post tertiary upliftment in the area.

For the sound environmental management of the natural resources few suggestions have been made for the conservation and regeneration of natural environment.

Assessment of Flooding Characteristics in Kaliaghai Floodplain for Appropriate Flood Preventive Measures and Control of People's Sufferings from Unsafe Conditions

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Some of the recent floods of Kaliaghai-Baghai-Kapaleswari-Chandia river basins (2005,2007 and 2008) of Central Medinipur were reported to be the worst on record. The scale of the recent floods and associated disasters drew immediate offers of technical assistance from major international aid donors to help the Government and NGOs of West Bengal for finding a solution the district's chronic floods problem.

The increasing flood levels, areas of flooding , number of people's sufferings, amount of crop damages, livestock losses and longer term social and economic consequences have proved that the people are living in the region of unsafe conditions. About 33 lakh people of 6 administrative blocks (Sabang, Narayangarh, Patashpur I & II and Bhagawanpur I & II blocks) of Medinipur West and East are still suffering in the longer term flood affected areas.

The present paper describes geographical aspects of flood and their characteristics in central Medinipur of South Bengal, particularly those in 2007 and 2008. The two successive floods had different causes, affected different areas and produced different effects. These differences have been considered for the design of flood mitigation measures. Other environmental aspects like geomorphological characteristics, slope types, hydrological conditions, traditional experiences of the people, land use alterations, historical drainage channels, tidal influences and various engineering structures of the floodplain region are also considered for the preventive measures of floods and people's sufferings.

The present study is based on the analysis of historical maps, SOI topo-sheets, CD Block maps, true colour images and FCC images of the region. Human perception survey is conducted to identify the disasters and ad-hoc relief and rehabilitation measures for the flood affected people during field visits in the region. Cross sectional areas of the channel have been measured and discharges have been estimated for studies on efficiency of the existing channels. Finally the traditional adjustments with the floods are also observed in few places along the course of Kalighai River for understanding the innovative ideas of people to live with the floods in another way of preventive method.

A flood preventive scheme is prepared for the region to reduce the misery of people on the basis of above study. The flooding characteristics are different in all over the river basin possibly due to the situation, micro-topography, drainage characters, location of embankments, encroachment of housing, agricultural fields, brick fields and fish farm ponds into the river beds, upstream limit of tidal flows and the present function of irrigation canals and drainage canals of the river basin. The recorded flooding characteristics of the river basin include as: river floods, flash floods, tidal floods and rain water floods. The geographical background of each flood is also described in this study. The rainwater flood will be a major problem in the region like other areas of the district in coming future.

River Bank Erosion Hazard in the Dalgaon Revenue Circle of the Darrang District of Assam

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River bank erosion hazard in the Dalgaon Revenue Circle of the Darrang District of Assam is studied through superimposition of bank lines layer of the Jia Dhansiri River of the year 2006 on the bank line layer of 2000 in the GIS environment and the spatial change therein is calculated and recorded in attribute table. To measure erosion areas at village level, the village layer created using Revenue Circle map is superimposed on the bank lines layers and erosion areas under each village are calculated and presented here.

It is found that 25 villages out of 167 villages of the study area were affected by river bank erosion during the period under study and in some villages the erosion is so severe that it takes the form of hazard. The river has engulfed 10.56 km2 (13.46%) area of the study area which are basically intensively cropped agricultural lands and homestead areas. The erosion affected villages of the study area are categorised into three categories on the basis of landed area lost due to bank erosion as High Erosion Affected Villages (loss of more than 30% area of the total village area), Medium Erosion Affected Villages (loss of 30% -- 10% area of the to total village area), Low Erosion Affected Villages (loss of less than 10% area of the to total village area). It is revealed in this study that of the 25 erosion affected villages of the study area 5 villages falls in the high erosion category, 4 villages falls under medium erosion category and 16 villages fall under low erosion category.

Observation and examination of the causes/processes of bank erosion reveal that low river bed gradient at some locations, rise of bed level and development of braids, floods, low channel capacity in respect of flow and sediment transportation, gully development, and few anthropogenic factors including deforestation are the principal causes/processes of bank erosion.

Geomorphic Effectiveness of August 2006 Flood on the Tapi River: Assessment based on Flood Hydrograph and Stream-power Graph

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In this paper an attempt has been made to quantitatively assess the geomorphic effectiveness of August 2006 flood that occurred in the middle and lower reaches of the Tapi Basin. Flood hydrograph available for this flood event reveals that the duration of flood can range from 10 to 11 days. Geomorphologically, the channel response to such long-duration floods is likely to be significant particularly in alluvial sections in terms of bed and bank erosion as well as coarse sediment transport. The temporal variations in specific stream energy over the flood period were evaluated for this flood event by constructing stream-power graph. The flood hydrograph, the channel slope and the hydraulic geometry equations were used to compute the unit stream power and to construct the stream-power graph. The graph derived for August 2006 flood indicate that the power per unit area during such fluvial event is sufficiently high for several tens of hours to produce substantial changes in the alluvial reaches of the Tapi River.

Alteration of River Regimes Hazards (Natural and Man Made) in the Upper Jaldhaka River Basin

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The dynamic characteristics of a river regime comes under hammer when dams, barrages etc. are constructed blocking the flow in channels. Such barriers are helpful for irrigation purposes and checking soil erosion but due to natural disasters the hydrologic regime is altered by regulating flow, decreasing peaks and increasing low flows causing drought problems. The present research is concerned with a synoptic and critical review of the existing geo-scientific hazard prevailing in the upper Jaldhaka river basin [latitudinal extent is 26015'N to 27010'N and the longitudinal extent is $88^{0}45^{/}$ E to $89^{0}30'$ E], a sub basin to the Brahmaputra river sub system comprising Darjeeling, Jalpaiguri and Koch Bihar Districts of West Bengal, with a total catchment area of about 3730 square kilometres (approx.).
The present work deals with the fluvial geomorphic hazard of the alteration of the river regime making the region prone to floods and landslides as well as sedimentation following its dynamic characteristics. A recent study on Jaldhaka barrage at Bindu indicates that while flood control, irrigation and to some extent power generation has been achieved, it has drastically altered the natural hydrological and sedimentological transport regime of Jaldhaka river system resulting in massive siltation in the lower courses hampering the paddy fields and creating problems to the paddy cum fish culture done in a rapid scale over there. The recent alteration of the Jhalong Khola and the Murti, the two main left bank tributaries of Jaldhaka has raised concerns for the tea gardens and the reserve forest which is in the verge of destruction as well as delimitation of the water divides causing the Jaldhaka to shift eastwards towards Bhutan and lastly increasing flood problems.

A Study on Flow Characteristics of the Pahumara River, Assam

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Observation and analysis of flow pattern in a river is considered to be one of the important themes in fluvial geomorphology. The potential energy of water under the influence of gravity and gradient starts to flow over the surface developing kinetic energy and erode the surface under the impact of frictional forces producing sediments in the water thereby sculpturing the basin landform. The Pahumara river is one of the important tributary of Beki river originates in the southern slope of the Bhutan Himalaya and traverses a distance of 72 km. covering an area of 793 km2. The basin receives an average annual rainfall of 2400 mm.
In the present paper an attempt has been made to study the flow characteristics of the Pahumara river during 1982 through 2004 at National Highway-31 gauge site. Based on available data related statistical techniques is applied to study the pattern of flow in the river. A rating curve has also prepared to understand the degradation in the basin.
Although the study is preliminary in nature yet it provides some base line information for further study in the basin besides it has academic value.

Flood and Associated Geo-Environmental Characteristics and Their Impact on Socio-Economic Profile at Lower Jinary River Basin in Goalpara District, Assam

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The geo-environmental setting of a region exerts considerable influence on the nature and development of cultural landscape. The general flood and the flash flood and sand deposition etc. are the significant natural hazards that highly influence the socio-economic condition of a region. The Jinari river is one of the important south bank tributaries of the Brahmaputra river originated in the Garo Hills of Meghalaya covers an area of 598 km2 and stretches between $25^0 42^/$ N to $26^0 7^/$ N latitudes and $90^0 20^/$ E to $90^0 40^/$ E longitudes and traverses a distance of about 94 Km. The basin receives an average annual rainfall of 2740 mm with much concentration in the summer months. The lower Jinari basin regularly experiencing flood during summer months affects socio-economic status of the people living in the region. The flood and associated geo-environmental events are influencing tremendously on the life and properties of the common people in the district of Goalpara, but it acts positively in the areas of lower Jinari river basin of the District. The study basically comprises in two villages namely Dubapara and Pahar Singpara covering an area of 672 hectares with a population of 4425 persons in the lower Jinari basin. The two villages is inhabited by a particular community of people migrated from the then East Bengal (now Bangladesh) in the early part of nineteenth century practice a typical agriculture " Sital Pati" for their livelihood. The prevailing flood and geo-environmental settings in the area helps to grow Sital Pati in the area. The present paper is a modest attempt to discuss the positive impact of flood and related geo-environmental characteristics on rural economy in the study area.
Key words : Sital Pati, Geo-environment

Assessment of Geomorphic Hazard in Rudrasagar Lake Basin Area with Special Reference to flooding : A Study from Information Level Data Domain

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Rudrasagar lake basin is one of the flood prone areas of Tripura which suffer by regular flooding during the monsoon. The geomorphic condition of this area is very much responsible for water logging in this area during every monsoon season. A systematic perception survey has been conducted by the present author to understand the problem of flooding to the local people in this area. It shows that flood is a serious hazard which creates problem like loss of resources, health hazard etc regularly.
Key words: Flooding, Geomorphic hazard, Information level data domain, Rudrasagar lake

Impact of Sandsplay as Morphological Hazard on Geo-Economic Environment in the Lower Ajoy River Basin, West Bengal

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Flood is undoubtedly the most dreadful event of West Bengal. River Ajoy, a right bank tributary of the Bhagirathi, has been suffering from flood since time immemorial. Sand splay is one of the major post flood geomorphological hazards in the lower Ajoy river basin. Due to various causes, like meandering nature of the river, varying width of both sides embankments and high discharge from the upstream located Hinglow barrage during peak flow period etc, frequent breaching of embankments mainly occur in its lower course along both left and right banks respectively. It has been recorded that in 1978 embankments breached at 20 places and in 2000 it was 22.Out of which sand splay occurred in 17 and 20 sites respectively. Generally huge amount of riverine sands have to pass through the breaching points and deposited in varying depth over micro-morphological units.

Sand splays have great effect on the changing micro morphology over the valley form and alluvial covered plain has transformed into sandy wavy land. The depth of sand cover varies from 50cm to 1 m, which inversely related to the distance of the riverbank. The grain sizes are coarser near the breaching point and gradually become fine towards the outer. Hazardous effect of it is the deterioration of the soil fertility and the agricultural productivity as well as the decreasing of the gross cropped area. The soil status reports of the before and after sand splay have proved the reduction in the nutrient concentration in the soil.

The resultant effect of it is the conversion of the agriculturer to the land less labourers and large landholders become marginal farmers. The villagers become perplexed in experiencing such hazardous elements, as they have not seen any hope of cultivation over those fields in future. This situation has compelled to shift their occupations and they have a tendency to migrate towards the nearby town. Moreover some social unrest, alcoholism, crime, suicide etc social problems have emerged.

The researcher on the basis of the collected official data; field observation and door-to-door survey has studied these painful events after the flood of 2000,remarkable last flood, and the review of the present situation have also been observed after the eight years gap in the year 2008. Though the agronomists and other scientists of different have suggested various measures disciplines but the viability of those are still questionable. Here we cannot ignore the role of the geomorphologists as we may highlight the causes of the frequent breaching of the embankments. We will think over the fact as protective measure whether we will suggest the increasing height of the embankment day by day or the decommissioning of it? So this is the high time for the geomorphologists to show the way to the alternative flood management programme and the proposals should be outlined without hampering the river arena.

Sedimentological Investigation of Bed and Bank Materials in the Jinari River, North East India

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Sedimentological investigation of bed and bank materials through grain-size analysis has been considered to be an important theme in fluvial geomorphology. Sediments are the basic compositional element of landforms reflect the availability of different kinds of bed rock or even pre-existing, resisting of particles to weathering, erosion and abrasion and the process of transportation and deposition. The competence and efficiency of transporting agent can also be estimated through grain-size analysis of sediments. Although, grain-size analysis has extensively been employed in sedimentary petrology, its use in geomorphology so far is rather limited. The study area confined to the Jinari river, a south bank tributary of the Brahmaputra which flow through the states of Meghalaya and Assam. The section of the river from Bajendoba to Dubapara with a length of about 73 Km is taken as the study area. The Archean and Quaternary deposits comprising pebbles, sand, silt, and clay found across the river.

The sedimentological investigation is based on the field work and subsequent laboratory analysis. Sediment samples from the bed and banks of the river are collected randomly. 42 sediment samples are colleted from six different cross sections selected across 73 km length of the river. The collected sediment samples are analysed in the laboratory through sieving and plummet balance method to ascertain grain-sizes and results are analysed using both graphical as well as statistical techniques.

Here an attempt has been made to examine the fluvio-sedimentary environment of the Jinari river of North East India based on sedimentological investigations of bed and bank materials.

Application of Geomorphology in Flood Hazard Assessment: The case of Kaliaghai Basin, Purba and Paschim Medinipur Districts, West Bengal

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Geomorphological understanding has long been applied in flood hazard studies. The approach has instigated a research paradigm which encompasses assessment of risks from flood events, accounting for people's perception about flood, identification of adjustment alternatives to cope with the hazard, evaluation of the method by which people choose to adjust and appraisal of the public policies adopted to mitigate devastating effects of flood. This approach has succeeded to collect enough intellectual support as it provides a framework that accommodates both physical processes and human systems into the fold of flood investigation and thus can guide towards pragmatic solution to the problem. The present work deals with geomorphological perspectives of the recurring flood events in lower Kaliaghai flood basin of Purba and Paschim Medinipur districts, West Bengal. Particular emphasis has been given to the 2008 flood, damaging effects of which has beaten all the past experiences in memory.

River Kaliaghai, after being originated from a sweet-water spring at Dhudkundi in Jhargram subdivision of Paschim Medinipur district, has followed a highly sinuous course towards east and ultimately debouches into River Kangsabati. Along with the Kaliaghai River itself and numerous canals, the basin under

study is drained by three major tributaries of Kaliaghai- Kapaleswari and Chandia on the left and Bagui on the right bank. The entire course of Kaliaghai exhibits three geomorphologically different segments. From its source to Bagui confluence, the river has traversed being guided by regional slope. Then it enters into a saucer-shaped central basin and continues to flow across the basin until it joins River Chandia. The lower Kaliaghai course is dominated by inflow and outflow of tidal water rendering the course segment an estuarine character.

The fluvial system of the region has undergone several autogenic and allogenic changes in response to past eustatic and isostatic forces as well as recent anthropogenic modifications in the stream environment. At some point of time, during early Holocene period (9000-5000 y. B.P), when rapid warming caused global scale deglaciation and world wide rise in sea level, the sea extended upto the area where the central basin presently lies and River Kaliaghai had been maintaining a straighter course over the Medinipur upland margin to join the then sea. But in Post-Holocene period (3000-2500 y B.P) sea receded to take present position and large scale depositional processes led South Bengal Basin to emerge in the form of a Delta complex inter-cepted by braided channels. As such, Kaliaghai had extended its course in a sinuous pattern over the newly exposed surface. In association with this, Medinipur upland had undergone slow uplift in response to neotectonics and River Kaliaghai had adjusted the uplift by increasing its sinuosity in its downstream section. Accretion and isostatic rise of delta masses to the north and south of the River Kaliaghai caused the central basin to evolve in an upward concave fashion. Accordingly, drainage system of the area underwent evolutionary changes with the alterations in river basin morphology which involved sluggishness in stream flow, develop-ment of meanders, sedimentation etc. within the central basin.

The flood problem of nine blocks in the Kaliaghai- Kapaleswari-Bagui riverine complex has emerged as a response to the adjustments in flow and sediment regimes under above mentioned topographic modifications. In addition to absolute mismatch between sediment load and power of Kaliaghai, estuarine influence that reaches upto Langalkata (to the west of Kaliaghai-Chandia confluence), has caused the river to become incapable of flushing out all the sediments. As such, enormous sedimentation near Langalkata has been manifested in the form of bar formation along with a reversal in channel bed gradient. Cumulative effects of all these factors have led the Kaliaghai channel to arrive into a new adjustment through revival of its earlier course along Rasulpur estuary. The situation becomes episodic in years of high intensity monsoon rainfall in the upper catchment of Kaliaghai. Furthermore, incapability of Kaliaghai to drain out water received form its tributaries (Bagui, Kapaleswari and Chandia) causes spilling of water and breaching of embankments and consequent devastating flood. Bottleneck like narrow outlet at the mouth of River Chandia is also another factor that frequently causes breaching of its embankment and the water finds a slope-guided straight course to Kaliaghai inundating the villages on its way.

Besides the above natural adjustments, human activities have also been found to be responsible for introduc-ing changes in the river environment which facilitate the flood situation to pick up momentum. River channelization through straightening, construction of levee and embankments etc. have changed the channel phase. A primary morphological response to the change in flow regime is a decrease in channel capacity, brought about principally by reduction in channel width by setting up of embankments on both the sides of river Kaliaghai and its tributaries. As a result, the rivers fail to accommodate and distribute sediments within the protective areas between embankments. Landuse change in the form of forest clearance for agriculture has caused sediment overloading in the rivers. Accelerated valley floor sedimentation has been increasingly responsible for lessening the recurrence interval of high magnitude floods, vertical accretion of floodplain throughout the drainage system due to increased runoff and extensive bank erosion even along the tributar-ies. Thus removal of natural vegetation has largely increased the catchment sensitivity to extreme climatic events. River flow has also been constricted by occupying valley floor for agricultural plots, fish farm ponds etc.

All the above mentioned factors have been found to orchestrate flood events in the flood basin in question. But several other factors co-acted to make the 2008-flood a catastrophe and exceedingly damaging. Most important among them is- over spilling of flood water from the nearby gigantic river basin of Subarnarekha as a consequence of sudden release of excess water from Chandil reservoir (on Subarnarekha River in Jharkhand). Subarnarekha itself is a flood prone river with frequent occurrences of high energy flash floods. Sudden release of water from Chandil coupled with intensive rainfall (400 mm. within 24 hours) had raised the energy of River Subarnarekha to such a high level that it virtually failed to distribute it within the available basin area. As a result, the natural barrier between Kaliaghai and Subarnarekha basins had been over run by spilling water from Subarnarekha and thus the episodic rise in energy level has been adjusted by inter-basin energy transfer. This has been favoured by the fact that the protective strength of the said divide has been weakened by deforestation. Furthermore, once Kaliaghai had served as a distributary to Subarnarekha River which probably got separated from the parent river due to neotectonic uplift of the said divide. Unprecedented rise in flood water level have made Subarnarekha to cope with the catastrophe by capturing the course of its older distributary. But Kaliaghai, being a small river basin, could not accommodate such a huge volume of flood water inflow came in the form of about 20 feet high water-wall which swept away everything that came in its way leaving no time for preparedness. Here lies the essence of the study as this is really a rare event of geomorphological interests.

The episodic flood event of 2008 in the study area has left many physical impacts on the landscape. Concentration of high energy flow have caused the system to cross geomorphic threshold set by channel slope modification that has taken place for a long period of time in response to its adjustment with modified basin morphometry as well as changes in flow and sediment regimes. The flood water of Kaliaghai had drained out down its older course through Rasulpur estuary inundating the areas in between. The embankment that was set to guide the channel flow along Hugli estuary has encountered breaches at about 26 locations within a stretch of only 2.5 km. The geomorphological significance of the fact is that, in response to long adjustment with slope modifications, Kaliaghai tends to reestablish itself along its older course that represents the present slope. Hence, the entire stretch of the earlier course of Kaliaghai, from Subarnarekha off-take to Rasulpur estuary, has been rejuvenated by the catastrophic flood event (2008) and any management decision toward flood control should take this point into account.

The nature of damaging impacts of the flood episode exhibits spatial variability along Kaliaghai course. The flood affected areas in the upper catchment experienced a short term but colossal impacts. Due to suddenness and unforeseen strength of the event people were readily exposed to high energy flood and could not save their assets and livestock. But the flood water drained out within three days. While in the lower catchment, vast area became inundated by over spilling of water and breaching of embankment. Water could not find any way to be drained out and became stagnant for more than a month. Hence, people suffered primarily from the long term effects of the flood. They had to temporarily settle on the embankments with all their belongings; depend on flood relief; suffer from epidemics, scarcity of drinking water, loss of agricultural crops etc.

Taking the above perspectives into account this is reasonable to state that, the key to handle flood hazards in this area lies in managing the fluvial environment as a whole. It should be considered that, the river Kaliaghai seeks to establish its channel morphology in the tune of the prevailing hydrologic and sedimentological conditions so that it can continue to carry its discharge and loads as efficiently as possible. Therefore, in formulating management strategies, attention should be paid to sensitivity of the river system to extreme climatic events, changes that may come about in response to the management actions, human activities that have either changed the catchment conditions of the river channel itself, linkages between fluvial and marine environments, interrelationships among the channel form components, importance of linkages among the flood plain geomorphic components etc. Proper geomorphological assessment of flood hazards encapsulates all these aspects and therefore, offers opportunities to take decisions in tackling the flood situations.

Geomorphic Hazards Associated with Decaying Channels of the Hugli District: A Case Study of the Kana Nadi Basin.

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River has a general tendency to maintain a state of balance or equilibrium right from the very beginning and irrespective of whether the river is flowing over a steep or gentle gradient. However, such equilibrium may be disturbed due to various fluvial, hydrological and hydraulic aspects. When such disturbances occur, the delicate balance is lost and is eventually followed by the occurrence of a number of geomorphic hazards..

As regards the geomorphic hazards of a decaying river like Kana Nadi, it has been observed that reduction the flow of water within the channel is one of the major hydro-geomorphic hazards and such decay may lead to further problems such as derangement of drainage, changes in the river course, moribund state of the channel and to some extent almost drying up of the channel. In addition, noticeable fluctuation in the river discharge may further lead to loss of equilibrium condition of the channel which in turn aggravates the hydrological problems.

A preliminary observation of the Kana Nadi from the secondary spatial data like Toposheet (Ref. No. 79 B/ 5 & 79 A/8) and imageries as well as from the field work of the study area clearly reveals that the catchment area of Kana Nadi is a fertile agricultural tract with a number of villages around. It is therefore very much significant to identify the spatial pattern of hydro-geomorphic hazards and to examine the impact of each problem on the agricultural land use as well as on settlements.

Apart from the natural processes, anthropogenic activities in the form of human interference in the catchment area, implementation of river valley project etc. may further accentuate the already existing geomorphic hazards that require proper attention and scientific management and on the basis of observation & analysis of various geomorphic problems some recommendations have been made in order to ameliorate the problems of decaying river & finally a proposal for rational water resource management & optimal land use planning has been suggested.

Geomorphological Characteristics and Fluvial Hazards of the North Tripura District, Tripura

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The North Tripura District of the Tripura State, being drained by the rivers like the Manu, the Deo, the Juri and the Longai, consists of various types of landscapes including relatively narrow hill ranges, low undulating hillocks, intermontane valleys and riverine plains. The present paper concerns a detailed investigation on the development of complex geomorphological entity of the terrain, the constituent elements of landscapes, the related landforms, geological setup, drainage status, soil characteristics etc. along with hazards related to exogenetic processes like soil erosion, landslides, river bank erosion and river migration, floods etc. Unfavourable climatic conditions in combination with human activity increases the severity of hazards, e,g, deforestation and shifting cultivation, locally known as jhum cultivation, accelerates soil erosion; unplanned constructional activity along with fragile hill slope enhances landslides and landslips as well as flooding and water logging in plain land. After elucidating the geomorphic personalities of the District some recommendations have been offered for combating the environmental hazards like landslides, soil erosion, river bank erosion, flood etc.

Intangible Bank Erosion: A threat to the life of Sundarbans, West Bengal

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One of the biggest challenges now days to the people living along with the rivers in the largest delta of the world i.e. the Sundarbans is the bank erosion, a notable geomorphic hazard. The rivers which served the people of this region years after years are becoming more and more unreliable to be inhabited. Bank erosion mechanics are not only related to the forces of erosion but to the size, geometry, and structure of the banks as well as the properties of the bank material also. Several Govt. and private or local efforts have been made to find out the root of the causes behind this mechanism and to finish the problem forever, but every time it has been proved wrong.

Several reasons have been found by different eminent geographers and social-activists behind the regular bank failure in this region. But this paper is focused on that invisible process which is working day and night without any indications and making the platform for the sudden bank collapse. We can also categorize the causes of bank erosion of this part on the basis of genesis or sources into two, such as -

A. Bank erosion caused due to cyclonic storm surges.

B. Bank erosion caused due to continuous tidal activities.

Due to the rapid and sudden bank erosion in the Sundarbans the socio-economic conditions are growing through a turmoil situation. This problem of bank failure was occasional just a few decades ago and local people were at least a little bit accustomed with this. But now days it's as regular matter in Sundarbans of India. As it's a result of combined activity of man and nature, so, a detailed study has been done in Sundarbans and Matla-Bidyadhari interfluve of this region has been selected as a study area. It lies in both the active and mature delta and is located in the central part of Indian Sundarbans. Here, in this regard, investigations have been done in some selected spots of Matla-Bidyadhari interfluve. Geomorphological studies have been done on the probable processes of bank erosion, causes of bank erosion and the dynamic pattern of bank erosion through field work. As this problem is of entire Sundarbans so, we can't ignore the natural causes also. Surprisingly it was observed that the major reason behind this awesome phenomenon in day to day life of the people of Sundarbans is the effects of the tidal and ebb currents occurring twice a day below and above the R.Matla, R.Bidyadhari, R.Hogol etc... In every case it was noticed that the under-current mechanism of the tide and ebb which play a major role in the building process of this largest delta, is mainly responsible to the bank erosion in the Sundarbans. Along with it a socio-economic study has also been conducted here through door to door survey with scheduled questionnaires.

As it is a problem of ours and nature should always be given priority, so, natural problems must be solved naturally. For this, some suggestive measures have been put forth in this regard as a geographer and hope this model area i.e. Matla-Bidyadhari Interfluve may reveal the pulse rate of the bank erosion which is a threat to the life of the Sundarbans.

Flood Hazard in Mangalkote Block, Barddhaman: Preparedness and Mitigation Issues

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Block Mangalkote is situated by the side of river Ajoy and Kunur in the Barddhaman district of West Bengal. This close proximity has been instrumental in bringing utmost misery to its people through disastrous flood every year. To mitigate this hazard, a comprehensive hazard preparedness and response plan has been formulated at the block level. Flood prone areas are delineated and identification of vulnerable groups & people along with flood shelter and its accommodation are assessed. Mapping of vulnerable area and resource availability is being done. Awareness generation and community- based preparedness have been given importance. Communication system for dissemination of message, both horizontally and vertically, is being developed through activating telecommunication service. Steps have been taken for collection of daily rainfall, weather report and river water level. When the message is received about the occurrence of flood, the task force at gram panchayat level moves to the spot, assesses the need, deploy action group through mobilizing volunteers for the purpose of rescue, if necessary, and report to the block. Having been received the report, the block level task force arranges necessary requirement with a view to minimizing the toll. Post disaster arrangement is done providing financial assistance for the rebuilding of damaged house, restoration of rural assets and alternative crop cultivation.

Natural Hazards andTheir Impact on Land-use of North Bengal

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The Tista-Jaldhaka interfluve is marked by the occurrence of complex, compound and composite drainage peculiarities. It is worth mentioning that the diametrically opposite drainage pattern has also imparted a uniqueness to the interfluve area. There are limitations of conventional study of Geomorphology and environmental hazards like floods etc. along with tectonic activity in this unstable area. The present paper is an outcome of a micro level study of Chel- Neora inter basin of North Bengal.Techtonically the area is very unstable and the lower part mainly near the confluence of R Mal and Neora flood has become more violent; even every year several agricultural plots, settlements are washed out. In the study area flood occurs where heavy and wide spread rain and water flows above the bank. Sudden break of slope from north to south causes huge amount of siltation on the lower reaches of the rivers and thereby decreases the depth. During every monsoon period most of these rivers fail to carry the extra amount of water and causes flood. Moreover, very deep, imperfectly or poorly drained loamy or silty soils in alluvial plains are highly erosive with low water holding capacity. Thus , almost every year rivers like Mal, Chel Neora change their channel due to flood and bank erosion which leads to the severe damage of agriculture, settlements, forest cover. If we compare the land use pattern, a vast change in area distribution could be noticed both in meso and micro level. Different types of management plan have so far been taken from both the government and non-government levels but most of them failed to check such hazard because of the lack of their scientific implementation. Thus, it is the high time to aware the common people and to take proper scientific measurement to control such menace on a long term basis.

Causes and Consequences of Flash Flood: A Case Study of Kharsoti and Its Adjoining River Basins, Jharkhand

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Flash floods, short-lived extreme events, which usually occur under slowly moving or stationary thunder-storms, lasting less than 24 hours are a common disaster in Jharkhand especially in Subarnarekha River and its tributaries like Kharsoti. This kind of floods is associated with convective events producing high rainfall intensities. As a result of the high velocity of the current which can wash away all obstacles in its way, this phenomenon has resulted in enormous loss of life and property in various parts of the region. Severe soil erosion is the result of flash flood in Kharsoti and its adjoining river basins. The disappearances of gullies are probably due to a high infiltration rate and thin soils which is also the effects of flash floods in this area. The aim of the present study is to analyse the recent flash flood event within the framework of the characteristics of flood events .To achieve this purpose all flood events occurred between 1980 and 2008 have been analysed.. Analysis studies have been implemented by means of Geographical Information Systems and Remote Sensing Technologies and also satellite images and topographical maps in different scales as well as water and sediment discharge data have been used. Data obtained by means of this analysis demonstrates that geopraphical feature Kharsoti River's Basin has very adequate conditions for natural disasters such as floods and flash floods. This work analyzes various morphometric characteristics of the Kharsoti river basin in order to evaluate flash flood hazards. For this purpose, the basin is divided into sub-basins and some basic measurements (surface, perimeter, basin length, river beds, elevations and slope of the main river bed, and of a number of minor river beds) are calculated. These measurements permit to predict approximately the behaviour of the basin in the presence of a series of theoretical rainstorms that may generate unusual runoff volumes that make up such flash floods. Because of the heterogeneities of the rain and of the behaviour of the surface, spatially distributed hydrological models can lead to a better understanding of the processes and so on they can contribute to a better forecasting of flash flood.

Effect of Jhum Cultivation on Manu-Deo River Morphology and the Role of WDPSCA for Its Management in Tripura, North-East India

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Shifting cultivation, popularly known as jhum cultivation, is a primitive type of agricultural system, well practiced by the tribal inhabitants of Tripura State in the hill slopes. It has a long-term negative impact upon the physical as well as socio - cultural environment. Both State and Central Governments, for last many years, are trying to decrease the rate of jhum practice but till now in the hilly interiors it is well practiced due to lack of proper awareness among the tribal people, slow implementation of government policies etc. Especially the upper catchments of the Manu-Deo River (North and Dhalai Tripura Districts) are under intense use of Jhum cultivation which accelerates the rate of some crucial fluvial hazards like landslip, sedimentation in river bed, bank erosion, changes in channel geometry, floods etc in upper as well as in the lower part of the river basin area. As it is a "slash and burn method" it increases the rate of deforestation, soil erosion, degradation of slope of land, depletion of soil nutrients etc.

From intensive field study, it has been found that within this river basin Kanchanpur Sub-Division has the highest number of jhumia families in the State which proves the fact that the upper catchment areas of the River Manu and Deo are characterized by this practice of jhum cultivation. A large number of tribal inhabitants of Chawmanu Sub-Division are also engaged in this agricultural practice. Previous Government Reports show that in northeastern part of the Manu-Deo River basin 50-75% area was under this jhum practice, whereas in east, west, and southern part 25-50% and in the northern part 10- 25% area were under jhum cultivation. Field studies also reveal that due to shifting cultivation several fluvial hazards have taken place, which are responsible for physical as well as socio- cultural degradation of the basin area. If this primitive agricultural system is not checked immediately then it may cause severe environmental disaster in the Lower Manu-Deo River basin. In order to tackle the problem related to shifting cultivation micro watershed-wise planning and management is fruitful. During VIIIth Plan period (w.e.f. 1994-95) Watershed Development Project in Shifting Cultivation Areas (WDPSCA) was implemented in Tripura with full assistance from Central Govt. In Tripura from VIIIth to Xth Five Year Plan Period total 53 micro watersheds have already been brought under this scheme and have implemented successfully. For XIth Plan Period 33 watersheds (07 in North Tripura District, 07 in Dhalai District, 10 in West Tripura District and 09 in South Tripura District) have been selected and proposed for the implementation of this project.
This paper deals with the assessment of negative effects of jhum cultivation on the channel geometry of the Manu-Deo River flowing through the vulnerable areas of North Tripura District and Dhalai District of Tripura State. The role of WDPSCA for proper management of such problems has also been analysed.

Key Words: Jhum cultivation, Fluvial Hazards, Socio-cultural environment, Tribal people, WDPSCA, Planning and Management.

Decaying River Ichamati and its Impact on Environment of West Bengal

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The River Ichamati, distributary of the river Ganga-Padma has been in a lamentable state of decay, since 1942. The upper course of the river has completely been silted up disconnecting the river from its source without having no water supply from the Ganga-Padma. The river can only be traced from Barigopalpur (North 24 Parganas, W.B.) to further south. At present the river is totally dependent for its supply of water from the tides, which has been influencing the river twice daily bringing not only salinity but also sediments. Such incursions of tidal water allow the river to be silted up due to the deposition phenomena of the low tide. Moreover anthropogenic activities in the form of paddy cum fish culture, dumping of refuses of the brick kilns to the river bed and encroachment the river bed by refugees from Bangladesh. As a result the river bed has been silted up and depth of the river has been alarming reduced. During the monsoon months high rainfall coupled with increased amount of run-off cannot be accommodated with in such reduced channel of the river Ichamati, increasing the intensity of flood. In recent years of 1968, 1978 and 2000 Ichamati basin had experienced devastating floods affecting the lives and properties of about 100,000 peoples.
Present researcher, as such has been investigating into the reasons of such decay with help of intensive fieldwork applying various quantitative methods to reach a possible conclusion.

Assessment of Risk and Vulnerability of Fluvial Hazards in the Khowai River Basin, Tripura, North-East India

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Tripura is located in the south-western part of North-East India and thus tectonically active and geomorphologically unstable. The River Khowai is an antecedent drainage flowing through a synclinal valley in between two anticlines namely Baramura Hill Range and Atharamura Hill Range which are the two off-shoots of the Himalayas. After cutting through the Atharamura Hill Range, the river takes a sharp northward bend near Teliamura and flows through the syncline towards Bangladesh and after crossing the border, joins the River Kushiyara. This river is highly vulnerable to different fluvial hazards like land slips, sedimentation, bank erosion, shifting of channel and floods. Presence of fragile rock, steep unstable slopes, heavy monsoon rain (>2000 mm), practice of jhum cultivation in the hilly catchments, deforestation in the hill ranges, rapid growth of population and consequent changes in land use and land cover, development of infrastructures and man-induced changes in run-off are playing active role behind such hazards.
Hazard is the probability of occurrence, within a specific period of time and within a given area, of a potentially damaging phenomenon (Varnes 1984 and UNDRO 1991). Risk is the expected degree of loss due to any hazard whereas Vulnerability is the ability of the exposed elements to withstand the hazard.
In this paper the researchers have tried to identify the causes, both natural as well as anthropogenic, responsible for each and every fluvial hazards of the River Khowai though they are inter-linked with each other. GIS and Remote Sensing tools have been used for different hazard and risk assessment. Vulnerability maps have been prepared on the basis of population, economic value of the property and infrastructure. At last, by combining the vulnerability map and the hazard map, areas have been categorized as per priority for implementation of different plans and mitigation measures.

Flood Hazard and Its Mitigation in the Lower Subarnarekha Basin, West Bengal

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Flood is common disastrous phenomenon in the Lower Subarnrarekha Basin in West Medinipur District of West Bengal. The river becomes unable to carry excess amount of water during monsoon period because of increasing bed height due to excessive sedimentation, flatness of topography, increasing bank erosion along alluvial soil layers and above all human intervention. Near West Medinipur district it appears as the most hazardous and sometime becomes a disastrous event causing huge damages to settlement and loss of agricultural resources. It may be essential to reduce the severity of flood because of such severe damages to lives and properties. This paper aims at studying such hazard and its mitigation in the Lower Subarnarekha Basin, West Bengal

Flood Frequency Mapping of Haora River - A Case Study in Pratapgarh

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Geomorphic hazard is always a burning problem to mankind and it is surely a work of a geographer to understand the causal factors in order to find the means to mitigate them. The present paper deals with the problem of flood of the River Haora flowing through the western part of the Tripura State. Haora is "the lifeline of Agartala Municipal Area" but on the other hand, the rural people on its left bank suffer from devastating flood in most of the years.

This paper deals with the probable causes of flood in the Haora River, amongst which natural causes like soil texture, heavy rainfall, wide catchment area, meandering course, high discharge etc and anthropogenic causes like large scale deforestation, soil erosion, sediment load, garbage accumulation within the channel, bank cutting, extraction of sand from the river bed, construction of bridges, embankments etc have been analysed. Effect of floods is confined in the lower part of the river at Pratapgarh, Jirania, Reshambagan, Old Agartala etc areas The effects of flood in the study area have been discussed under three heads namely, Primary, Secondary and Tertiary effects Lastly some mitigation measures have been suggested to minimize the frequent loss of agricultural crops and also the loss of property of the poor people who acquire the land within the channel slopes.

In this paper, only, flood hazard of Pratapgarh has been considered as a case study. An attempt has been made to prepare flood frequency map of Pratapgarh area. For this purpose different statistical records have been collected. These records contain mean daily discharge, monthly discharge records and water level of the River Haora at Pratapgarh for last 20 years. This data has been used for constructing rating curve and flood frequency curve (plot of discharge versus statistical recurrence interval) for a particular gauging station i.e. Pratapgarh. On the Mouza Map of Pratapgarh each and every plots affected by last year floods have been marked after consultation with the villagers. From this flood frequency map of Pratapgarh, areas susceptible to flood can be identified. Again with the help of this flood frequency mapping the return period of a particular magnitude of flood can be chalked out and accordingly chances of the occurrence of the same event can be announced well in advance.

A Study on the Changing Behaviour of Rangapani Nadi due to Land Degradation in West Tripura

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Rivers of Tripura are characterized by muddy water due to high rate of siltation and therefore the region is known as the "Land of Red Rivers". Now a days the Rangapani Nadi (Ranga = red and Pani = water i.e. river with red water), a tributary to the River Bijoy, is suffering from some problems originated due to degradation of tilla lands of the river basin. The river basin is located in a syncline surrounded by the Rokhia anticline in the southwest and Baramura anticline in the northeast. 30% of the total basin area is occupied by tipam group of rock formation and 20% by dupitila rock formation which are fragile in nature. Geomorphologically, the Rangapani basin area is composed of Tilla land (60%), Lunga land (10%) and Plain land (30%). In Tripura, tilla means small mound or hill, lunga is narrow valley adjacent to the tilla lands which are fluviatile in origin and ultimately merges with the plain lands.

In this paper an attempt has been made to study the hydraulics of the Rangapani Nadi like velocity, discharge, cross sectional area, wetted perimeter, hydraulic radius etc. In the study area both natural and anthropogenic factors have been identified for degradation of tilla lands which are ultimately responsible for the gradual retreat of the tilla slopes of this basin. Physical factors include nature of rock, weathering, mass wasting, high rainfall, rill and gully erosion, slope retreat, nature of soil etc. and anthropogenic factors include deforestation, jhum cultivation, overgrazing etc. and these have been identified as very much crucial for such problem.
Main stress has been given on the consequences of this tilla land degradation which ultimately affects the normal behaviour of the Rangapani Nadi. The effects are high rate of land slip and sedimentation, flood, bank erosion and shifting of the channel bed etc and thus changes in the river geometry. In this paper all the above mentioned factors and resultant changes have been discussed with the help of quantitative analyses. Such changes in river behaviour become responsible for different natural hazards and often become disastrous. Therefore some proposals have been put forward to mitigate such changes in the river behaviour of this neo-tectonic region like Tripura.

Spatio-Temporal Analysis of flood and Flood Hazard Zonation Mapping in the West Tripura District

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Every year the state of Tripura experiences different natural calamities like-floods, river bank erosion, droughts, hails, storms etc. Being the most populous district of the state, West Tripura is considered to be the most flood prone zone. Flooding in the district largely affect people and their livelihood. Rainfall, thunder squalls, low gradient of the plains, shifting river courses and human interferences are the main reasons behind such menace among which heavy and concentrated monsoon rainfall is the most important. For the present study spatio-temporal analysis of monsoon rainfall of this district during last 10-15 years has been made along with other factors to prepare a detailed flood hazard zonation map.

Changes in Channel Morphometry of the River Gumti: Some Case Studies in South Tripura

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Gumti is the largest river of Tripura State. It is 133 km long and its average width is about 100m, total discharge is 3,738 cumecs and total annual flow is 24,93,99,000 cubic metre. At the time of normal rainfall, water level of the river rises above 1.5 m than the level of the surrounding areas and during winter it shrinks and become fordable at most places. Now a days the river is suffering from different hydrological problems. Moreover, the building of dam for generation of hydel power and other multipurpose activities have affected the river morphology to some extent.
This paper deals with the causes and effects of some fluvial hazards at some selected sites of the River Gumti and more emphasis has been given on the effects on channel morphometry.
(i) Bar formation near Radhakishorepur. At this place a small bar was first identified in the year 1998 and within this period of ten years a good number of bars have been formed within a total stretch of 1 km length and now the total lenth of the bars is 380m and average width is 32.60 m. This bar formation is closely associated with the largely reduced fluvial discharge and increase in sediment load. Due to the rapid growth

of channel bar, the river Gumti is gradually loosing its water holding capacity and therefore frequency and magnitude of flood has been increased in the rainy seasons. These bars are extended towards right bank as a result of which erosion is becoming more on the left bank. Due to this bank erosion, people of the left bank are forced to shift their houses elsewhere. As a result of which landuse pattern of that particular area has changed. Above all, the cross sectional area, Hydraulic Radius, wetted Perimeter etc have also changed.

(ii) Bank erosion at Fotamati. At this place huge slumping of the right bank took place in the monsoon month of the year 2007 which caused 40 families to lose their home. In this paper, causes of this particular incident have been studied in detail. Different changes in channel morphometry like hydraulic radius, wetted perimeter, cross sectional area etc have been studied Moreover, some measures for minimizing the chances of huge losses have been mentioned.

(iii) Effect of Dumbura Dam at Nutan Bazar. After construction of the Dumbura dam at the junction of the River Raima and Sarma in the upstream of the River Gumti in the year 1979, some hydrological changes in the river have been marked. The Dumbura Hydel Power Project generates about 08 MW electricity. This dam restricts the steady flow of water and causes heavy siltation in the lower reach of the river. Primary data shows that1980 onwards, width of the river Gumti has gradually increased and the depth has gradually decreased in the downstream at Natun Bazar At this part changes in the channel morphometry from 1980 to 2008 have been studied and the changes have been identified very clearly.

In all three cases, the measures for mitigating the losses due to such changes in channel morphometry have been mentioned. For this purpose areas under risk of fluvial hazards related to such changes have been identified.

Effects of Shrinkage of Wetlands and Barrage on Fluvial Environment: Two Case Studies in Khowai River Basin in Teliamura Subdivision, Tripura West

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Wetlands are places where land and water meets. Wetlands have been described as "the kidneys of the landscape" because of their water purifying roles and "biological supermarkets" because of their natural resources which humans exploit. Human dependence on water is absolute and so is our dependence on wetlands. A marked change in extension of wetlands during pre and post 1950's on either side of the River Khowai in Teliamura subdivision, Tripura (West) is responsible for some changes in fluvial environment of the Khowai River basin. These wet lands or mara lands were the depositional features formed in the flood plains, behind the natural levees as back swamp deposits. During field survey in the year 2008 some seasonal or parmenant bils are found only in Golabari, Trishabari, Champlai and Icharbil. This paper deals with the causative factors behind such shrinkage of wetlands in this part of the Khowai basin and the consequences on fluvial environment, particularly the occurrences of frequent flood, bank erosion and shifting of the channel.

Again a few km upstream from this area a barrage has been constructed at Chakmaghat, 5 km away from Teliamura town in the year 1997. This barrage was constructed to facilitate the rabi crop cultivation in large part of the Teliamura Sub-Division. With the implementation of this barrage good agricultural progress has been taken place through the left bank canal and the irrigation facility through the right bank is yet to be started. An attempt has also been made to identify the effects of this barrage, both positive and negative, on the fluvial environment at this part of the basin.

Fluvial Processes and Related Hazards: A retrospection of Kosi flood of 18th of August, 2008

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The Kosi is an important tributary of the Ganga. The river originates in Tibet (China). Having a turbulent course across the Nepal Himalaya where it receives a number of tributaries it enters north Bihar plain and ultimately joins the Ganga to the west of Katihar. The catchment area of the Kosi River spreads over eastern Nepal and further to the north in Tibet (China) where the river originates. During southwest monsoon the river collects enormous discharge from Nepal. Especially in years when the monsoon rainfall in the Nepal Himalaya exceeds 1200 mm, the Kosi is in spate.

Through ages the Kosi used to fan out its silt laden water over the Bihar Plain. The plain of Mithila, which is the contribution of the Kosi River is a fertile alluvial tract, genetically defined as Kosi alluvial fan. But embankments associated with the Kosi Project have hindered the spilling. Occasionally, during the southwest monsoon, the river breaches the embankment and causes inundation.

The Kosi River, because of its oscillatory nature and devastating floods, is known as "the sorrow of Bihar". This year also, Kosi breached its eastern embankment at Kusaha in Sunsari district of Nepal on 18th of August, 2008, vast area of north Bihar got flooded and millions of people were seriously affected. A hundred people have died, about three million have been rendered homeless and a thousand are missing in Bihar. Another 35,000 people became homeless in four panchayats of Nepal. Bursting through the embankment, the Kosi has created a water mass that is 150 km long and 36 km wide. It looks like a distributary branching off at breach point. Satellite images provide a synoptic view of the affected area in near real time. Hence proper management of the Kosi floodplain can be done.

HILLSLOPE GEOMORPHOLOGY AND HAZARDS

Special Lecture

Landslides in Sikkim Himalayas and Their Control

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What happened earlier to Darjiling happened in Sikkim about 60 years later. The situation here is equally bleak. Steep to very steep hillsides are under shifting cultivation leading to formation to slip cycles and descent of slides. Transportation is fairly hazardous, slips occurring frequently, blocking and damaging roads, especially during rains.

The region under consideration has a very intricate geological history. Socio-geographical factors have combined with it to produce a site of very diverse sliding phenomena. Many of them endanger settlements, highways, canals and public utilities. The residents of this area and the large influx of yearly tourists are forced to consider themselves possible victims of landslides. Total yearly loss of agricultural products, mainly tea, vegetables and rice is fairly high. Threat to human lives and property is ever increasing.

In recognition of the acuteness of problems relating to landslides, it is found desirable to sum up our knowledge of slope stability in the present research work, so as to provide information on the origin of slope movements and the methods of their investigation, prevention and control. A series of case studies has been performed in the capital town of Gangtok and its surroundings and their comprehensive treatments for a better understanding of the acute natural disaster.

Human Activities, Deforestation and Occurrence of Landslides in Meghalaya

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Geomorphology is an important component of environment resource management. It provides scientific basis for analysis of terrain particularly geo-hazards and geomorphic risks associated with it, Among the natural hazards mass movement is one of the most important catastrophic process involving modification of the surface morphology. Lithologic characteristics of rocks, nature of slopes and seismic activities are the main natural factors that lead to occurrence of landslides. But today with increase in various human activities in mountainous areas the occurrence of landslides are becoming more anthropogenic in nature than any other factors. With its total neglect towards ecology and environment, man himself has generated the phenomena of landslides and has become its victim.

Meghalaya is one of the seven states of North-Eastern Region of India. The neo-tectonic movements in the region indicate that these sutures are still active. The over exploitation of resources has caused serious imbalances. Most of human activities are aimed to exploit land, mineral and forest resources. Landslides are mostly confined along road sides. The present paper has tried to analyse the anthropogenic activities and its impact on occurrence of landslides in Meghalaya.

GIS- Based Landslide Hazard Zonation (LHZ) Map Using RESOURCESAT - I LISS IV MX 3-Band and Cartosat - 1 PAN Stereo Data Along a Road Corridor in Tamil Nadu and Kerala

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Landslide Hazard Zonation (LHZ) map, following the modified BIS guidelines by interpretation of RESOURCESAT - I LISS IV MX and Cartosat - 1 PAN Stereo digital data on macrozonation was carried out in parts of Tamil Nadu and Kerala. GIS - based LHZ map is needed for perspective project planning, especially in hilly terrains. The present study area falls in a road corridor of NH-220, from Kanjirapalli (09 33 20 N/ 76 47 40 E) via Kumuli (09 06 15 N / 77 10 00 E) in Kottayam District, Kerala to Lower Camp (09 37 35 N / 76 11 00 E) in Theni District, Tamil Nadu covering about 80 line-km. Thematic maps of facet, slope morphometry, lithology, structure, landuse, landcover, relative relief in NH-220 road corridor of Kerala and Tamil Nadu on 1:50,000 scale were prepared and additional data on hydro-geological condition , landslide evidence, average annual rainfall and slope erosion condition were collected during field studies.
Resourcesat - 1 LISS IV MX data and Cartosat - 1 PAN stereo data were processed initially. Structural and lithological data were incorporated on 1:50,000 scale pertaining to SOI topo-sheets 58 B/16, C/14, F/4 and G/ 1 & 2. Digital Elevation Model (DEM) of the entire road corridor was generated from Cartosat - 1 PAN stereo data which was used for generation of slope morphometry , relative relief and slope facet maps. The interpreted maps were verified through limited field checks. The LHZ map was derived by calculating the total landslide hazard evaluation factor (LHEF) of each facet on all themes like lithology, structure, slope morphometry, landuse, landcover, relative relief, slope erosion condition, hydro-geological condition, landslide incidence and average annual rainfall. The result shows the study area failing under Low intensity Hazard Zonation except for a stretch between Kumuli and Lower camp. This is mainly due to the presence of less weathered massive charnockites, less deformation, moderate vegetation and relief. A few areas with thick soil cover are slide prone in which human interference is the main causative factor.

The Sonapur Landslide: A Case Study Using RS & GIS Techniques

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Landslide and related phenomenon are natural events that would occur with or without human intervention. The causes of many landslides can be examined by studying relations between driving forces and resisting forces. The fragile hilly slopes of Northeast have experienced innumerable incidences of landslides in recent times, mainly because of heavy monsoon rainfall, seismic ground shaking, excessive urbanization and road expansion. However in places, human intervention has accelerated the phenomena, where as timely preventive measures have decelerated the phenomena in certain places. In this context the study was taken up to find out the causative and triggering factors of the slide. Understanding the landslide problem in any area requires a sound knowledge about the terrain and its characteristics such as land use/cover, rock types, landforms, drainage pattern, density etc. Remotely sensed data coupled with conventional data can be effectively utilized in the preparation of various thematic maps, which are very useful and essential for terrain evaluation. The importance of remote sensing (RS) data for landslide studies is well understood. Role of Geographic Information System (GIS) in integrating those huge databases is also properly evaluated by

different workers.
The slide area is located at km 141.80 from Shillong, in the Jaintia Hills District of Meghalaya. It is an active landslide area, since 1988 and a recurring road transportation issue in the vital link connecting Tripura, Mizoram, southern part of Assam with rest of India. The slide area is about 146.533 sq km, it is a rock-cum-debris slide and is "rapid to very rapid" in nature. Al most every year during monsoon season debris and mud flow along with huge chunks of rocks takes place causing road blockage starting from few hours to few days. It is observed that in the very high drainage density area there is no slide, which means slide is taking place where infiltration is more. Study also shows a direct relationship between landslide and lineament density which complements the fact that areas with more fracturing and faulting are prone to landslide occurrence.
Briefly, the slope failure problem is resulted due to interactions of different causes such as geological, structural, hydrological and seismological. Beside these, the quantity, duration and kind of precipitation have also been considered to be as direct mechanical cause.

Macro Landslide Hazard Zonation Mapping along the National Highway-53 from Keithelmanbi to Tupul in Manipur.

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The Landslides Hazard Zonation mapping is the first step in planning the development programmes especially in hilly terrains. In the present study, Macro Landslide Hazard Zonation Mapping along the National Highway-53 from Keithelmanbi to Tupul in Manipur is carried out using the geo-environmental factors like lithology, structure, slope morphometry, relative relief, land use and land cover and groundwater conditions as the respective indexes for statistical analysis. The present study adopts the methods of the landslide hazard evaluation factors (LHEF) rating scheme and calculated the total estimated hazard (TEHD), which indicates the net probability of instability. On the basis of the distribution of TEHD values of each facet, five landslide hazard zones have been identified namely, very low hazard (VLH), low hazard (LH), moderate hazard (MH), high hazard (HH), and very high hazard (VHH).

The Fury of Nature: " Uttarkashi Land Slide 2003".

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Land slide is very common geomorphic hazards in Garhwal Himalaya, particularly in district Uttarkashi. A devastating land slide occurred in township of Uttarkashi on 24th September 2003 which located at the toe of Barunabat hill and right bank of river Bhagirathi. This land slide continued for 11 days and a part of this township was completely buried under huge amount of debris no fortunately no loss of life. It was an old slide zone which was reactivated further mainly due to heavy rainfall although several other factors are responsible for it, such as highly metamorphosed fragile rocks, presence of free faces, scarps and cracks in Barunabat hill, unlined drainage system, unscientific and unplanned use of land, construction works, increasing population pressure and so on.

Rainfall as a Triggering Factor of Landslides in North Western Himalayas

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Climate is a major component of the physical environment. The present study is a topo-climatological study of the area, which attempts to estimate how the lithology, topography, surface roughness and surface covering influence the important climatological parameters, such as precipitation and its trends.
The precipitation change in elevation causes striking meteorological contrasts. In the Lesser Himalayas, the distribution of precipitation increases with the altitude. The precipitation and its patterns as such increases from Duns to Lesser Himalayas because of orographic influence.
It has been observed that the wet spells of less than 12 hours shows an increasing trend during the last twenty years, which is 7.6mm to 47.3mm of higher intensity in comparison to 4.2mm to 39.0mm during the period 1977-1997. This increase in hourly rainfall system and decrease in number of rainy days has close interaction with lithologs of the study region that leads to soil creep, mud flows and sheet wash erosion, which is accelerated because of anthropogenic activities in the Lesser Himalayan belt. It has also been observed that the rainfall intensities are higher in the monsoonal season. A week prior to the monsoon, dry spells prevail, owing to which in many parts of the study region, soils are pulverized and loose adhesion.
Geomorphic instability processes that are common in the study region are accentuated by the weathering of the week lithologs. Almost every year, landslides, mud flows and debris flows in the Lesser Himalayan belt causes severe damage to structure and infrastructures and often claim human lives. Rain of high intensity causes acceleration of the processes of weathering and denudation in the deforested areas. Where the surfaces are bare with scanty vegetation, heavy rainfall causes considerable changes in landscape of the study region. The strengths of the present paper discuss, in particular the precipitation change that accelerate the mass-movements in the North - Western Himalayas

Causes of Landslides in Tea Gardens of Kurseong - Natural or Anthropogenic?

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Tea is one of the 3 main sources of income in the Kurseong subdivision of the Darjiling district. The economic growth of the region started with the introduction of Tea. But the industry started in the Kurseong hills in a highly vulnerable environment after clearing off the fragile multistoried subtropical forest ecosystem. Thus, Tea is an essential part of the landscape over the last 140 years and has been the most important crop for the thriving economy of the area. The livelihood of a large percentage of rural population depends directly on Tea. In National context, the contribution of tea to Gross Domestic Product (GDP) comes to nearly 10% of agricultural commodities and hence it is of great economic importance to the nation (George, 1997).
But, presently the industry is beset with the problem of augmentation of income due to deteriorating condition of the industry, affected by environmental and ecological factors, the most important among which are massive landslides that pose serious threats to its sustainability.
The main cause of this problem has been identified as more anthropogenic than natural. The methods of tea cultivation may be regarded as the major factor causing instability in slopes. Tea cultivation started on slopes

made of talus materials that have been formed due to weathering and loosening of rocks. Such materials, when under the cover of a thick layer of humus under a multi-layered canopy of natural forests, is stable even at an angle of 45?, and is not affected by rain or flash floods. But in Tea garden situations due to clean cultivation and torrential rains in the monsoon periods much of the soil gets washed away leaving a thin layer. So, when the Tea bushes are uprooted landslides occur because of the poor infiltration capacity of thin soil layers and the effect of the direct impact of rain.

So the gardens face a problem of landslides at the time of replanting when carried out after the removal of the old bushes especially in the steeper slopes. Thus, the tea gardens of Kurseong are subjected to a constant danger of landslips and landslides, most of which takes place during or soon after the monsoons. Landslips of great or smaller extent occur in the area almost every year. Major damages have been caused in the years 1899, 1950 and 1968.

It is thus evident from the above facts that care should be taken on man's activities in order to maintain properly the slopes to regain the economic prosperity that once prevailed in the region.

Slope Analysis Around Morni in the Shiwalik Hills of Haryana

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Slope and elevation are two basic but separate concepts in the study of landforms. The slope, defined as an angular inclination of the terrain between the hill tops and valley bottoms with the horizontal, is generally expressed in degrees. The slope is the resultant of all the preceding aspects in combination (viz. relative relief, dissection index, drainage texture and drainage frequency, etc.) and also the climatic and tectonic factors operating in the area. It also determines human inhabitance and occupation.

The sub-mountainous parts of Haryana on the north-east, the Shiwalik Hills which forms a narrow belt have straight and sharply rising slopes. A place nestled in these ranges is Morni Hills (study area) the famous hill resorts of Haryana extends 76o 56' to 77o 11' East longitude and 30o 34' to 34o 45' North latitude, covering an area of 255 km2 on a scale of 1: 50,000 (Survey of India topographical sheets Nos. 53 F/2 & 53B/14. It falls under lower Shivalik the area comprises of hills open valley foot hills and two small lakes (Tals). The highest peaks viz. Dharot Kahlog (1499 m above mean sea level). On the northern ridge and Thandok on the southern ridge.

In the present study the area has been analyzed as proposed by C.K. Wentworth's (1930). Which properly represents the slop morphology of the area under study. The study area has been divided into grids of uniform size i.e.

1 sqkm. The value derived by Wentworths Method is converted into degrees with tangent table. In this way 255 grids have been taken into consideration for slope analysis. The area has been classified into six generalized slope categories ranging from below 5o to >25o that is moderately steep slope (15o-25o) covers the maximum area followed by gentle slope (<5o) and moderate slope (5o-15o). Moreover it represents the most distinctive remarks of the area under study as southern slope of Morni (16.07%), intermediate side slopes (13.33%), valley troughs (34.90%), upliftment (17.25%) and break of slopes (18.43%). In this way this technique is very useful in quantitative generalization of the study area.

Landslide Hazard in Mizoram

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The physical set up of Mizoram s composed predominantly of mountainous terrain of tertiary rocks. Due to the physiographic condition of the area, landslide occurs frequently and cause huge damage to the area and to the people. Such frequent occurring of landslide is due to terrain, porosity of rocks, unstable slope, deforestation, heavy rainfall, vegetation removal, artificial vibration, water leakage, etc. Landslide danger may be high even as emergency personnel are providing rescue and recovery services. The present study addresses itself to the question of the landslide effect in Mizoram and how it creates the changes in the socio-economic condition of Mizoram. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition structure, hydrology or vegetation.

Study of Landslides in the Northern District of Sikkim Himalaya, India

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The widespread occurrence of Landslides and other mass-wasting phenomena in varying geological and geomorphological domains are serious geo-environmental hazards in the northern district of Sikkim Himalayas. In the young folded mountain realm like Himalaya where neo-tectonic activities are going on and which one is still rising, the problem of slope instability and landslides are particularly severe. The northern district of Sikkim Himalaya is griddled by high ridges and convex arc of the greater Himalaya separates the state or the country from the Tibetan highland. The high ridges, convex arc, etc. in the northern Sikkim Himalaya have experienced several major landslides and mass movements in recent years. The landslide hazard poses variety of problems such as affecting highways, communication routes, urban and rural settlements and various other civil engineering structures. Rain-induced landslides and earthquake-triggered landslides along the highway and inner-sides of the region are most potential hazard having direct impact on physical infrastructure of the region and also create many geo-environmental problems. Most destructive landslides and mass-movements are complex and deep-seated, so, it is essential that a powerful database is created covering the details of problematic unstable slopes of the study area. A large body of documented experience suggests that major destructive impacts of these natural geo-environmental hazards can be avoided if timely remedial measures are taken. This paper presents the Inventory with extensive areal data base will be a useful guide to planners and executors in selecting broadly the safer and hazard free location for various development schemes and also presents the classification of major landslides in hilly terrains in the northern district of Sikkim Himalaya. The present Inventory includes attributes - such as location, morphometric characteristics, geology, landuse pattern, causative factors etc. with regards to landslides already investigated or (recorded during hazard zonation mapping) or other investigations in the region. These data are expected to be a good tool for beforehand knowledge of landslide prone location or stretches. The present paper also describes some remedial measures and highlights the need for caution in future development of this region.

Geo-Technical Analysis and Landslide Hazard Zonation in Khasi Hills, Meghalaya

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Landslide can be defined as the downward and outward movement of slope forming materials composed of rocks, soils and artificial fills or a combination of all these along the surface of separation by falling, sliding and flowing either slowly or quickly under the influence of gravity. Landslides are frequent where developmental activities have modified slope profiles particularly making the profile segments steeper. Detailed studies are necessary to access and calculate the factors which are responsible for landslides. The factors are such as the size and shape of the unstable mass, the nature and composition of the soil and rock types and their structures, the attitude of joints and bedding features and water availability, etc. have to be geo-technically analyzed in terms of total cost-benefit ratio to determine the level of safety index through landslide hazard zonation.
The study area Khasi Hills lies between 25015/ to 26010/ N latitude and 90040/ to 92008/ E longitude and covers an area of 11,168 km2 and experience an average annual rainfall of 2400 mm. The Cambrian rocks of the study area is constituted by quartzite, granite, quartzo-feldspathic gneiss, khasi greenstone and metapheletic rocks and overlain by red loamy, laterite, red and yellow and alluvial soils. Physiographically the study area mainly comprises mountain and hill ranges and narrow valleys. The study basically confined along the National Highway, Guwahati-Shillong(NH-40) upto Pynursla, Shillong-Cherrapunji, Shillong-Mawsynram and Shillong -Mairang.
In this paper an attempt has been made to study Geo-Technical characteristics of soil and rock in the landslide prone areas to explore the causative factors of landslides and based on analysis Landslide Hazard Zonation maps have been prepared to facilitate further developmental activities in the region.

Prepatration of Landslide Hazard Zonation Map using BIS Scheme- A Study on the Kurseong Subdivision of Darjiling Himalayas

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Landslide and soil erosion are the common disastrous phenomena in the Kurseong sub-division of Darjiling Himalaya which possesses a very complicated geological structure. Almost every year during the monsoon and late monsoon periods, when heavy and concentrated downpour occurs, these phenomena take place. Although natural parameters like vulnerable geological structures, high amount of slopes over flat areas, unstable slopes, infiltration of rain water through porous as well as fragile rocks and soils are responsible for the occurrence of such hazardous phenomena, still human intervention is also responsible to a greater extent. To reduce the magnitude of such risk, preparation of Landslide Hazard Zonation (LHZ) is very much necessary. The present study has been carried out in the study area using for preparing such detailed landslide Hazard zonation map using the BIS rating scheme.

Different thematic maps or layers, namely, thrusts buffer, lineament buffer, road buffer, lithology, relative relief map, drainage density map and aspect map have been generated from the topo-sheets and remote sensing data using ARC-GIS and Geomatica V10 software. Intensive field investigations have also been carried out ground truth verification. The weighting and rating system based on the relative importance of different causative factors as derived from remote sensing data and other thematic maps were used for the LHZ.

Finally five Hazard Zones namely Very Low Hazard (VLH), Low Hazard (LH), Moderate Hazard (MH) High Hazard (HH) and Very High Hazard (VHH) were generated. The 'very high hazard zones' covers only about 14.8% of the total area with 9 landslides spots out of 81 landslides of the study area where as 'moderate hazard zones' covers the highest area of 28.7% out of total area with maximum number of landslides occurrence i.e. 61 followed by the 'low hazard zones' and 'high hazard zones'. In case of 'very low hazard zones' constitute only 8.6% of the area and include 5 landslide occurrences. Therefore, it is considered that the landslides in the moderate hazard zones and low hazard zones may be more governed by the local effects, i.e. deforestation, unscientifically construction of houses, roads in the valley slope.

Variability in Erosional Topography Under Fourth Order Watersheds of Lesser Himalayan Terrain, Uttarakhand Himalaya

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Landforms are the result of slope-wasting and channel deepening processes. High kinetic energy of Himalayan fluvial system has created acute erosion conditions within the watershed. Infect, the analysis of area-height relationships provides a means to study the degree of dissection and stage of cycle of erosion. The different land use environment also contributes differentially for erosion status consequently the Himalayan watersheds present varying degradation scenario under different land covers.

Present study is an attempt for the comparative study of the erosional topography of fourth order watersheds of Lesser Himalaya covering an area of about 10.22 km2, 9.39 km2, 15.38 km2 and 7.29 km2, viz. Ghuniyoli, Kodiyari, Gaunap and Santri watersheds.

Ghuniyoli watershed registers inequilibrium stage while the rest watersheds are under equilibrium stage. Erosion status has also been evaluated under different land use categories for the comparative study of erosion status of watersheds. It is observed that all three watersheds when compared with Ghuniyoli watershed (under inequilibrium stage) present an absolute reverse erosion status in case of landuse/landcover studies. Ghuniyoli watershed possesses inequilibrium stage while rests three have equilibrium stage of their geomorphic development under each land use environment. The comparative analysis of erosional landscape of watersheds has been done under certain parameters, viz. i. zone of critical height, ii. altitude with maximum erosion integral, iii. altitude with nil erosion integral iv. altitude with minimum erosion integral v. altitude with maximum hypsometric integral vi. altitude with minimum hypsometric integral.

Geo-Technical Investigations of Rajapur Landslide Along the Birchandramanu Belonia Road, South Tripura

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Landslide is a common disastrous phenomenon in hilly tracts of Tripura. A hill slope near Rajapur at 80km south of Agartala along the Birchandramonu-Belonia road in South Tripura district experienced several landslides during July, 2007 which blocked the road for a few days. The whole area was almost detached from the rest of the state. To find out the exact nature and mechanism of this particular tract a detailed geo-technical investigation has been carried out on two of such landslides through several intensive field investigations using different modern instruments. Different techniques have been applied for such study, like measurement of micro slopes along the face of the slide, careful analysis of soils, observation of the geological structure, nature and extent of human inferences etc. Finally a management plan has been proposed to control the slide.

COASTAL GEOMORPHOLOGY AND HAZARDS

Special Lecture

Coastal Vulnerabilty Due to Natural and Anthropogenic Disturbances Along the Southern Coast of Tamilnadu.

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The sustainable coastal resource management requires the safe guarding and transmission to future generation of a level and quality of natural resource that will provide and ongoing field of economic and environmental issues . India has along history of development and flood protection in coastal areas has chosen to adopt shoreline management. Southern tamilnadu coast has uniqueness of economic placer mineral and are being mined intensively. Besides special features such as mangroves , coralreefs, spits , barrier islands, vast sandy beaches, sand dunes exist only on the coast. The altitude of the coastal plain is generally less than 50 m above sea level. Geomorphologically the coastal zone is an emergent coastline with well developed raised platforms and beaches. The coast also is characterized by a predominance of sand dunes and tombolos. On the otherhand, these coastal regions are used for human settlement, fishing, trade, chemical industries, maritime activities etc. In the same coastal zone, destructive natural disaster took place in the year 2004, killing several peoples and destroying upland properties in recent tsunami. The fast development along the coast has also enhanced coastal erosion and salt water intrusion. An increase in damages caused by erosion and salinity in coastal zones is clearly discernible. In many areas an increasing socio economic pressure, intensive human alteration and over exploitation of coastal environments have reduced the resilence of the coastal system. These changes could be attributed to human activities and become vulnerable with in the time scale of coastal development and planning. For this adequate polices are needed, as well as consistent political interest and decision making.
This lecture elaborate on the above issues, illustrate with geomorphology hazard along the coast of Tamil Nadu to determine the areas of high risk and to reduce the risk.

Special Lecture

Environmental hazards and Human vulnerability to cyclone in the Eastern Coastal Zone, Orissa and Eastern Medinipore

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Present paper concerns a study on the Environmental hazards and Human vulnerability to cyclone in the Eastern Coastal Zone, Orissa and Eastern Medinipore. Normally, disaster means crushing misfortune or ordinarily, calamity befalling upon mankind whereas hazard implies probability of destructive phenomenon occurring at particular place within specific period of time. We know that our mother earth is meant to face periodic onslaught in the shape of natural events or hazards but it is losing the flexibility and self adjusting capabilities due to phenomenal increase in global population and allied pressure associated with action and

activities of human kind required for survival and maintenance. Man's encroachment and interference in areas of manifestation of such natural processes has resulted in many catastrophic/disastrous events throughout the history of mankind. Vulnerability (V) indicates the degree of expected loss to given element or a set of elements from occurrence of natural phenomena of a given magnitude. Specific risk (RS) means the expected degree of loss due to particular natural phenomenon. It may be expressed as H. x V. Element of risk (E) means the population, properties, economic activities including public service etc. at risk in a given area. Total risk (RT) means the expected number of lives to be lost, persons injured, damage to property or disruption of economic activities due to particular natural phenomenon and is, therefore, product of specific risk (RS) and element of risk (E). Thus RT = E x RS = E (H x V). ... (i), where ET is total Risk (H x V), is vulnerability, E is element of risk, H is natural hazard and RS is specific Risk.

During the recent past, due to the phenomenal growth of population, especially in the developing countries, these natural disasters have been of very serious type causing huge number of death of man and animal and colossal loss of property. Disaster/hazards management plays a vital role in rendering the risk to life and property and is a collective term. However, the effect of national hazards on the less of human lives is directly related to the poverty levels in India. Present investigation also relates to the fulfilment of the recent concept of Integrated Coastal Zone Management (ICZM) of Sunderbans West Bengal, Mahanadi delta, Orissa under the prevailing fluvio-marine environments. Orissa is a multi-hazard prone state requiring drought proof mitigation in the western parts and mitigation related to floods and cyclone in the eastern deltaic coastal parts of the state. In the recent past Orissa was ravaged by two major calamities, the Super cyclone in 1999 and the flash floods of 2001 between which there was a drought spell in 2000.In a theoretical sense, co-operation between various factors in the integrated coastal zone management can be presented as a Jigsaw, which make sense only when it is fitted together correctly. This includes primarily - (a) General dependencies on other actors vary, but they are of equal importance for the stability of the biosphere (mosaic). (b) There is not only one relationship with different actors nor are they limited to the core zone of the coastal region, and (c) only the co-operation of all the actors results in the desired stable ecological, economic and social cohesion. Actually, the core zone is the living area of the coastal inhabitants. In rural areas, they are fishermen, small traders, farmers, hunters and gatherers. They benefits from ICM in many different ways, as may be explained in the usual manner involve the major points like : sustainable growth on the basis of the utilization of natural resources, protection of the natural habitats and the variety of species, controlling the entering of harmful substances and changes to coastal land beaches, control in the area of water inflow (deposits of sediments and harmful substances), controlling the removal of corals, chances to lagoons and the sea-bed, rehabilitation of destroyed areas and provision of technologies and relational allocation of resources etc.

The coastal belt under consideration stretches over a long line (morethan 1000 Km), covering specially the states of West Bengal, Orissa and Andhra Pradesh and is under severe stress. Such stress relates to deal with the aspects of human vulnerability concerning peculiar situation on context of Integrated Coastal Zone Management (ICZM), (Mulkopadhyay 2005, 2006, 2007 and others). This peculiar situation arises mainly from the interaction of several constrains. Such constraints are found to be imposed by -a) the violent cyclones and storms, b) the development of polygenetic and multicyclic fluvio-marine landscapes, c) set in a neo tectonically unstable terrain, d) under the tropical monsoon (Modified climatic condition). Present author has made an attempt also to formulate the management strategy in addition to the necessary measures to reduce impact etc involving the human vulnerability to the coastal environment hazard. These relate to the arrangements for providing i) Adequate infrastructural facilities (updated and modernized) to the local residence including different stake holders, ii) Strengthening participatory mechanism for land and water management, micro watershed- micro level land use planning etc in the arena of Integrated Coastal Zone Management (ICZM).

Mapping Temporal Changes in the Extension of the Bay-mouth Bar, vis-à-vis Bay Siltation, Shrivardhan Bay, Konkan Coast, Maharashtra.

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The present study has been carried out in Shrivardhan bay, Konkan Coast. The most significant characteristic of the bay is the development of a bay mouth bar. Extension of the bar southwards is almost closing the mouth of the bay. A narrow inlet marks the southern extremity of the bay mouth bar. The western margin of the bar acts as the present beach, which is backed by a dune line. The water inside the bay remain restricted in two narrow arms during low tide, but during high tide the water spreads almost over the entire bay area, with a small portion of the central island remaining above water. The Southern margin of the Bay consists of a rocky platform.
To make an assessment of the temporal changes in the extension of the bay mouth bar and how these changes in its extension is affecting the inlet situated at its southern extremity. The extension of the bar would essentially reflect on the siltation process within the northern and southern arms of the bay, changes in the extent of the central island and the marginal mudflats
In this study an attempt has been made to trace the changes in the extension of the bay mouth bar and the adjoining beach and northern arm, over a period of time. The earliest available topographical map is of 1925 and the most recent information of the area has been incorporated from a sounding chart of 2000. The changes within the period have been incorporated from SOI topographical map of 1968, sounding charts of 1965, 1982, 1990, LISS-2 and PAN fused image of 1998 and GPS survey coordinates of 2003, 2005 and 2008.
For temporal change detection, the HT and LT lines of successive maps, sounding charts and images have been superimposed once those were carefully georeferenced with the help of image processing software - Geomatica (version 9.0). The shift of the HT and LT lines have been taken into consideration because, these are the best indicators of progradation or retrogradation of the land.
The condition of the northern arm, especially near Mulgaon Koliwada, shows drastic changes in the width of the channel. The width of the channel at this location was about 310 m in 1925, which narrowed down to a mere 129 m in 1968 and there after continued to become restricted. In 1982 and 2000 the average width of the channel was about 125 m and 97 m respectively.
In the period 1925-1968, the southern spit of Shrivardhan showed 150m extension towards SE. From 1968-1997 the SW end of the spit shows an increase of 100m towards the W. This trend of westward extension seems to get reversed since 2000. The Central Island shows maximum change in the northern and NW part of the island, which has direct bearing on the reduction of cross sectional area and shift of the northern arm. The southward extension of the spit has also restricted the main inlet.

Seasonal and Annual Variation in Sediment Dynamics of Beaches Between Redi-Vengurla, Maharashtra, West Coast of India

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The Indian coast is witnessing an increase in anthropogenic activities owing to population explosion, urbanization, expansion of settlements, industrialization and so on involving activities like marine fishing, off-shore oil and gas extraction, marine transport, dumping ground for waste disposals, aquaculture etc. all of which are accentuating drastic changes in the coastal environment. Such a dependence and increased activity along the coast is a major concern for coastal zone management and development activities or programs of any country.

The grain size analysis is one of the important tools to delineate littoral drift. The understanding and assessment of this littoral drift and the littoral drift data help to assist in the harbor development schemes, coastal development programs; location of sand traps, growth of coastal bars/spits, beach starvation and associated erosion; matching coast protection measures and artificial nourishment of beaches (Crickmore, et al., 1990).

The textural study is made in order to understand the depositional agencies of transport and the sediment movement along the study area (Figure 1). The present paper highlights cross-shore and longshore variation of grain size parameters, their inter-relationship between different grain size parameters and the characteristics of depositional agent using various bivariant plots following Folk and Ward (1957), Friedman (1967, 1979), Passega, (1964), Passega and Byramjee, (1969) and the multivariate linear discriminant function analysis following Sahu, (1964). The sediment transport paths both across the beach and along the beach have been deduced following McLaren and Bowles (1984).

The mean size vary between coarse to very fine sand during the study period; majority being the fine sand. The Vengurla beach has seen reduction in medium sand and enrichment of finer sand during pre-monsoon 2004 as compared to pre-monsoon 2003 that is supporting growth of the beach.

It is clear from this study that, the sediments are deposited under moderate to high-energy conditions. At Redi beaches the sediments are scattered between coarse to fine indicating turbulence owing to mixing of Redi River (between stations 14 -19) and Terekhol River (around station 20) with the ocean.

Key Words: Beach, Sediment, Texture, Depositional Environment

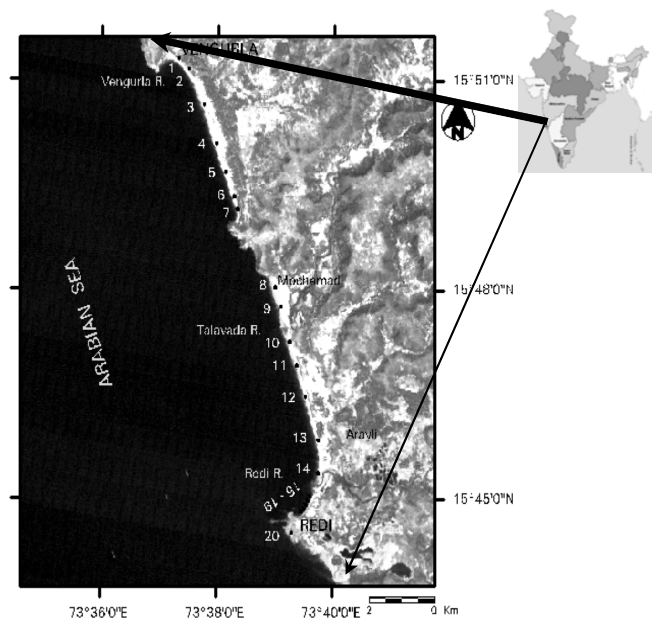

Figure 1: Location map of the study area between Vengurla – Redi along with the study sites. (LANDSAT ETM+ 1999).

Spit Development Near Estuaries and Its Implication on Coastal Morphodynamics Study: A Case Study Along Midnapur - Balasore Coast, Eastern India

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A coast is the most dynamic region of the world, bounding land and water. Numerous geomorphological processes operate along the coasts ranging from very short to geologically long spatial-temporal periods. One of the consequences of such processes is the formation of elongated sand bodies parallel to shoreline, known as 'spits', found to occur in many coastal regions of the world. These 'spits' are usually large-scale geomorphological features, spanning in length from 1 km to 100 km, with time period of development process spanning from 1 year to 100 year. Since their occurrences are related to the interactions between the longshore current and inlet dynamic processes, many coastal geomorphologists prefer to study their formations for coastal morphodynamic interpretation and estimation of hydrodynamic parameters.

The region chosen in the present study, the 113.5 km long Midnapur - Balasore coast, covering parts of coastal West Bengal and Orissa respectively, shows existences of this geomorphological feature and its typical association with marshy environment. Using an integrated remote sensing and field based observation, this study reveals that 'spit' development could be an important process in influencing the future coastal morphology. Four major 'spits', controlling the local erosion and accretion processes along this coastal stretch, have been observed during this study. Among these four 'spits', three are situated nearer to inlets, while only one is within the littoral stretch. Using multi-date satellite imageries between the periods 1973 to 2000, the rates of 'spit' advancements have been estimated. These rates are found to be comparatively high, ranging from 83.4m/yr to 141m/yr. It has also been observed that on the downdrift side, after crossing the 'spits', erosions at very high rates, ranging from 8m/yr to 11m/yr, have been taking place.

Based on these observations, a morphodynamic model of 'spit development' in the study area has been proposed. According to this model, the initial orthogonal position of an estuary may become oblique to the shoreline, due to decrease in the tidal prism or river discharge with passage of time, resulting in the predominance of the longshore current. In view of the long term planning for construction of a 'harbor' within the study area, it is very much necessary to carry out a detailed study related to the development of these 'spits' in this area.

Spatio-Temporal Analysis of Coastal Erosion Using Remote Sensing and GIS: A Case Study of Balasore - Bhadrak Coastal Track, Orissa

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Coastal erosion or Sea erosion is the wearing away of land by the action of natural forces like wind, waves and currents that constantly moves land materials i.e. the landward displacement of shoreline causing the loss of a huge land mass. Coastal degradation not only threatens the environmental well- being of shorelines but also endangers the economic welfare and public safety of the coastal communities. Indian subcontinents suffer from severe coastal hazards almost every year. The Balasore-Bhadrak coastal track, which is about

140 kms long, has faced severe shoreline changes due to coastal erosion. The concave strip like coastal area of Balasore-Bhadrak district of Orissa is frequently affected by severe cyclones every year which is the most significant agent of coastal erosion in the area. This phenomenon has resulted in enormous loss of land, mangrove as well as economic property. It is crucial, therefore, to analyze the impact of such hazards on their economic development and provide a solid basis for future development strategies. The purpose of this paper is to assess the causes of coastal erosion and its impact on the economic development as well as mitigation strategies. The aim of the study is also to develop systems to predict the coastal erosion. Data from Survey of India (topographical maps of 1932 & 1976) and NRSA Satellite data (1998 & 2006) as well as intensive field survey data are used to find out the extent of coastal erosion in this fragile coastal environment. Modern techniques and methods are incorporated study like remote sensing and geographical information system. A large portion of this coastline is vulnerable to sea erosion and tidal overflow. Only a portion of the vulnerable sea coast has been protected so far and lot of efforts are required to be made to protect the remaining part within the limitations of the availability of funds and other constraints.

Assessment of Coastal Vulnerability and Dimensions of Beach Dune Systems and Mud Bank Swamp Systems in Response to Storm Impact - A Study in the Shoreline of Northern Bay of Bengal

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The super cyclones of previous centuries and present century have been considered as an increasing threat to the coastal communities of Bay of Bengal for the frequency of events and large-scale damage types. The natural coastal buffers are largely affected along the seashores of the Bay of Bengal due to the collision course between increasing risks and hazards caused by global warming and local subsidence induced rising sea level, and increasing risks of inundation, flooding and erosion caused by various human activities in the coastal areas.

The physical, ecological and social vulnerabilities of Bay of Bengal coasts are assessed on the basis of response types of geomorphology to high magnitude cyclone events, habitat conversions due to greater coastal development and community preparedness along the coastal societies against such hazards. The shore fringed beach and dune systems are highly sensitive to the sudden change of natural processes caused by the events of super cyclones and large-scale drift of sediments supported by increased wave and current energy in the cyclones. The fragility of the low-lying coasts is increased due to habitat conversions of beach and dyne systems and delta flat mangroves for the expansion of coastal tourism and coastal fish farming in the Bay of Bengal at present.

Coastal vulnerability in response to storm impact can also be assessed by obtaining accurate and updated measurements of beach and dune dimensions in relationship to the position of buildings. It indicates that in addition to the large seasonal fluctuation in width, most beaches are narrowing through time in response to a long-term erosional trend.

There are four important south Asian countries (India, Bangladesh, Myanmar and Srilanka) in and around the Bay of Bengal shorelines. The monthly statistics of cyclones of different categories (between 1877 and 1995) are analyzed in terms of striking rate in the countries around Bay of Bengal for the identification of vulnerable areas under cyclone attacks. Most of the deltaic coasts are low-lying and moderately to densely populated, with numerous dwellings and other infrastructure. This combination presents a highly vulnerable

situation to a major storm in the region.

Sometimes the high astronomic tides coinciding with the cyclonic storms become a major factor contributing to coastal flooding, beach erosion, over washing of barriers, inlet formation, and wave induced damages to the shoreline. Another factor that influences the vulnerability of beaches to storm erosion and damage to adjacent structures is the interval between storms. In many areas of the sandy coast the previous storm has removed the sand buffer (beaches with wide accretionary berms) along the shoreline, and the impact of the next storm will be much greater in that areas than that of the first. Thus the shoreline vulnerability increases with the reduction of interval period between successive storms that strike the coast.

The impact levels of storms and relative vulnerability of the deltaic shoreline are also estimated for the Bay of Bengal coasts in response to hydrological, geomorphological and sedimentological changes at the storms of different categories. The hazard potentiality or the hazard vulnerability increases with various impact levels of cyclonic storms that strike the coast.

In the present study, the unsafe conditions of the coastal belts have been identified with the analysis of physical, ecological and social vulnerabilities in response to cyclonic storms and finally by using numerical scoring method for mapping vulnerability at the Bay of Bengal coasts. Secondly, the frequency and magnitude of cyclones are studied on the basis of available cyclone data of the past 130 years period fir the countries around Bay of Bengal. Finally, the models have been prepared for the identification of impact level variations of cyclones after their landfall on the coasts particularly in deltaic and non-deltaic areas of the Bay of Bengal Shorelines. The entire study is based on the pre- event and post- event field visits of respective storms, field measurements on geomorphological, hydrological and sedimentological changes, damage analysis of various cyclones and satellite image analysis of the changing shorelines.

Methods of Identification of Shoreline Changes in the Historical Past - A Study at Khejuri (Historical Kedagree) of the Hugli Downstream Section near the Bay of Bengal Shoreline

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Historical Kedagree or the modern Khejuri is located on the western bank of Hugli downstream section near the Bay of Bengal shoreline. Physiographically, the low- lying coastal tract of Khejuri is a part of Hugli estuarine delta formation which belongs to the western most limit of Ganga delta in the Bengal Basin. The shoreline of the region has been advanced seaward in the historical past. A certain portion of the shoreline towards the north of Khejuri is also eroded at the same time.

The nature of shoreline changes is studied on the basis of simple overlays of older maps and images, analysis of aggradation of tidal channels, identification of mangrove tree trunks from the pond beds of wide areas, analysis of the names of villages and relative historical structures, and analysis of existing geomorphological evidences of the region.

In order to develop a database for assessment of historical shoreline changes, relevant data have been gathered from different sources and field survey reports. The compilation of this data set is essential for accurate mapping of historical shoreline changes of the region.

Finally the study shows that the western bank of the Hugli mouth is probably rising comparing to the eastern bank. The local shoreline is also advanced seaward in successive stages with east and south-east direction for the above reasons. The low-lying areas with intersection of numerous tidal creeks are now modified with

Geomorphological Evidences	Archaeological Evidences
* Tidal sand ridges parallel to the Hugli mouth shoreline * Wide and seaward slopping tidal flat younger origin * Older beach ridges with overlying sand dunes * Raised tidal flat of inland areas * Abandonment of tidal channels * Channel shifting and temporal channel activities with older and younger natural levees * Development of beheaded streams	* Historical structures and their locations * Remains of wreckages of boats and ships * Historical charts and maps
Biological evidences	**Other Historical evidences**
* Remains of mangrove tree trunks into the pond beds * Remains of marine shells under the blanket of beach ridges	* Historical shoreline change maps * Aerial photographs/satellite images * Older published reports * Analysis of the names of villages located in the coastal belt

rapid aggradation of tidal sediments and successively united with the mainland. The erosional activity of the shoreline is probably episodic in origin with the respective extreme events like High Magnitude cyclones, tidal waves and seismic activities.

Trend of Sea Level Change in the Hugli Estuary, West Bengal

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Rise in sea level (SL) is probably the most important effect of global warming on low-lying coastal localities like a tropical estuary. The Hugli estuary, with the ports of Haldiya and Kolkata, is the primary maritime gateway to eastern India. The banks and most of the tidal islands of the Hugli are reclaimed and support a population density of 795 persons km^{-2} in its lower reaches. The significance of long-term changes in water level of the Hugli is therefore obvious.

An estuary can be defined in a number of ways. Based on morphological constriction, tidal range and saltwater intrusion, the landward limit of the macrotidal Hugli estuary is up to Diamond Harbour (Hospital Point), 70 km from the sea. The tide penetrates another 219 km along the estuary up to Swarupganj. The tidal characteristics and channel evolution of the Hugli is extensively studied. However, long-term trend of its SL variations have not received much attention although the basic data for its analysis are available at the Permanent Service for Mean Sea Level (PSMSL: www.pol.ac.uk/psmsl).

Although some authors maintain that a 20-year record of mean annual data are adequate for computation of the rate of sea level change, a 50-year record is considered preferable for offsetting all local and short-term variations like effects of ENSO and tropical storms. Among the data of 28 Indian stations available at the

PSMSL, only five stations have 40+ years of usable records. Most previous studies on the Indian PSMSL data have considered all available records above 20 years.

In the Hugli estuary, the data are provided for eight stations: Sagar (Dhablat & Beguyakhali), Gangra, Haldiya, Diamond Harbour, Kolkata (Garden Reach & Khidirpur) and Tribeni. After filtering out possible inconsistencies like datum shift, riverwater influence and inadequacy of records, data of four stations were retained for sea level trend computation (Table-1).

Table 1: Selected characteristics of tidal observatories of Hugli estuary (Data from PSMSL, Survey of India tide tables and 2008 IRS-L3 image)

Station	Distance from sea (km)	Estuary width (km)	Tidal range (m)	LMWL above MSL[1] (m)	Period covered in PSMSL records	Usable data (a)	Sea level change (mm a^{-1})	Confidence limit (99%)
Sagar (Beguyakhali)	0.00	51.58	4.38	0.18	1937-1987	48	-3.82 + 0.95	-6.37 to -1.36
Gangra	31.37	17.25	4.77	0.34	1974-2003	25	+0.76 + 0.93	-1.84 to 3.36
Haldiya	43.36	10.47	4.90	0.41	1971-2004	31	+3.51 + 0.70	1.68 to 5.54
Diamond Harbour	70.11	1.88	5.04	0.48	1948-2004	55	+5.22 + 0.43	4.09 to 6.36

Note: 1. LMWL: Local Mean Water Level; MSL: Mean Sea Level

An anomalous feature of the records is that the Sagar observatory registered decrease in sea level. This is difficult to fit in the general scenario of increasing SL in all nearby stations and continuation of coastal erosion at the vicinity of the observatory for the last 100 years.

Overall, the estuary's SL trends indicate a positive relationship with the distance from the sea: as one moves northward from the mouth of the estuary at Sagar to its apex at Diamond harbour, the rate of sea level change escalates at 0.13 0.02 mm a^{-1} km^{-1}. The rate marginally reduces to 0.11 0.03 mm a^{-1} km^{-1} if the data of Sagar is excluded. Although not strictly comparable to the Hugli, the data from Okha (22 a) and Kandla (37 a)-situated at the mouth and 135 km landward of Gulf of Kachchh respectively-do not agree with the trends of Hugli with rates of SL rise decreasing from 1.62 0.83 mm a^{-1} at Okha to 1.32 0.52 mm a^{-1} at Kandla. Rates of glacio-isostatic rise along the Hugli estuary have been modelled by Richard Peltier at 0.48 mm a^{-1} (Sagar), 0.51 mm a^{-1} (Gangra & Haldiya) and 0.52 m a^{-1} (Diamond Harbour). These values are not significant for explaining the marked differences in the rates of SL change from the widely agreed global secular SL rise rate of 1-2 mm a^{-1} on both ends of the scale. Influence of some regional factor(s), the intensity of which change(s) along the length of the estuary, is obvious here. The possibilities include: (1) land subsidence due to sediment compaction and/or groundwater withdrawal and (2) rise in the LMWL due to increasing river discharge and/or sedimentation and/or incidence of tropical cyclones. The morphological constriction of the Hugli would increase the effects of the second category of factors landwards.

GALCIAL GEOMORPHOLGY AND HAZARDS

Special Lecture

Late Quaternary Glacial Events of Naradu Galcier Valley, Sangla Basin, Kinnaur District, Himachal Himalaya

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The glacial landforms and glacial and para glacial sediments of the Naradu valley of upper Kinnar region have been extensively surveyed and resolved into sequence on the basis of the morophostratigraphy,moraine morophology, striated rock surfaceand lacustrine sediments.The Naradu valley is a narrow valley 11km long,covering an area of 23 sq km.The longitudinal profile of the valley is parabolic in outline with convexity at trough head and the body of the glacier (5.15 km long) has four treads with steps in between .The snout of the glacier is located at an altitude of 4390 m.The valley as awhole is one of the steepest valleys having a relative relief of 2100m above sea level .The valley extends between the altitudes 3340m and 6000m.

The reconstruction of the glacier history has been derived from c-14 Stratigraphy data of palaeo-lake located at an altitude of 4000 to 4125 m as well as fossil flora and geomorphological evidences of laterall ,kattle moraines , moulin kames ,and further on the basis of subsurface weathering,boulder frequency, and percentage of lichen cover to establish a relative chronology.Two glacial advances are envisaged from the evidences of lateral and kattle morains located an altitude of 3680 and 3900 m.The pollen analysis and radio-carbon datting of clays suggest two short cold periods around 13000-14000years BP followed three phases of retreat.The geomorphological evidences as well as analysis glacio-lacustrine sediments (collected from two sites from 2.5m thick profile) reveal five phases of glacio-climatic history :(a) Around 13000 years B.P.,a cold climate in the entire valley extending to main Baspa glacier, (b)warm temperate climate around 12000 years B.P. resulted of Naradu glacier to Tulatung site(3680m) from the altitude 3344m,(c)A cool climate prevailed

Special Lecture

Nature and Characteristics of the Quaternary Geomorphological Landforms Around the High Altitude Areas of the Upper Beas Basin in the Himachal Himalaya

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A wide variety of Quaternary geomorphological landforms of glacial, paraglacial and periglacial types occur on the mountain slopes above timber-line in the Upper Beas Basin in Himachal Himalaya. Both relict and contemporary glacial landforms in the form of exposed and vegetation-covered morainic ridges, melt-water channels and galcio-fluvial deposits are wide spread through the deglaciated valleys and over the mountain slopes. Occurrence of fresh morainic ridges has been attributed to the impact of rapid glacier retreats as a consequence of global warming. Large debris cones, talus slopes, anti scarps, elongated grabens and collapse pits have developed as a result of stress release on the valley walls under paraglacial activity following rapid deglaciation. Frost-wedging, frost-creep, solifluction and patterned ground features developed under periglacial processes have been detected on the exposed slopes above the timber line.

Mountain Geomorphology of Karakorum Ranges, Nubra Valley, Ladakh

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The Karakorum is a large anticlinorium of Precambrian crystallines in the core , flanked to north by synclinorium of Precambrian to dominant Palaeozoic metasediments, slates and graywackes of Carboniferous to Permian predominates with subordinate areas of volcanics and plutonics of the Carboniferous-Permian age. The southern part of Tibeto-Karakorum belt has been affected by widespread granitic activity of Upper Cretaceous to Palaeozoic age (70- 40myr) as is manifest in the batholiths of Ladakh, Kailas and Lhasa.
The Ladakh granite is separated from the main Karakorum body by the strike slip Karakorum Fault traceable along the Shyok valley and delineated by huge bodies of ophiolites and hot springs. Nubra valley is situated along the Karakorum Fault and its sympathetic faults. The Nubra valley is predominantly represented by granite rocks rising as high as 6000 m amsl and about 2000 to 2500 m above the present-day river bed of Nubra. The valley walls are upright and steep with slope angle as high as 75? and above. Alluvial cones/fans are widespread in the valley at regular intervals. The head/apex of all alluvial fans/cones originate from the same elevation marking the plane that separates the granites from the Palaeozoic metasediments and represents the fault plane of strike-slip fault. Hanging glacial dry valleys are all situated above the level of fan apex. The melt water originating from the dry glacial hanging valleys entrench the granite deeply to form narrow gorges before debouching in the main stream Nubra.
The complete absence of evidences of Quaternary glaciation in the valley, abundant occurrence of alluvial fans/cones, occurrence of hanging glacial dry valleys, deep entrenchment by melt water of valley rocks and steep slope angle of valley walls subscribe to the geologically young activity in the valley along the Karakorum Fault that has completely destroyed / modified the earlier evidences despite the fact that Karakorum Ranges were first to emerge Tethys after the Indo-Asian collision of plates in Cretaceous.

Geomorphic Features in Jamdar Bamak Glacier: A Short Note

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Jamdar Bamak (IN5O12301039) in the Tons catchment of Yamuna basin is one of the largest glaciers of Himachal Pradesh. The geomorphic features in this area present a complex set of landform. It is terminated on the valley basin, release large quantities of melt water that drains onto broad out wash plain of the Harkidun Gad rivers, a tributary of tons, which cross these plains, erode and rework the previously deposited sediments and redeposit them as distinctive suits of glacio-fluvial lithofacies.
Geologically the study area consists of Haimanta Group of early Cambrian rocks and Intrusives of granite of Paleozoic rocks that are metamorphosed into granite gneiss. Main Central Trust and Vaikrita Thrust pass through this area.
The main types of land forms that have been identified from the LISS-III imageries are U-shaped valleys, escarpments, flat terraces, lateral moraines, parallel moraines, central moraines, parallel debris cones etc.
Jamdar Bamak (IN5012301039) is one of the twelve glaciers located in the Harkidun area, 5th order Basin of

Tons River. The glacier is oriented towards north eastern part of the Harkidun area and stretch of 20 km and occupies the area of 58 Sq. km. At present the snout is at an elevation of 3760m. Solid ice or precipitation of fresh ice is available at the head portion of the glacier i.e. situated at 5000m. Three small glaciers are also located in the northern and two are in the north-western part of the main glacier.
The study area covered 355.41 sq. km. There are nearly 143 melt water streams, of which 136 have their origin in the present glaciers. The drainage are picked up from the SOI toposheet and after that modified by the imageries. Bifurcation ratio 2.05 indicates that the drainage are highly structurally controlled and the terrain has rocks of low permeability. Elongation ratio (Rb) value, 1.067 indicates that the basin is circular in nature. The morphology of the streams is variable. Near the trough heads of the glaciers, the streams tend to be flat-floored with steep sides and are wider than deep. In the middle section streams are incised into deep gorges. The streams have been divided due to nature of drainage texture. First group is parallel to sub parallel in nature and the second group is dendritic in nature indicating the granite gneiss as country rock.
Monitoring of glacier for discharge prediction and the flood analysis is emphasized for proper watershed management planning.

Changing Spatial Extent of Glaciers: Their Impact and Management in Kashmir Valley

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Glaciers are dynamic entities which have changed in the past and will continue to change in response to the pulsation in the climatic scenario. 30 % of the total area of the earth was covered by glaciers during Pleistocene period while it is only 10 % at present. Global temperature has increased by 0.3-0.60 C since the last century, as a result the mountain glaciers have thinned, lost mass and retreated. As per the recent reports Siachin, Baltora, Yamnotri, Gangotari and other Himalayan Glaciers are receding at an alarming rate. Glaciers exert a direct influence on the hydrologic cycle by slowing the passage of water through the cycle. Like groundwater, glaciers are excellent natural storehouses of water. The Himalayan glaciers are melting fast in Jammu and Kashmir as a result of global warming, thus taking Kashmir to the brink of a climatic disaster. In the past four decades, Kashmir has witnessed a decline in the amount of snowfall. In most of the areas, the snowfall season has been reduced from four months a year to only two months a year, particularly in the districts of Anantnag, Kulgam, Srinagar and some areas of Ganderbal and Pulwama. Besides this there is also a possibility that heat-trapping gases released by various cement manufacturing industries which have reduced snowfall in Khrew-Pampore and some areas of Anantnag could spill over to other areas of Kashmir, resulting in less or no snow in the coming two decades.
Most of the glaciers of the Himalayan range from Harmuk to Drungdrung, including Thajiwas, Kolahoi, Machoie, Kangrez, Shafat, have receded far back (4,000-5,000 metres) during the last 50 years when a comparison is made between their extent from Survey of India sheets which are 50 years old and latest satellite imageries. In this backdrop, an attempt has been made to quantify the impact of changing spatial extent of glaciers its impact and management in Kashmir Valley. The work was carried out by utilizing remote sensing, google earth and GIS in the arcview 3.2. The study reveals that there has been a considerable change in the spatial extent of glaciers which has a great impact on the water availibility in Kashmir Valley. The other adverse effects are on the agriculture, hydel power generation and other sectors of the economy. The whole ecology also gets impacted in Kashmir Valley.
Keywords: Glaciers, pulsation, climatic disaster, heat-trapping gases.

TROPICAL GEOMORPHOLOGY AND HAZARDS

&

SOIL EROSION

Special Lecture

Desertification Status Mapping of India

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The United Nation's Environment Programme estimates that some 30 percent of the Earth's land surface area suffers from slight, moderate or severe desertification, with an additional 6% classified as "extremely decertified" land which can not be recovered.

Desertification is assumed to be caused by a complex relationship involving human impacts on arid, semi-arid and dry sub-humid areas but excluding hyper arid deserts, Causal components includes:

* Rapid growth of human and animal populations
* Detrimental practices-overgrazing, deforestation, unsustainable agricultural practices and mis-management of ground water.

India is endowed with a variety of soils, climate, bio-diversity and ecological regions. About 69 percent of the geographical area falls in the dry lands(arid, semi-arid and dry sub-humid). The geo-hydrothermo folio of India makes large parts of the country vulnerable to water and wind erosion, salinization and water logging, mass wasting, frost heaving etc. Vulnerability of the land to different forms of degradation is accentuated by high biotic pressure-human and livestock population, resulting in unsustainable land use.

A large part of India is undergoing the process of desertification. There is an urgent need to arrest the process of desertification and combat land degradation. One of the prerequisite for combating desertification is to identify areas undergoing the process of desertification.

Keeping this in view and also to fulfill the commitment of TPN-1(Thematic Programme Network on desertification monitoring and assessment under UNCCD) implementation in the country, ISRO has taken up the task of preparation of land degradation/desertification status maps for the entire country on 1:5,00,000 scale, involving 17 institutions of the country.

The paper deals with the methodology of preparation of status maps and status of land degradation/desertification in India.

Management of Geomorphic Hazard in Humid Tropics: A Case study of Khoai Landscape of Birbhum District.

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The present paper is a modest attempt to examine geomorphic hazards and Management of badland topography in Humid Tropics. The study area encompasses the badland terrain within the Kopai basin and physiographically the area represent the lateritic track of Santiniketan,Sriniketan area on the northern slope of Ajay Kopai interfluve of Birbhum District. In fact the morphology of stream behavior, environmental condition, characteristics of landform are typical in this environment.

Badland geomorphology is an important domain of Humid Tropical Geomorphology. The area under study offers an ideal example of how the geomorphic processes operating in Humid Tropics and displays most of the common & associated features of duricrust. Here the very basic process of laterisation is one of the significant pedo-geomorphic processes notable for the development of Badland. Like other areas of Badland topography, the Khoai landscape exhibit different types of landforms like rills, youthful gullies, mature valley etc. The area is a good example of diversified terrain& slope characteristics.

The Khoai landscape can be identified as an area of geomorphic hazards. Processes of degradation have been responsible for the occurrence of a number of hazards like soil erosion, formation of hard alumino-silicic complex with resultant development of unproductive soil, gradual encroachment of badland at the expense of the loss of suitable land use. In addition, such processes also have some indirect impact on the fluvial geomorphic processes as evident from the observation of the Kopai river.

From the sample site observations at Goalpara and Kabimohanpur village, some geomorphic hazards have been identified & mapped. From these observations the major hazards that have been identified include transformation of minor rills into gullies and their encroachment, formation of hard alumino-sillisic complex on the top soil & surfaces of badland topography, problems of soil erosion, removal of top soil, loss of arable land, problem of deforestation at gully heads, development of rills & gullies and the subsequent weathering & erosion beneath the hard crust of sesqui oxide and increasing erosion leading to the increase of sediments in the Kopai river and consequent fluctuation of river discharge.

Formation of rills and gullies is a continuous process and their encroachment, subsequent expansion lead to the deterioration in the quality of environment .Such deterioration are manifested in a number of ways such as loss of vegetal cover, change in the vegetal cover; greater areas are being brought under uncultivable waste land etc. Transformation of rills into gullies has impacts on hydrological characteristics of the Kopai river and its stream segments. In fact, when rills are subsequently enlarged into gullies, two processes simultaneously co-operate with each other viz., the process of slope wash and the process of encroachment of gullies.

Coming to the particular consideration of the impact of badland on gullies & on landform development it can be observed that modification of topography & further development of badland topography take place through transformation of rills into gullies, intensification of mechanical weathering in the form of disintegration, increase in the gradient of flow & resultant process of slope failure , greater development of runnels beneath the formation of allumino-silicic complex etc are significant.

Apart from the decrease in the arable land due to environmental degradation processes of landform development are also responsible for shrinkage of arable land. Through digital data processing and field observation it appears that the Kopai river has been constantly changing its course & erosion on the concave side results in the development of cliffs. Subsequent recession of the cliff face leads to shrinkage of arable land. The processes of aggradation in the convex side & formation of terraces are also reflected in the natural increment of land surfaces but such process of increment is not reflected in the use of additional land for agricul-

ture. Hence, overall areas under cultivation have decreased through geomorphic changes over time.
Under the existing state of weathering processes & related development of badland, proper land management is required. Some measures have been recommended such as leveling up of the badland, treatment of soil, ploughing of gullied surface& plantation of trees to minimize the hazards of weathering. In addition, excess water during the rainy season can be stored for the purpose of rain water harvesting in areas, or ploughing up of the uncultivated waste land that are either poorly drained or suffer from inadequate water(as in the case of land capability class three).Hence any rational management of existing river systems should consider the management of badland topography along with soil conservation & soil treatment, otherwise simple dredging of sand from the river bed will not revive the capacity & competency of stream as observed in the Kopai river.

Study of Depressions over Lateritic Surfaces of Ratnagiri

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Near circular depressions are prominent features over the lateritic surfaces in South Konkan. They are also observed in lateritic areas in Africa. The formation of these is described as pseudo - karst in nature. The soluble part is lost with the percolating water. This solution produces hollows at the base. The crust over these hollows sinks, forming depressions. Their regular and prominent appearance over the surface is striking especially in the satellite images. These also serve as inland depressions where the streams converge. With these streams sediment generated over the plateau gets collected into these depressions. Therefore they are filled with thin sediment. These are environmentally and economically significant because this sediment supports growth of vegetation and paddy cultivation over the otherwise barren surfaces.
An attempt is made to study the characteristics of these depressions using image analysis technique. IRS 1-D PAN Point geo-coded image was analysed. The sediment was studied. Mapping of monsoonal overland flows was done an its association with ground water was studied in this work.

Wetlands (Holas) of Tezpur Town, Assam : A Study in Urban Geomorphology

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Tezpur is one of the most beautiful and historically important towns of Assam. The topography of the town is dominantly characterized by the peculiar wetlands locally known as 'holas'. The 'holas' are elongated features and they represent abandoned channel sections of the Braahmaputra and it's major tributary- the Jia Bharali River. Being created due to fluvio-geomorphic actions, these 'holas' play an important role in the urban environment of the town. With the expansion of urban activities, these ecologically important features have been suffering from human encroachment and other allied problems causing degradation of urban environment. This study attempts to analyze the fluvio-geomorphic characteristics and the environmental importance of the 'holas' of Tezpur town besides discussing the geo-environmental problems of the 'holas'. A conservation and management plan for the 'holas' has been also suggested in the study based on the prevailing topographic and geomorphic make-up of the town.

Soil and Water Quality Assessment of the Wetlands of Brahmaputra floodplain in Kamrup District: A case study in Garjang and Kukurmara Beel (Wetland)

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Wetlands are an important geomorphic feature of the floodplains. The present study area of the Kamrup district is endowed with numerous floodplain wetlands of varying shapes and sizes. For the purpose of the study two wetland, one each from the north bank and the south bank of the river Brahmaputra is taken into consideration. The wetlands act as a habitat for the different flora and fauna and also provider of livelihood for the local community who inhibit in the nearby areas. But the productivity and the survival of the wetlands depend on the criteria of soil and water quality. Soil plays a crucial role in the survival of a water body and aquatic life form supported by it. The quality of water determines the ecological conditions of wetlands. Soil and water quality assessment is important in order to understand the productivity of the wetlands. In this paper an attempt has been made to examine how soil and water quality vary over the study area, how they are related to the species abundance and biodiversity of the wetlands and whether the location of the wetlands within the floodplain can be related to inter-wetland and intra-wetland variability of the soil and water quality of the study area.
Key words: floodplain, ecological conditions, wetland variability

Shrinking Wetlands Threat to Biodiversity: A Geomorphological Study on Dhamar Beel (Wetland) of Goalpara District, Assam

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The wetland is one of the most important physical features of the earth surface and it has been identified as a store house of number of flora and fauna within the aquatic ecosystem. The interdependence of productive wetland and man's activities has made a biologically productive and ecologically significant relation among them. But in recent time different wetlands have gone under a serious threat with the expansion of human activities in and around wetlands especially nearby urban areas.
Assam is well known for its wetlands. There are about 3000 wetlands (Beels) in Assam and among them Dhamar Beel is one of the prominent ones, and is important in western part of Goalpara district of Assam. The beel is located on the south bank of the mighty river Brahmaputra and south east of Lakhipur town covering an area of 37.08 hectare. In 1991 the beel area was 150.40 hectors which is reduced to 37.08 hectare in 2007. In recent years the wetted perimeter of the beel has been shrinking at an alarming rate which causes enormous reduction of fish population, threats to flora and fauna and it affects the economy in the surrounding areas too.
Here an attempt has been made to discuss the salient features of the Dhamar Beel, its floral and faunal diversity, the causes of shrinkage and to see possible linkage with the human activities of the surrounding region.
Keywords: interdependence, ecologically significant

Assessment of Eutrophication Hazards in the Lakes of Patan Plateau, District Satara, Maharashtra State

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Eutrophication hazard in the water bodies remained overlooked in many parts of the nation. It is the alarming condition to many freshwater ecosystems in India and other parts of the world. It is the major cause of deterioration of freshwater ecosystems. The causes of eutrophication are natural as well as anthropogenic. Present study was aimed to analyse the lake water quality and to know the severity of Eutrophication hazard. The study area is one of laterite terrain in which some lakes have developed by geomorphic processes that occur in laterite landscape. The lakes are the only sources of surface water for the local people. Over the years due to continuous exploitation and use of fertilizers by the people, the lake water has become polluted. The present study aims to look into the extent of contamination of the lake water and the degree of hazard posed to the local people. To know the level of eutrophication water quality is assessed for pH, electrical conductivity, chloride, nitrate and phosphate contents. On the basis of analysis it is concluded that quantity of chlorides, nitrate and phosphates are above the maximum limit of eutrophication. All the lakes in this area are in the category of hypertrophic phase. Based on observation of lakes it is also concluded that currently no algal bloom are observed but in near future all these lakes may face the eutrophication problem like algal bloom and deterioration of the ecosystems.

Landform Evolution of Guwahati City, Assam - A Geoenvironmental Approach

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Guwahati city, the gateway to the North Eastern part of India is growing rapidly covering an area of about 262 sq km (lat. 26 0 5' E to 26 0 12' E and long. 910 34' N to910 51'N). The area is a part of the northern extension of Shillong Plateau otherwise again north easterly continuation of Indian Peninsula. The city is dotted with hills and inselbergs surrounded by plain areas and wetlands - some of which are the places of large water bodies and beels (lakes) namely Dipar beels, Sola beels,Tepor beels etc. The mighty Brahmaputra river is flowing along the northern margin of the city which as exemplified by history, is playing a major role in shaping the landscape of the city area. Guwahati city gets its present position by enlarging and reducing its extent between the hills situated in the area. The present study is an attempt to examine the trace of Brahmaputra through Guwahati in the context of modern day science. For this study, geological, geomorphological, drainage maps have been prepared using satellite images (IRS LISS-III, Cartosat-1, Landsat- 7 ETM+) and the Survey of India toposheets) along with consultation of published documents. Log data of deep tube well have been collected and samples have been analyzed in the laboratory for grain size analysis and heavy mineral study. Samples are collected from deep tube wells as well as from the locations where we belief that old course of Brahmaputra existed and also from surroundings areas of the hills and valleys. The deep tube well sediments along the linear depression yielded heavy minerals like epidote, kyanite, zircon, sillimanite, tourma-

line and staurolite where as marginal part of the hill and valley area heavy minerals are found are hornblende, zircon and garnet. Kanite and epidote are key heavy minerals of Brahmaputra sand. The study indicates probably, the Brahmaputra was flowing along the linear depressed are south of the city. Statistical study of the textural parameters also indicates that the deep profile of the depressed valley was filled up by sediments contributed by river system. The study tells that Brahmaputra flowed through Guwahati as three river courses. The southern course was coming from Panikhaiti, Satgoan, Bonda, Beltola Dispur, Hatigoan and Deepar bills. Northern course was flow through Sunsali, Japorigog, Narakasur, Phatasil, Lankeswar and third one was flow through Panikahaiti, Satgoan, Basistha, Garbhanga an Monakhurung. Though all this course was not exist now but presence of the beels like Raja beel, Hahchara beell, Damal, Silsako, Bonda, etc. is all probability indicate the ancient course of the Brahmaputra. The profiles of the sediments generated from the deep tube well data also indicate a riverine floor for the sedimentation.

Impacts of Groundwater Contamination with Arsenic in India

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Chemicals in drinking water can have acute and chronic toxic effects on humans. The crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families can not be overstated. According to some estimates, it accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India. In India, where, groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource. Its over - exploitation is causing aquifer contamination in certain instances, while in certain others its unscientific development with insufficient knowledge of groundwater flow dynamic and geo hydro chemical processes has led to its mineralization. Over the years the problem areas that emerged witnessed excessive exploitation of groundwater for domestic and industrial uses. As pollution control enforcement activities gained momentum there were observed cases of indiscriminate waste disposal, subsurface discharge of effluent and inappropriate wastewater management by industries. Today as a result of these malpractices there is a palpable stress on groundwater, in term of quantitative imbalances as well as quality deterioration.

The incidence of high - concentration of arsenic in drinking water has emerged as a major public - health problem. With newer - affected sites discovered during the last decade, a significant change has been observed in the global scenario of arsenic contamination, especially in Asian countries.

Arsenic or saline contamination of groundwater is not a new problem, but it has achieved unprecedented dimensions since the mid- 80s because, as sea levels rise and shrimp cultivation grows unchecked, saline in now flooding the water supply. The situation is worst, Along with the present situation in severely - affected countries in Asia, such as India.

Keywords: Groundwater Contamination - Arsenic in drinking water,

An Account of Soil Erodibility Indices in Soils of Tripura under Variable Land Use Systems

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In North East India, according to old soil classification, there are 6 types of soils, viz., red loamy soils, red and yellow soils, alluvial soils, mountain soils, laterite soils and terai soils. Now, the USDA classification has indicated that the soils of the region were of 5 orders, 22 great groups and 45 sub groups. The soils of Tripura , according to USDA classification , belong to 5 orders,7 suborders,9 great groups and 19 subgroups. The 5 orders are Inceptisols, Entisols, Ultisols, Alfisols and Histosols occupying 80.6,8.1,6.6,4.5 and 0.2 per cent, respectively. According to climatic/topographical variations, there are 3 zones in Tripura and the zone wise distribution of soils in Tripura is presented below.
Under the Zone 1 (Humid Dissected Mounds), the geology , in general is represented by sedimentary rocks which ranges in age from Miocene (25 million years) to loosely consolidated sediments of recent origin (less than 1 million years). Depending upon the characteristics and presence of fossils, these sedimentary rock sequences are divided into Surma Group (the oldest), Tipam Group and Dupitila Group (the youngest). In low lying dissected mounds and undulating to rolling plains, Ultic Hapludalf, Typic Paleudalf, Typic Dystrochrept, Typic Paleudult and Typic Hapludult soils are common. In valleys and flood Plain areas ,Typic Ochraqualf, Aeric Ochraqualf, Typic Hapluquent, Aeric Hapluquent, Typic Udifluvent, Typic Fluvaquent and Aeric Fluvaquent soils are frequently encountered. Ground water is good in valley fills, dissected mounds and certain parts of denudational hills. Under the Zone II (Sub-Humid Hills) , sandstone belonging to Tipam group constitutes the major geological formations of the area. These rocks range in age from mid Tertiary (15 million years old) to recent origin. Most of the soils occurring in the hilly tract, comes under Typic Hapludalf , Typic Paleudalf, Typic Paleudults, Typic Hapludults Typic Palehumult and Typic Dystrochrept Sub-groups . Under the zone III (Sub humid denuded hills), sandstone belonging to Tipam group also constitutes the major geological formation . The age of these rock formations ranges from mid-tertiary (15 million years) to recent origin . Denudational hills are dominated by Typic Hapludalf, Typic Paleudalf, Typic Hapludult, Typic Paleudult, Typic Palehumult and Typic Dystrochrept soils. Lowlying disserted mounds, undulating to rolling plains are dominated by Ultic Hapludalf , Typic Paleudalf , Typic Dystrochrept, Typic Paleudult and Typic Hapludult soils.
Soil erosion ,described as a global epidemic ,is the maximum in India ,being 18.5 per cent of the total soil losses from the croplands of the world. The undulated terrain of the North East India, particularly Tripura faces an alarming rate of land degradation. There are various erodibility indices to identify the soils under the threat of erosion. The indices are as follows.

* Clay Ratio = (Sand + Silt)/Clay.
* Suspension Per cent = (Silt + Clay suspended in soil after shaking in water)/total contents of silt plus clay.
* Stability Index =Clay ratio /Loss on ignition.
* Dispersion Ratio =Suspension per cent /total contents of silt plus clay.
* Erosion Ratio = Dispersion ratio /clay -available water ratio.

Soils were collected from 3 topographical situations, viz., upland, lowland and river valley in Tripura and erodibilty indices were measured in soils. Clay content was significantly and negatively correlated with erosion ratio thereby corroborating the findings that the fine textured soils were less erodible than the soils of light texture. Clay ratio was found to vary from 1.5 t0 24.0. The lower the ratio, the more would be the clay accumulation. Suspension percentage was found to vary from 3 to 20 in these soils. The greater the value, the more easily the soil could be eroded. On the other hand, the stability index was found to be more pronounced in lowland as compared to upland soils.Clay- available water ratio was negatively correlated with erosion ratio (0.723). The higher the ratio, the more would be the relative permeability of the soil for water, thus reducing the possibility of soil erosion by runoff water. Soils having the dispersion ratio more than 10 were erosive in nature thus indicating the most of the soils are highly erodible. Upland soils appear to be more susceptible to erosion, although the surface soils of river basin are also observed to be erodible. Similarly erodibility indices are also measured in soils under multipurpose tree species(MPTs) in agroforestry arboretum in upland toposequence. The dispersion and erosion ration of soils under MPTs were found to vary from 1.91 to 6.8 and1.75 to 5.55, respectively. The low values (< 10) of dispersion/erosion ratio indicated the less erosive nature of soils under MPTs.

So, it can be said that erodibility indices may be effectively used to ascertain the soils vulnerable to erosion in such a way that the control of soil erosion in uplands particularly under sloppy toposequence can be planned to sustain the soil productivity.

Estimation of Soil Erosion in Digaru River Basin, Assam, Using Fournier Model of Sediment Yield

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Soil erosion is a major problem anywhere in the world because it removes the top layer of fertile organic content of the soil. The acuteness of the problem could be understood from the fact that the process of soil formation is too slow with profiles developing at the rate of about 1cm in 100-400 years, in comparison to the rate of erosion. The combined impact of the lithological characteristics climogenetic forces, vegetation, slope, drainage density, relief etc. determines the intensity of soil erosion of any region. It is observed that the natural rate of soil erosion vary greatly from place to place on the basis of the variation of role played by these factors. In the present study an attempt has been made to estimate the soil erosion of Digaru River in Assam considering different variables. The estimation of soil erosion in the present study has been made by applying the empirical equation put forwarded by Fournier F. to predict sediment yield from the knowledge of relief and climate.

Estimation of Soil Loss on Artificial Cut and Artificial Deposit Slopes in Tripura University Campus

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The present paper aims at studying the nature and extent of soil loss in two different category of artificially made slope, one of which is artificial cut slope and the other one is artificial deposit slope in Tripua University Campus. Most areas in the University Campus have been modified articially for different types of construction work. In most of the cases very low tilla lands have been cut unscientifically which creates huge amount of soil loss during every monsoon period. Thus, the present study has been undertaken to measure the amount of soil loss on artificial cut and deposit slopes from the field by manual sediment trapper, to estimate the average amount of soil loss from different slope units and to propose some effective field validated means of controlling such menace.

Geomorphic hazards In and Around Aizawl

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In recent times, there has been an unprecedented increase in the frequency, intensity and extent of geomorphic hazards or geohazards related particularly with processes of mass wasting, erosion and deposition. Geohazards associated with hill slope processes, especially mass movement, are very common and devastating in the hills of Northeast India, including the Mizo Hills, generally affecting large human settlements and means of communication. Fragile lithology and weak structure coupled with incessant rainfall are mainly responsible for it, but human alteration in geomorphic processes and forms has also accelerated the incidence of geohazards. In the present paper, geomorphic hazards related with the hill slope processes have been studied in and around Aizawl.

Various types of slope failure events in Mizoram from 1959-2006 have been briefly highlighted, including the disastrous events locally known as 'Minpui Kum' (Year of Major Landslide) which is believed to occur approximately every 36 years. Notable landslide events were reported from three towns viz., Lawngtlai, Saiha and Aizawl. In the year 2007, there were 227 slope failures of different dimensions in and around Aizawl. The number of landslide events followed the trend of monthly rainfall, which clearly reveals that rainfall is the most important triggering factor of landslides. Most of the landslide occurred during the rainy period of 4 months, highest (156 events) in the month of September because by that time the hill slope material is wet enough to increase shear stress leading to sliding down of the material. This fact is negatively evident in 2008, because there has not been any notable slope failure in the study area as the amount of rainfall has been much below the average. The estimated value of damage during September 2007 was Rs. 12.10 lakhs affecting as many as 276 families with six casualties. Interestingly, most of the affected families are confined to localities having high population, suggesting human intervention/alteration in the geomorphic system. About 32 localities were affected by geohazards, out of which 20 were affected by landslide, 10 by subsidence and land-crack and the remaining by collapse of retaining wall due to slope failure. However, in case of 276 families affected by geomorphic hazards, it is observed that the number of families affected by land-crack and subsidence is more (176) than landslides (97), because the former covers larger area directly damaging the houses lying on it. It can be concluded that the various inherent geoenvironmental factors like lithology and structure, seismic activity, angle of slope, amount of rainfall, type and depth of soil, vegetation and degree of deforestation, level of urbanization, erroneous anthropogenic activities related with construction of public infrastructure are the factors responsible for occurrence of geohazards in and around Aizawl. Of course, it appears that the anthropogenic activities are playing greater role in occurrence of geomorphic hazards.

ANTHROPOGENIC IMPACT ON GEOMORPHIC HAZARDS

Special Lecture

Anthropogenic Role of Flood Hazard Management in Sub-Himalayan North Bengal

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Bank failure, river shifting and river deposition in association with high intensity rainstorm induced flush flood in Sub-Himalayan North Bengal are primarily nature's way of adjusting fluvial dynamics in the sub-Himalayan North Bengal. Such an adjustment has been deleteriously distributed by the human interferences. The catchment area of these rivers has mostly been deforested and the clearings of the steep slopes have been used for the extension of settlement, agriculture, plantation and communication, disrupting the overall hill slope hydrological balance. As a result, during heavy and concentrated rainfall, catastrophic soil erosion and innumerable landslides are caused transporting huge amount of sediment to the rivers which are incapable of transporting the load efficiently under the existing hydrological conditions, especially along their lower reaches. As a result, the riverbeds are rising at some sections in the plains, resulting in the lessening of cross-sectional areas which being incapable of arresting the unusual monsoon discharge and allow water to spill, causing floods.

Moreover, the narrow road and railway bridges across the rivers as well as the supporting pillars are always considered to be the barriers, interrupting natural load movement behavior of the rivers. This often cause accelerated deposition at the bottom of the bridge and thereby, narrowing the outlets of the rivers gradually. Such constrictions, sometimes due more to the entanglement of uprooted trees to the voluminous flows of the flood, often multiply its effects many times damaging the bridges, human habitations and firm lands. Consequently, the frequency and magnitude of such events has increased many fold during the recent past. Such catastrophic events during the past few decades demonstrate the enormity of damage and ever-increasing threat to the society, economy and the environments of North Bengal.

Contemporary flood disaster in North Bengal is essentially man induced. The following processes are in fact responsible for increasing frequency and magnitude of flood disaster:

* Degradation in catchment area
* Construction of unplanned and wanton embankments
* Filling up of wetlands/depression for the extension of agriculture & settlement
* Encroachment of river valley
* Converting dormant/seasonal/paleo-channel into arable and/or settled area

Flood, like many other natural processes have many beneficial effects on the economy and environment. The traditional flood protective measure not only deprives of beneficial effects but also accelerates the detrimental effects like aggradations, bank failure and avulsion. It is tempting to improve on nature to control flood and to reclaim land through channelization followed by bank protection. The effect of such arterial drainage channelization as recorded would be the increase of peak flows, whilst the flooding problem in protected area was reduced in addition to reclaimed land, the problem of bank erosion and flooding was found to be moved downstream at higher magnitude and frequency. The NBFCC constructed 787 km long embankments (2006) along the Sub-Himalayan rivers. It could partially protect 950 sq. km area at the cost of 2400 sq. km area that brought under threat of flood hazard. Following are the major effects of embankment on the fluvial dynamics of sub-Himalayan rivers:

* Aggradations vis-à-vis raising of riverbed at an alarming rate and in many cases riverbeds found higher than the ground level inducing avulsion.

* Providing false security among the local inhabitants and instrumental for large scale human settlement in the river valley e.g., between embankment and active channel.

* Responsible for making the river unpredictable.

Flood Management

A. Short term area-specific structural measures

Keeping in mind the inadequacy of Embankment in controlling flood menace over a large area and its long term adverse effects on environment, the following suggestions are proposed:

* Embankments should only be constructed in strategic and high priority area with proper layout and materials i.e., ACM.

* The existing embankments should be strengthened and be properly maintained since breaching of such structures often caused catastrophic loss and avulsion.

Uninterrupted natural load movement of the rivers must be ensured through widening of existing road and railway bridges and culverts. This will also reduced the chance of avulsion and flood to some extent.

De-silting of wetland, depression, cut-off channel and paleo-channel for promoting of rainwater harvesting and also to act as detention basin.

B. Short term area-specific non-structural measures

* Identification of flood valley vis-à-vis flood plain zoning:

i). Prohibitive ii). Restrictive & iii). Warning

* Prevention of human encroachment in flood valley.

* Construction of flood shelter in high priority area at G. P. level.

* Introduction of Flood Insurance.

* Introduction of Flood Management Information System (FMIS) involving real time:

i). Data accusation, ii). Transmission, iii). Processing, iv). Forecasting & v). Dissemination.

* G.P. based disaster preparedness and response planning

* Awareness programme on flood-man relation at GP level.

C. Long Term Measures:

" Setting up Hydro-meteorological Stations in the catchment areas including in Bhutan to monitor: a) rainfall, b) temperature, c) humidity, d) discharge, e) sediment load and other hydrological properties and f) land use pattern in the catchment area. This is a must to understand the mechanism of flood generating forces and to evolve a full proof flood forecasting for North Bengal.

* Watershed management, under this, at least one Proto-type catchment area should be monitored for 5 -10 years. This will ultimately helps in developing a flood protection model for North Bengal.

* Check dams should be constructed across suitable third order streams along the hill slopes to prevent sediment load.

* Measures to protect landslides and soil erosion should be taken in the upper catchment.

* Introduction of R&D wing in the North Bengal Flood Control Commission.

* Monitoring land-use change both in upper and lower catchment area.

The Future

Let us tell our people living in threshold areas (prohibitive/restrictive zone) categorically that they are living in an unsafe area and it is not possible to provide them security against possible flood. The land use pattern, house type must be suitable to cope up the possible threat. The traditional art and life style of living with flood must be adhered to. However, the life both human and animal along with movable property must be protected through the construction of Flood Shelter nearby preferably within the radius of 2 km. The following anthropogenic flood management model has been proposed.

* Identification of flood prone area and plot it on Cadastral map (Scale 1:3960) at Gram Pancheyet level.
* Flood Plain Zoning of the major rivers at Gram Pancheyet Level on Mauza map.
* Identification of Prohibitive zone and listing of families settled, land use practice, domestic animals, source of drinking water and other services existed in such zone.
* Identification of Restrictive zone and listing of families settled, land use practice, domestic animals, source of drinking water and other services existed in such zone.
* Identification of Warning zone and listing of families settled, land use practice, domestic animals, source of drinking water and other services existed in such zone.
* Projection of possible damages under different degrees of hazard.
* Identification of sites for Flood Shelter and facilities needed.
* Developing FMIS under GIS platform. An on-line linkage with the forecasting agencies will help decision taker to take right decision at right time.
* It will be possible to arrange for emergency evacuation, rescue for human and animal and also for movable commodities.
* The FMIS thus developed will also be of great help in providing efficient relief measures.

Although, the task is enormous, expensive and time consuming, yet the concern departments with the help of Gram Pancheyet can initiate such programme. Expert agency can also be engaged. Such approach although, would not control flood yet it will definitely help in reducing the loss and sufferings of the victims to a maximum extent. A portion of money spent every year for the construction of traditional flood protection may be kept aside as the emergency fund for the possible victims. Individual Gram Pancheyet can also mobilize fund for such purpose. The GP may also consider the proposed scheme for flood insurance in future.

Special Lecture

Gender Perspectives in Environmental Management and Mitigation of Natural Disasters: The Case of Climate Change

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As predicted by the IPCC, "climate change impacts will be differently distributed among different regions, generations, age classes, income groups, occupations and genders" (IPCC, 2001). The IPCC also notes: "the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other resources." A study of disasters in 141 countries provided decisive evidence that gender differences in deaths from natural disasters are directly linked to women's economic and social rights. In inequitable societies, women are more vulnerable to disasters. In the face of extreme weather events, desertification, and a rise in sea levels, governments and communities around the world increasingly recognize that the need to mitigate and adapt to climate change is urgent. This paper considers the gendered dimensions of natural disaster occurrences with a particular focus on climate change and examines the potential impacts of environmental degradation and change on vulnerable groups. Men's and women's differing experiences of natural hazards are not well researched, particularly in developing countries. However, it is well known that women experience high level of pre-disaster poverty, often experiencing unequal status in workforce, being more likely to be employed in the informal sector and having less equitable access to land and other natural

resources compared to men. The impact of a natural hazard depends on the social context within which it occurs. This socially constructed vulnerability extends to the contextual gender and power relations. Natural disasters - particularly erosion and other forms of soil degradation, pollution of freshwaters, shore-line erosion, flooding, loss of wetlands, drought and desertification- impact directly on women in their roles as providers of food, water and fuel. Climate change can also impact on women's productive roles since the physical impacts of global warming - rising sea levels, flooding in low-lying delta areas and increased salt-water intrusion- can jeopardize sustainable livelihood strategies. Food security and family well-being are threatened when the resource base on which women rely to carry out their critical roles and obtain supplementary incomes is undermined.

Depletion of A Wetland And Its Impact Assessment: A Micro-Study

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It is an utter ignominy that a virtual prosperity under the heel of an almost irretrievable loss of the ecological support-base ails hard today's country humanity set in quest of a square meal. Who is to blame? It is humans who alone have the ability to adversely affect the environment often to deleterious effect. The study aims at presenting a comprehensive picture of such a misdeed-- a sample case of wetland disappearing in the 'Bagri' sub-region of Murshidabad in West Bengal.

The depletion of wetlands could partly owe to natural processes like siltation. The study, however, precludes these natural pathways, and tends to deal with only the anthropogenic impacts on them. Agriculture-- the growing of paddy, in particular-- having been extended, the interaction between man and wetlands has considerably been enhanced, the human population explosion has brought an undesirable pressure exerting a thrust towards draining water out of bills on account of getting more arable land, leaving the wetlands in the most parts of the district under threat of over-exploitation and undergoing degradation due to extensive farming and other development works.

Bagri region of Murshidabad is a part of muriband delta where numerous shallow water bodies, ox-bow-lakes, abandoned channels of streams are in plenty. 'Bado Bil' was an important fresh water wetland of this Bagri region providing for a large biodiversity and a resource-pool for livelihood of the community inhabiting around it. The economic and ecological impact of drying- up of this inland water body is immense and far reaching. The 'Bado Bil' was drained out by dredging a canal. Maybe, a large tract of fertile land was derived, and consequently a few families have been benefited in a short-term count, but the entire community, particularly encompassing fishermen whose whole economic life revolved around the wetland is now drowned under the unfathomable depth of aridness. The crisis emerged out of alteration of occupation of the local community is a serious problem in terms of derangement of the pattern of local economy. The ecological impacts of death of water body are not only indirectly affecting local economy, but also the environmental harm in one system must have ill influence on the other surrounding systems' functioning.

This paper intends to respect the evolution of a new paradigm as the consequence of a wetland being transfigured into a high yielding paddy land as it was claimed by a smaller group of the local farmers. The study is to poise the controversial outcomes of the wetland being converted into arable fields. The study anticipates that it can create a data-base to be channelised in the making up the policy for the wetland management and conservation, with a view to a sustainable development, in terms of human sustenance and ecological wholesomeness.

Natural Disaster Management - Socio-Political Awareness

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India is one of the most vulnerable developing countries to suffer very often from various natural disasters, namely drought, flood, cyclone, earth quake, landslide, forest fire, hail storm, locust, volcanic eruption, etc. Which strike causing a devastating impact on human life, economy and environment. Though it is almost impossible to fully recoup the damage caused by the disasters, it is possible to (i) minimize the potential risks by developing early warning strategies (ii) prepare and implement developmental plans to provide resilience to such disasters (iii) mobilize resources including communication and telemedicinal services, and (iv) to help in rehabilitation and post-disaster reconstruction. The article describes the natural disaster management and socio-political awareness among the human beings and disaster management for the well being of the society. Besides to find out the major impacts of natural disasters, Suitable Strategy to Mitigate the Disaster and Provide the Sustainable Security to the Nation and Society. In this article more emphasis are given on the uneven distribution calamities fund in India. The most affected areas by natural disasters are getting less calamities fund as compared to the less affected areas. And finally to synthesis all the findings and give feasible suggestions and recommendations for further management of natural disasters in India.
Key Words: drought, flood, cyclone, communication, nation, sustainable security

Impacts of Arsenic Pollution in Rural West Bengal with Special Reference to the Districts of North and South 24 Parganas

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Access to a safe water supply is one of the most important determinants of the society. This recognition of the importance of safe water supplies had led to an emphasis on the provision of appropriate facilities in developing countries. Traditionally, in most of the regions of West Bengal, before 1969-70, rural population got its drinking water from surface ponds, rivers etc. But it was realized that due to severe micro-biological contamination of surface water caused death of million people from water borne diseases. Then shallow water tables and favourable geological condition made installation of shallow tube-wells in different places of West Bengal. But the ground water in a huge alluvium tract along the river Bhagirathi- Hugli covering a stretch of about 470 km., encompassing nine districts of West Bengal are severely affected by arsenic pollution and the shallow tube-wells having a depth of approximately 20-100 metres are the main sources of drinking water supplying the arsenic contaminated water. After drinking the arsenic contaminated water the people of the West Bengal are suffering from "arsenical dermatosis" known as "ARSENICOSIS" It is estimated that 6.5 million people are drinking high level arsenic contaminated water and 8.7 million people are drinking moderate arsenic contaminated water. Arsenic related health problem of rural population includes physical weakness, respiratory problem, cold and cough through out the year, darkening of skin, gangrene, cancer etc. The severity of arsenic hazard is turning to disaster in rural areas of West Bengal. For arsenicosis people are also sufferings from different social and economic problems such as isolation, job loss etc. Author is trying to establish how the factors, i.e. low income, poverty, malnutrition illiteracy, health condition, intake water etc. are affecting susceptibility to arsenic poisoning of rural communities in West Bengal.

Assessment of Forest Degradation Types Under Different Topographic Units of Kasi-Subarnarekha Interfluves (Jhargram Subdivision) and Forest Restoration Process with Different Management Options for the Region

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The topographic diversity with rolling upland surface of Kasai- Subarnarekha interfluves (Jhargram Subdivision) was densely covered by monsoon forest dominated by Sal (Shorea robusta) and associate plants even in the early decades of previous century. Now the forest areas are heavily degraded due to several human activities as well as natural consequences of land degradations caused by forest removal process from the upland margins of region. The regeneration of true forests with diversity of plants are not possible at present to support the various ecosystems and forest based societies of Western Medinipur.

The types of forest degradation under different topographic units are discussed in this paper for identification of specific management options and also to fulfill the needs of forest resources by traditional forest dwelling units of the region. There are four significant topographic units in the region over which the forests are more or less degraded in different ways particularly due to intentional habitat conversion, land use practices, expansion of human settlements and also for communication networks and developmental activities. A true forest with core trees and associate plants not only supplied fuels and timbers but also the other available forest resources for the maintenance of the livelihood of the forest dwellers.

Topographic Units	*Degradation Types*	*Management Options*
Minor valley cuts and valley fills surface	Conversion	Agro- forestry
Laterite upland surface with forest cover	Fragmentation and isolation	Eco-park, and afforestation and JFM
Laterite upland surface without forest cover	Complete degradation	Water resource management by check dams
Wide valley fills surface with active rivers	Conversion	Agro-forestry and pasturelands

The study shows that joint forest management is not the only solution of forest degradation or protection and also the fulfillment of other social needs of the traditional forest based societies in the region. The regeneration of true forest is needed at least for a certain area of completely degraded sites. Agro- forestry and soil management practices are also needed for the remaining degraded sites of upland tracts with the selection of suitable economic plants to conserve the semi- natural ecosystems of the region from further intensified land degradation process under altered environment. The soil is acidic in reaction on the upland tract and NPK status is also ranging low to medium in the valley fills surface of the region. Therefore, the traditional agricultural activities (rice paddy farming in the Aman season) of the valley fills surface also needs modification for introduction of dry crops and mixed crops with the adjustment of altered soil environment and available water resources in the region.

In order to develop a database for the local scale assessment of forest degradation, relevant data have been gathered from local, state and district level agencies, as well as field survey reports and other available reports. The satellite image data (both FCC and true colour images) is also utilized for the identification of degraded sites and their characters. The village level survey of the forest interface society is conducted in administrative blocks and forest ranges for identification of present day livelihood patterns of the forest dwellers of the study areas. Finally, the compilation of data set has produced several thematic maps for the utilization in management options for the different degraded sites of forests.

Deforestation as an Agent for Modification of Rainfall and Runoff in the Middle Terai Planis and Adjacent Hills of the Darjiling District, West Bengal, India

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Rainfall when occurs in normal amount is a boon but when it deviates from normality is obviously a bane since it plays a key role in intense soil erosion, devastating land slides and even in catastrophic crop failure. It is generally thought that the deforestation changes the normal occurrence of rainfall. But it becomes very difficult to prove unless some correlation and comparison are done (with available data) between deforestation and rainfall among different areas having varied amount of forest cover.

Therefore, the present paper takes an attempt to carry out a comparative analysis of the rate of deforestation and the occurrence of monsoonal dry spells, the non-monsoonal number of rainy days (when rainfall occurs due to local reason) between two contrasting areas and runoff of the different periods with varied amount of forest cover in the Middle Terai plains and adjacent hills of the Darjeeling District, West Bengal, India. In this region there are some areas where severe deforestation has taken place compared to some other parts where forest has remained intact, but if we look at the total amount of forest cover there has been a steep decrement since pre-independence time. The rainfall data has been used for this analysis ranges from 1950 to 2001.

It is found from the analysis that the several dry spells interspersed with high peaks in the monsoonal rainy days have occurred in the Simulbari area which has undergone severe deforestation in comparison to the Long-View site (comprising Bamonpokhri reserved forest and other forested areas) where forest still exists almost in its pristine state. Similarly, the non-monsoonal rainy days are found to have reduced suddenly in significant number after mass clearing of a vast forest cover in Simulbari area for establishment of military settlement followed by Indo-China border conflict in comparison to its Long-View counterpart. The runoff has been calculated for this region which shows gradual increase in amount in different periods with steep fall of forest cover from 48.03% in 1931 to only 19.40% in 2001.

Effect of Open Case Mining on Landform and Landuse - A Case Study on Bansra OCP, Raniganj Coalfield, West Bengal

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With the growth of scientific knowledge and development of technology man has emerged as a significant geomorphic agent and is capable of changing the earth surface at a rate many times fast than the natural processes. The researcher here intends to judge the above mentioned statement through thorough study of an open cast mine in Raniganj Coalfield area. Among different mining processes, open cast mining is such a process which disturbs entirely the upper part of the crust including the soil layer. The method is capable of changing the entire landform and land use within a very short period. This feature is well exemplified in Bansra OCP which is an abandoned open cast mine of the Ranigang Coalfield. Here the entire landscape, which was initially a rolling one with a very low angle of dip has changed into a highly undulating surface with very steep dip and even escarpment faces. The landscape and the landuse pattern of the abandoned Bansra OCP are completely different and noteworthy compared to its surroundings. Thus the researcher's aim is to highlight the effect of opencast mining on landform and landuse through the study of Bansra OCP.

In Situ Conservation- A Means to Check Biodiversity Loss in India

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Maintaining biodiversity is a necessity for keeping nature in perfect balance. But human interferences have been threatning this balance causing loss of biodiversity at an alarming rate worldwide.India is no exception. IUCN has brought out a Red List of threatened species of plants and animals of which India has a good share. Scientists have suggested conservation measures. In situ conservation is the most talked about conservation techniques adopted by various countries worldwide and India as well. Project Tiger is a unique example of in situ conservation in India. In the present topic, issues related to counter biohazards through in situ conservation has been discussed.

Geomorphological Environmental Management at Indian Antarctic Station - MAITRI

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The 'Bottom of the World' or 'last real Wilderness of the World', is in true sense 'Last Frontiers' and MAITRI - Indian Antarctic Station - is the Farthest most proud post of India. And also, it is indeed a 'threshold value' or 'base - line' for any measurement, especially environmental aspects. Various ingredients of the environment has been observed and measured here in this paper. But the measurement and observation of 'ozone depletion' in the month of September - October is very significant and worth -mentioning. Antarctica is the coldest, harshest and pristine and can be treated as open environmental laboratory for scientific research work.

Antarctica, it is a misnomer, that being at the 'Bottom of the World' may be having hardly any elevation or relief. Antarctica is the highest of all continents having an average elevation of 2300 meters. This seventh continent covers an area of about 14X106 sq. km. and contains approximately 90% of the World's ice. Antarctica almost controls the climate and weather of the whole world and is called pulsating island continent as its snow-mass is increased during winter and decreased in summer.

During winter, its temperature fluctuates between -50°C to -60°C while in summer it ranges from -15°C to -20°C (excluding wind chill factor). World's lowest known temperature has been recorded at VOSTOK as -89.4°C, a Russian station during 1983. Winds, as fast as 320 KMPH has been recorded, and this is why Antarctica is also called Windiest place on earth. During the Eighteenth Century adventurers, sealers and whalers were exploiting the flora and fauna of Antarctica. To curb the exploitation of the frozen continent finally International Geophysical Year (IGY) was promulgated (IGY began on 01 January 1957 and ended officially on 31 December 1958). Later Antarctic Treaty System(ATS), Scientific Committee on Antarctic Research (SCAR), International Council of Scientific Union (ICSU) and many other NGOs (Non Governmental Organizations) came in vogue. IGY and formulation of Antarctic Treaty have heralded a new era for Antarctic declaring that Antarctic shall be used for scientific and peaceful purposes. All the above organizations have controlled and monitoring the indiscriminate ingress of exploitation of Antarctic environment.

In the present paper special attention has been given to the Indian Antarctic Station, MAITRI for the control and protection of environment in and around the station. As has been observed, to protect the environment of Antarctica, many NGO's have been established. The Environmental Management Plan (EMP) Specially Protected Areas (SPAs), Biological and conservations of marine life, flora and fauna have been in existence. Madrid Protocol, formulated during 1981 - 82 has been implemented for protecting Antarctic Continent and its surrounding.

Environment and Development in India- A Thematic Introduction

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Ever since its emergence about three million years ago, the humankind has adapted and is adapting to varied environmental zones in the tropical and temperate regions of the world. Adaptability, which is a fundamental property of the living beings, is the mechanism of self-regulation and perpetuation, which is the case of human species is achieved through culture. Therefore, culture is defined as man's extra somatic adaption - it is an adaptive system which integrates a society with its environment and other socio-economic systems. Environment, it is important to note, has two components, i.e. the physical and the social. The former comprises of the natural resource zones, while the later consists of social groups that share the environment with different adaptive strategies.

Culture, which is the key variable in mediating between the social groups and their respective environments, is esplicated as a system. Cultural system, in other words, is an adaptive system with three major elements (viewed as subsystems), which are technological, sociological and ideological. A systematic approach to the study of cultures, either of the past or the present endeavours at an interpretation of the historicity of cultures (cultural history), the adaptive mechanism (cultural processes), and cultural change (the causative factors that trigger a change from one mode to the other) in spatial-temporal framework. Even during the post colonial period, despite the implementation of several programmes for there development and to bring them into the mainstream the indigenous social group remains alienated. In such a kind scenario, this volume aims to present insights, contextual sing Indian examples, in to the interrelationships of the environment vis-à-vis culture (from the prehistoric past to the modern times) and situate (the role of) 'development' as an euphemism for appropriation)i.e. commercial exploitation) of the environments which are the habitats of many traditional societies, by the 'state'.

Since humans are a part of the natural world, their survival and development depends on maintaining harmonious relationships with the nature rather than destroying it. The aim at exploring the critical balance between the humans and their environment from prehistoric times to the present. Despite population and other pressres, tribal and forest communities have been striving to keep this balance through their cultural practices. But the worth of indigenous environmental knowledge has faded before the greedy, clutches of industrialization and technology of our culture.

Physico-Socio-Economic Sustainibility of Tea Gardens in Bisalgarh Sub-Division, West Tripura

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Tea is one the most important growing agriculture based industries in Tripura which shares a major part of the economy of the state. But the industry is facing different types of problem directly and indirectly. Excessive deforestation is taking place for preparing lands of tea plantation which enhances the quantity of soil erosion as well as affecting the climatic condition of the state, soil fertility is deteriorating due to excessive use of chemical fertilizers, cultivable land area is shrinking because of investing more land towards the plantation, unavailability of skilled labour and high cost of production, problem of transportation for marketing the products threat the industry for survival. Very few studies have so far been carried out but none of them addressed the problem together in a scientific manner, by which suitable measures can be proposed for sustaining the industry in the long run. Thus, the present study has been undertaken to analyze the physico-socio-economic problems scientifically and to propose proper remedial measures to restore the problems. For such an intensive study Bisalgarh sub-division of West Tripura district has been selected which is very close to the capital city Agartala. The sub-division consists of 2 (two) big tea gardens (Harishnagar Tea Estate & Kamalasagar Tea Estate) covering a total area of 298 ha. (approximately) and about 50 small grower's gardens.

Natural Disaster Reduction and Management

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All the natural events which occur very rarely are called extreme events such as volcanic eruptions, seismic events, land slides, Tsunamis, atmospheric disturbances, light tornado, hurricane, cyclones, typhoons etc., avalanches, cloud bursts, heat and cold waves etc. Generally, extreme events and hazards are considered as synonyms but some times hazards are taken as processes of extreme events. When an extreme event occurs in uninhabited areas, it is called disasters. It is evident that disaster is always considered interns of loss of human health and wealth, it is thus apparent that all the extreme events are hazards but not all the extreme events are disaster.

The natural disaster reduction and management involve two major aspects such as components or elements of disaster reduction and management and (2) stages of disaster reduction and management comprise hazard analysis, vulnerability analysis and risk analysis. The stage of disaster reduction and management includes pre-disaster stage and post disaster stage. The pre-disaster stage includes the consideration of disaster preparedness (P). This is mitigation (M) and disaster prevention (P). This is called PMP stage. On the other hand post disaster stage comprises (i) Relief measures (ii) Recovery and (iii) Rehabitation this is called (RRR) stage. The pre-disaster stage lays emphasis on to adopt such measures, which may minimize the disruptive farces of disaster and damages done by them. In this regarded the disaster preparedness is very important complements of disaster management wherein we give more importance to disaster research, disaster reduction, disaster prediction and disaster warning system. On the other hand the post disaster stage comprises to undertake immediate relief mark for the disaster affected people, to prepare the disaster affected victims to get them rid of physical and mental agony and trauma under the scheme of disaster recovery and to provide substantial facilities for proper rehabitation of displaces people.

The post disaster stage of disaster management requires substantial monitory funds from the government sources and voluntary social organization,participation of individual communities, social groups, NGO's Govt. organization and international communities for successful execution of relief work. The disaster recovery falls in three categories e.g. mental recovery, economic recovery and social recovery. 'The economic disaster recovery and rehabitation processes are more significant aspects of post disaster phase, stage of natural disaster reduction and management which needs assistance from individual to communities concern national and international communities. The success of recovery and rehabitation processes depends upon political system, nation readiness for any contingency plan, community participation, financial position, organization structures of post disaster activities such as relief work, recovery and rehabitation, social structure, fixation of priorities for rehabitation of accurate plan for rehabitation, cooperation of local people, administrative assistance, resilience of the community.'

Issues Related to Anthropogenic Hazards: A Study Upon Global Climate Change

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Climate refers to the mean behaviours of the weather over some appropriate time (roughly 30 years). The most fundamental climate variable is the global annual mean surface temperature, although other variables such as the frequency and amount of rainfall can also be considered. Climate change involves changes not only in the mean values of these variables but also in their variances. Any factor that alters the Earth's radiation balance, the radiation received from the sun or lost to space, or that alters the redistribution of energy in the atmosphere-land-ocean system can affect climate. Changes in the solar energy reaching the earth are the main external forcing mechanism on climate.

The concept that as human activity results in ever more Co2 being released the temperature of the globe can increase was first enunciated by vante Arrhenius on 1896. Now it is indisputable that the concentrations of greenhouse gases (GHGs) have been increasing over the past century. As the concentration of GHGs increase, the net trapping of long-wave, infrared radiation is enhanced. The climate change that will occur as a result depends on a number of factors, including the amount of increase of concentration of each GHG, the radiative properties of each, interactions with other atmospheric constituents, and, importantly, climate feed-backs.

Climate varies naturally over all temporal and spatial scales. To distinguish anthropogenic effects on climate, it is necessary to identify the human induced signal in climate against 'the background' of natural climate variability. Although climate changes can occur for many reasons, it is conceivable that human forcing of climate change is increasing the probability of large abrupt events. The economic and ecological impacts of such change could be large and potentially serious. In light of there impacts, policy-makers should consider expanding research into climate change, improving monitoring systems, and taking actions designed to enhance the adaptability and resilience of ecosystems and economies. In the face of the recent looming economic downturn, the agreement to combat global warming becomes still more uncertain.

Geomorphic Hazards in the West Sikkim and Their Mitigation

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The present paper aims at highlighting the nature and magnitude of geomorphic hazards in the district of West Sikkim in Sikkim Himalayas which claim huge lives and properties. Among such hazards landslide, earthquake, soil erosion and flash flood are important. The Himalayan range of West Sikkim comprises a tectonically unstable zone which subjected to seismic activities along with fragile geological structure. Apart from this unscientific and unplanned usage of land, deforestation, construction work as well as heavy and concentrated rainfall aggravates such hazards. With the development of tourism, both mobile population and local inhabitants are increasing very fast which exerts enormous pressure on land and creates soil erosion. Flash flood also occurs (very few) in the rivers of West Sikkim which is mainly due to snow melting and unprecedented amount of rainfall during monsoon. Mitigation involves structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Role of Local Self Government in Disaster Management in Rural Tripura

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A disaster can be understood as a 'grave occurrence having ruinous results' (Webster Dictionary). Disaster affects everyone; affected populace wait for relief and rescue while others directly coordinate the relief and rescue operation. In fine both affected and non-affected persons suffer in case of disaster. Disaster hence is a share reality. Any disaster is a social phenomenon and particularly enough in most of the developing nations it is handled through short-term emergency interventions of fire-fighting nature instead of eliciting response from the community. This pre-dominant attitude thus adds to the burden of state's exchequer besides encouraging chronic dependence of the victims on the governmental largesse. A change is this paradigm is necessary. The entire community should be involved in disaster management and mitigation. For better involvement of the community as a whole, local self governments (LSG) can play a very significance role.

Tripura is experience different types of both natural disaster like flood, cyclone, earthquake, land slides and man made disasters like riots, insurgency etc. Tripura is predominantly a rural state and therefore in all the cases majority of the people who are victim from those disasters are automatically in rural areas. In the other hand, Tripura has a deep rooted LSG in rural areas with three tired Panchayat Raj Institutions and Tripura Tribal Area Autonomous district council (TTAADC) covering 1035 villages.

Present paper is divided into three sections. The first section reviews the experiences and intensities of different types of disasters in Tripura. Second section portraits the structure and functions of LSG in the state. The third sections discussed the role may played by the LSG in Disaster Management. The paper tries to find out the major obstacles faced by the LSGs and come out with some strategy for involving LSGs in disaster management.

Place Perception of an Exurban Landscape of Aligarh City -A Study on Land Use Change

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Place is the space on which the human enterprises are exercised by utilizing its available
resources and perception is the process of using the sensors to acquire information about the surrounding environment or situation.

This paper describes the land use changes in the exurbia of Aligarh city particularly beyond its northern boundaries. Aligarh has been an old and important urban centre of north India known for its commercial and political activities. The exurban development of the city towards the north shows remarkable changes in the form of urban encroachment on rural agricultural lands. As a result many commercial and residential pockets have been developed in the outskirts of the city. A number of industries, commercial centers, educational institutions, and residential complexes are mushrooming progressively.

Since, Aligarh is well connected to the National Capital Region of Delhi, therefore, the development is more remarkable towards northern portion of the city. The study perceived noticeable changes which are taking place along the National Highway -91 i.e. Grand Trunk Road towards Delhi, the National Highway- 93 i.e. Moradabad Road and the Ganga Ramghat Road. Here the exurban population is increasing day by day. The paper highlights the conversion of agricultural lands for non agri uses and how the resources are exploited for changing the exurban landscape.

Studies on Land -subsidence and Related Hazards vis-à-vis Overuse of Groundwater In and Around the City of Kolkata.

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The stark reality is that land-subsidence and related hazards vis-à-vis water challenges in this century are becoming increasingly urban in nature. An overwhelming majority of world cities and towns are now dependent on groundwater supplies mainly. Thus over-drafting of aquifers is the major cause of subsidence and as more it is done indiscriminately, it is faced with still greater severity.
Good examples of similar water predicament are the cities like Kolkata, Dhaka, Bankok, Jakarta, Mexico City where groundwater is pumped from pore space between grains of sand and gravel. The landsurface thus subsided through this process becomes permanent in nature.
Land subsidence causes many problems like change in elevation of a stream, canals, and drains; damage to bridges, roads, sanitary sewers; damage to buildings; water logging; water pollution and failure of well structures and so on. Several methods may be adopted to monitor such problems. Modern equipments like GPS of various capabilities can be used for surface levelling survey in a repetitive fashion. Land subsidence can be checked by switching over dependency from groundwater alone to conjunctive use of both surface and groundwater supplies.

Role of Land-use Change on Sedimentation of the Burigang Nadi, Bishalgarh Sub-Division of West Tripura

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The process of sedimentation is a comprehensive natural geomorphological process which operates through the chain of erosion of soils, unconsolidated surface materials and parent rock; transportation and deposition of these sediments. Thus basic source of the supply of sediments is erosion of loose and unconsolidated surface materials i.e. geological or natural erosion without human interference. Whereas the increased rate of erosion caused by various land use changes affected by man causes accelerated erosion and causes several environmental problems which adversely affect the basin morphometry. The Burigang Nadi, a tributary to the Bijoy Nadi, of Bishalgarh Sub-Division, West Tripura District, is characterized by the presence of huge sediment in its bed. This paper deals with the causes and consequences of sedimentation in this river at Golaghati village. Large scale change in land use pattern in the basin area is found responsible for such menace. Land use pattern of this area has been greatly changed after Bangladesh war in 1971 and ethnic problem of 1980 when huge influx of population caused large scale deforestation in the catchment area of the Burigang Nadi basin. This change in land use and change in sediment yield and sediment load for last 20 years have been analysed. Sediment yield (total amount of sediments removed per acre per year), sediment load (total amount of sediments of various sizes) have been measured to know the quantity of sediment removed. The consequences identified are rising of the river bed, bank erosion and shifting in river course, increase in the frequency and magnitude of flood in the basin. At last some mechanical protection devices and some measures of crop management have been proposed.

Economic and Ecological Sustainability of Rubber Plantation - A Case Study on Bishalgarh Subdivision

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Rubber has become the most accepted and commercially viable plantation crop in Tripura. The present study aims at analyzing economic and ecological sustainability of rubber plantation on Bishalgarh subdivision of West Tripura District which covers a planted area of 5267ha. Major economic activities which partially dependent on this plantation often gets hampered due to some problems encompassing climatic vagaries along with technological, economic, social, political and institutional loopholes. The tree itself poses certain problem as the shaded leaves do not get decomposed with the soil. Furthermore, soil holding capacity of the plant roots is inadequate, because the trunk root does not deeply penetrate into the soil. The secondary roots are also branched out in different directions, which can hold the top soil layer only. This enhances soil erosion especially in lateritic soils of Tripura. These problems could be reduced by increasing the areal coverage of plantation, educating the tappers and proper utilization of fertilizers in order to maintain economic and ecological sustainability of plantation.

Ground Water Arsenic Contamination and Mitigation Programme in Tripura and other states in India

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For all mankind water remains a basic demand, an issue which influences and alters the social, cultural, political and religious heritages of different communities. The need for plentiful supply of water is universally perceived and demanded. Lack of perception among the common people about the quality of water often acts as a harbinger of death, causes for so much morbidly and morality.

Water can act as a vehicle for transmission of various disease causing organisms pathogens). Water can also transport unwanted chemicals like arsenic, fluoride or nitrate to the human body without the knowledge of the consumers.

The sources of arsenic pollution in water are generally industrial wastes, contaminating water bodies, either directly or by leaching through soil and also some agricultural insecticides. though rare, natural arsenic pollution can occur in ground water from arseniferous belts in specific geomorphological conditions, as has been found in some areas of West Bengal, Tripura and a few districts of Bihar, Chhattisgarh and Uttarpradesh. It has affected neighboring Bangladesh, light in several districts of Punjab and Sind in Pakistan. Nepal, China, Taiwan, Mongolia, Ghana, Argentina, Chile, Mexico, Britain and more recently Northern Vietnam, Canada and USA.

The symptoms of chronic arsenic poisoning include various types of dermatological lesions, muscular weakness, paralysis of lower limbs etc. Arsenic is potential carcinogen and skin and lung cancer can occur after prolonged exposure.

Arsenic concentration in ground water ranges from 50 ppb (parts per billion) to 5 ppm (parts per million). The standard for arsenic in drinking water set by the World Health Organization is .01 mg/l (10ppb), whereas analysis of water collected by WHO, NIPSOM, School of Environmental science, Jadavpur University, PHED of W.B., Harvard School of Public Health and several other organizations of Bangladesh have Indicated arsenic concentrations ranging from 0.05mg/l - 5mg/l, which is far above the permissible level.

It is noticed that ground water extraction in Tripura is lower in comparison with other states like West Bengal, Bihar and Uttar Pradesh. It may be due to the occurrence of less number of individual wells and tube wells unlike the above mentioned states. Most of the people in the state depend on public tube wells which controls excessive amount of water lifting and thereby checks the concentration of toxic substances like arsenic in the subsurface layer.

In spite of this fact very little amount of Arsenic concentration has been found in ground water level in some parts of the state which needs to taken care of immediately to root out the problem at its onset, thereby preventing a David to become a Goliath. It is also evident that along with governmental effort, community motivation through NGOs are equally required for challenging the problem effectively.

TECTONIC GEOMORPHOLOGY AND HAZARDS

Special Lecture

Tectonic Landforms of North Eastern India and Associated Natural Hazards

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Geomorphologically the Northeastern India is the most bewitching part of our country presenting contemporary land forming tectonic activities since Cretaceous time. This region is comprised of two mobile mountain belts (the eastern Himalaya and the Indo-Myanmar hill ranges), block uplifted Meghalaya Plateau and Mikir hills and the subsiding narrow Brahmaputra valley. The eastern Himalaya and the Mishmi block, lying to the northeast corner of the region, has originated due to reactivation of the Indian shield elements as a result of collision of the Indian plate with the Tibetan landmass. This belt is characterized by 4 distinct E-W tectono-geologic and geomorphic units. From south to north, they are:

i). Piedmont fan zone lying in front of the Siwalik hills and north of the alluvial plain of he Brahmaputra, formed by coarse clastics, deposited by the rivers debouching in to the plain from the hills with sharp fall of gradients. Braiding and constant change of river course are the characteristic.

ii). The sub-Himalayan unit consists mostly of low lying, linear, folded and faulted, coarse to medium grained Siwalik sandstone. This terrain is characterized by linear moderately round to sharp-crested hills, poorly dissected by fine textured drainage network. This zone is bounded to the north by the Main Boundary Trust (MBT).

iii). The Lesser Himalayan belt lying further to the north is composed of mostly low to high grade metamorphic rocks that are folded, thrusted and faulted generally in E-W direction though N-S, NW-SE and NE-SW active strike-slip faults are also common. These oblique faults cut across all the E-W belts of the Himalaya giving rise to frequent earthquakes. This belt is marked by sharp fall of elevation from the higher Himalayan zone, from about 6000m to 4000m. It shows fine dendritic drainage texture. The rivers follow the transverse faults and lineaments cutting across the sharp crested ridges. This unit is bounded to the north by the Main Central Thrust (MCT).

iv). North of the MCT occurs the High Himalayan zone with average elevation of 6000m. This zone is composed of high grade crystalline rocks-mainly granites and gneisses and is characterized by deep transverse dissection, medium dense drainage texture, sharp-crested ridges and some places are covered by glaciers and perpetual snow.

v). The Mishmi block, lying in the most northeast corner of India, is mostly composed of NW-SE trending diorite-granodiorite complex with the frontal belt of low to high grade metamorphic rocks. The low grade shists of the interior belt are associated with limestone and serpentinite. The frontal belt is bounded in between the Mishmi and the Lohit thrusts. This terrain is deeply dissected with medium drainage texture.

The Indo-Myanmar mobile belt lying to the east of the region is characterized by subduction related arcuate Paleogene outer arc ridge (subduction-accretion complex) formed of Eocene Disang flysch and Oligocene Barail subflysch that covers most of the terrain of Nagaland and Manipur. This litho-tectonic unit is folded in many N-S trending anticlines and synclines, in most cases forming anticlinal valleys and synclinal hills. Most of the rivers follow the N-S strike direction of the formation, some time transversely cutting the ridges along cross faults. The hills are linear, round crested, coalescing and bifurcating along the strike. Isolated basin of Neogene accretionary prism and subduction accretion complex occur to the west of the Paleogene outer arc ridge. They are represented in upper Assam by folded and intricately thrusted Miocene Tipam molasses and the long linear folded Mio-Pliocene Surma group of rocks south of the Meghalaya Plateau covering the terrain of Tripura, Mizoram and Cachar district of Assam. The very long linear anticline and synclines form linear ridges and valleys respectively, giving the appearance of 'Ridge and Valley Province' of Europe. Almost all the rivers follow the long linear synclinal valleys that sometime cut across the ridges along cross faults and plunge depression. The hills are rounded coalescing and bifurcating along their strike. The folds get gradually more appressed and the terrain gets higher elevation from west to east.

The Meghalaya Plateau is a block up lifted physiographic feature hinged along the E-W Raiba and Dauki faults along its southern margin forming distinct fault scarp. Structurally it is a half horst sloping to the north and uplifted against the subsiding Sylhet plain of Bangladesh. The Plateau is traversed by N-S and NE-SW lineaments and faults which guide the drainage system.

The Brahmaputra valley of Assam has evolved during the last two million years by alluviation of foreland depression in between the young mountain chains of the Himalaya, Indo-Myanmar mobile belt and the uplifted block mountain of the Meghalaya Plateau and Mikir hills. All the rivers from the surrounding mountains debouch in to the master channel with sudden loss of gradients from very high gradient to very low gradient of the Brahmaputra River creating drainage congestion.

The terrain of the Northeastern region constituted by active tectonic regime suffers besides earthquakes from perennial problem of landslides which are becoming aggravated every year due to unmindful developmental activities. The Brahmaputra Valley suffers from flood hazards almost every year mostly due to its tectono-geologic and geomorphic setting aggravated by deforestation and other developmental activities in the catchments areas of it tributaries.

Special Lecture

Grain Surface Features & Clay Mineralogy of the Quaternary Sediments and their significance in the interpretation of the Environmental History.

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The grain surface features have the diagnostic properties of the sedimentary environment of the deposits from which they have come. Such diagnostic surface features are viewed and photographed by a scanning electron microscope (SEM) on the quartz grains on sediment samples collected from different such environments. The shapes of clastic particles and microscopic textural patterns on their surfaces are repositories of information about the physical and chemical processes to which the particles have been subjected to. Likewise Soil clay mineralogy is the result of several factors interacting with the parent material. Certain combination of circumstances influence soil forming processes which ultimately exhibit their effects on the clay mineralogy. The amount of clay in a soil has a very important bearing on the genesis, characteristics and physical and chemical properties of soils. Significance of clay minerals lies in their interpretative value in terms of the source material as well as the physical properties that they influence. Therefore the role of SEM studies and clay mineralogy in the environmental interpretation has been highlighted here through the case study of riverine alluvial sediments formed along a tributary of Godavari River in Maharashtra.

Quartz sand grains obtained from a deeply gullied topography along the banks of two tributaries of River Pravara in Godavari Basin, Maharashtra have been examined with a scanning electron microscope (SEM). In all ten samples have been short listed for SEM studies. Samples that were collected from different facies, (such as sandy, clayey and gravelly facies) from various depths were considered for the final selection. By sieving, fine sand size fraction between 2-4 phi were separated and subjected to heavy mineral separation by following the method adopted by Carver (1971). From the light mineral fraction quartz grains were separated out under the binocular microscope. Iron oxide and organic coatings were removed from the separated grains. From each sample, fifteen grains were randomly selected and the selected grains were coated with platinum and put on double sticker carbon conducting tape and mounted on a stub which are arranged in two rows and put into JEOL-JSM-6360A Analytical Scanning Electron Microscope. After that micro-photographs of each grain were taken at various angles and magnifications.

The sediments reveal features resulting from mechanical grinding as well as from chemical alteration. Conchoidal fractures, cleavage planes, grooves, V-shaped indentations etc are the mechanical features documented on the grains whereas solution pits of varying sizes and intensity, precipitation surfaces, oriented V-pits, solution crevasses and etching are the features of digenetic origin. These features do not follow any particular trend in their occurrence in terms of their location from the source area and also the depth. Few sand grains show the evidence of wind transported sediments. Several evidence indicate that the samples have undergone digenetic changes. Few grains exhibit the features of intense chemical breakdown. The overall assemblages of the grain surface features suggest that the samples have been subjected to subaqueous transport for a considerable period of time. The minor chemical features such as solution pits or semi circular arcuate steps that are found in plenty in these grains are due to the dissolution of the sediments in a low energy fluviatile environment.

Clay minerals of these samples also have been studied to understand sedimentological environments of these deposits. The international pipette method (Jackson 1979) was employed for separating clay fractions (<2 and <0.2 mm) from the sediments following the removal of organic matter, calcium carbonate and free iron oxides. The clay fractions were subjected to examination by X-ray diffraction (XRD) of oriented K/Ca saturated samples using a Philips Diffractometer and Ni-filtered Cu Ka radiation. The scanning speed was 1^0 2 min -1.

The main clay minerals for all the samples are identical and show the presence of hydroxy-interlayer smectitites with minor quatities of mθca, kaolinite, smectitites, quartz and feldspar. The first weathering product of the Deccan Basalt (DB) is the dioctahydral smectite. The present semi aridic climatic condition of the study area can not transform a smectite to HIS and also smectite to kaolin. It is quite likely that both the HIS and Sm/K are generated in the tropical humid climate of the Western Ghats and then carried through the exiting river system like Godavari, Adula and Mahalungi. Therefore it is evident that the clay minerals present in these sediments represent another climatic history more humid than the one existing at present.

Earthquake Hazard Zonation in the Kaveri Basin - Contribution of DEM-derived Lineaments

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Lineaments are distinct linear or slightly curvilinear geologic or geomorphic features, such as faults, dykes, joints, shear zones, river segments, erosional and depositional features, etc. Geologic lineaments are considered to reflect subsurface phenomena, lithologic discontinuities, etc. Traditionally, the identification of lineaments has been based on visual interpretation of topographical contour maps, aerial photographs and satellite imageries. On the contour maps and/or images/photos lineaments are indicated by distinct patterns of topographic features, near-straight stream segments, vegetation or soil tonal alignments, etc. However, the presence of drainage lines and man-made features introduces a bias in the identification of lineaments. Often there is a tendency to interpret straight stream segments and sharp bends in the river courses as lineaments.

Further, obscuring effects of vegetation cover or cultural features may also limit the utility of satellite images and aerial photographs. Therefore, many lineaments may not be real and reproducible geologic or geomorphic linear features. These problems could be minimized by using DEM data and its derivatives.

The major objectives of this study are to identify lineament frequency and occurrence in the Kaveri Basin and to evaluate the association between mapped lineaments on one hand and the earthquakes epicenters and drainage network on the other. An attempt has been made to prepare an earthquake hazard zonation map of the Kaveri Basin by using lineament map, the geological map and earthquake epicenter map.

In the present study, the mapping of lineaments is based on the interpretation of shaded relief, slope, aspect, curvature and pseudo-relief images created with ArcGIS and SRTM-DEM data. The delineated lineaments were then superimposed on LANDSAT-5 and IRS P-6 satellite images in ArcGIS for verification as well as for ascertaining the occurrence of missed features. In order to ascertain the association between DEM-derived lineaments, the earthquakes epicenters and drainage network, the mapped lineaments were overlaid on the seismicity map and the SRTM-DEM-derived drainage network map. The information regarding the location and magnitude of the recent and historical earthquakes was obtained from various research publications.

The comparison reveals that earthquake epicenters are concentrated predominantly in areas of high lineament density in the middle part of the Kaveri Basin. The exercise also suggests that some of the lineaments may be seismic lineaments. Further, the comparison of DEM-derived lineaments indicates that there is very little evidence to support the view that the structural fabric of the area has exerted a strong control on the drainage network of the Kaveri River.

The present study demonstrates that integration of various datasets (DEM-derived and satellite-derived lineaments, geological map, earthquake data) in GIS may lead to a general better understanding of the tectonic setting and to a better delineation of hazard prone areas.

REMOTE SENSING AND GIS

Special Lecture

Monitoring of Hazard Areas Through Remote Sensing Techniques

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Natural hazards may be defined as the largely unpredictable sudden changes in the environment, which may have disastrous effects on human activities. These include earthquakes, volcanic eruptions, tsunamis, floods, avalanches, drought, forest fire, exceptional storms associated with rain, hail, snow, hurricane, tornado, etc., diseases of human (e.g. plague), animals (e.g. bird flue) and plants, swarms of locusts and other pests. Some of these hazards have short term or long term effects on morphology of land surface.

By applying remote sensing technology, now a days it is possible to monitor such hazard prone areas, along with severity of damages and extension of hazard zones. Ultimately by analyzing the data necessary measures may be adapted to mitigate the problem.

However, in the present paper an attempt has been made to tackle with some of the problems associated with hazards like shifting cultivation, flood, degradation of lagoon environment, soil salinity, ravine, tsunami, volcanic eruption, etc.

In north eastern part of India, shifting cultivation is considered as a dangerous agricultural practice causing environmental degradation. The present case study clearly depicts different stages of jhum cultivation. The light tone on the image indicates the forest cut, dry and ready for burning. Actual burning is apparent with profused smoke. Dark patches denotes freshly burnt areas, whereas plots that have been abandoned after cultivation appear in medium light tone. Such data are very useful to locate problem area along with the actual stage of Jhuming. It may be mentioned here that in long term, degradation of forest exposes the parent rock surface causing landslides. Deposition of debris in the valley region results silting of the river channels causing flood.

Bihar-West Bengal flood situation during the beginning of new millennium may be clearly visualized with the help of available satellite imagery. A comparative study of images belonging to September 5, 2000 and September 22-28, 2000, depict the extent of flood damage and also existing flood situation in and around important reservoirs in that part of the country.

Chilka is the largest brackish water body in the eastern coast of India. Narrow channels cutting across linear spit connect the lake to the Bay of Bengal and create an estuarine environment. It has been observed that the FCC created with the help of IRS data is very useful in studying the environmental situation of Chilka Lake area. Remote sensing data can easily detect the growth of water weeds, which cause fluctuations in dissolved oxygen content consequently affecting the fishing ground along with the fish population. The red tone on the image indicates the development of weeds in the shallow fringes which causes a threat to the fish population because of biological oxygen demand. The turbidity level of the lake water can also be monitored during different seasons thus estimating the influx of sediment carried by different rivers.

It has been estimated that about seven million hectares of land area in India suffer from problems associated with salinity of soils. For the purpose of reclamation of such land, the prerequisite is to know their areal extent, which is possible by analyzing the remote sensing data. Detailed analysis of the image indicates that the croplands appear in different shades of red, whereas salt affected areas can be recognized as dull white to bright white patches depending upon the encrustation of salt.

Typical ravenous lands have been developed along the river Chambal. A careful observation of satellite imagery reveals the fact that grey to dark grey smooth textured patches seen along the Chambal River indicate deep to very deep ravines, while light grey to yellow toned patches depict medium to shallow ravines.

Table lands and valley lands are manifested as smooth textured red tones on the image because of existence of crops and vegetation.
Scenario associated with pre Tsunami and post Tsunami situation by the end of 2004, can clearly be observed with the help of remote sensing products. Volcanic eruption scene may also be monitored through satellite image. It may be mentioned here that such synoptic view cannot be recorded with the help of traditional surveying instruments.

Real Time Mapping for Tidal Flood Monitoring and Development of Low Cost Warning System in Coastal Areas by Simplified G^2 Integrator

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This paper deals with a framework of tidal flood monitoring scheme by integrated GPS-GSM function. In this scheme two modules have been planned namely RTDGM or real time data generator module and CSM or control station module for monitoring position of water level. The first module is actually simplification of 'short messaging service based GPS data transfer'. To minimize the cost of technical setting and maintenance local operators can be appointed. It can also develop social participation in disaster mitigation programme in coastal areas. The second module can be prepared by GSM receiver and PC with GIS software. Geo-referenced images, maps, toposheets or Google images can be used for data storage base. This system can regularly monitor fluctuations of water level in a wide area. The objective of this scheme is to prepare real time mapping of shoreline shifting for the development of low cost tidal flood warning system in the rural areas of the developing countries like India.
Key words: Tidal flood, Coastal area, G2Integrator system, Low cost warning system, Real Time Mapping.

Remote Sensing and GIS Based Ravine Mapping: A Case Study of the Lower Part of Chambal Valley, M.P. India

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Remote Sensing and GIS has tremendous potential for the study of in accessible terrain features .A Ravine intensity Map Of part of Lower Chambal Valley of M.P. has been generated from the Survey of India Top sheet with the help of various types of satellite imageries as well as the other secondary data. Here using digital image processing to understand the morphology of ravine. GIS techniques have been used to understand the rate of spreading. As ravine is a very inaccessible terrain where these kinds of advance techniques are very much useful for getting the clear view of a particular area. The data applied are digitized topographic maps, LANDSAT Imageries, IRS IB LISS- II hard copy, and IRS ID LISS- III digital satellite images. The specific themes of the study include Ravine Geomorphology, Normalized Difference Vegetation Index (NDVI) and Land Use/Land Cover condition of the area. Information on land use/land cover derived from temporal LISS-III data enabled three categories of ravine to be delineated, namely shallow, medium and deep. The area under deep, medium and shallow ravines has been estimated in GIS environment.

Risk Zonation Mapping of Gangtok Town and Surroundings for Urban Planning

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Gangtok, the capital of Sikkim, is situated at an elevation of 1780 m. above m.s.l. on a NNE-SSW extending ridge covering an area of 30 sq.km. Lithologically, a major part of this area is covered by highly crushed and fractured meta-sedimentary rock of Daling series with a patch of high-grade gneissic exposure. Due to deep weathering accompanied by high rainfall, the rock has been transformed into thick soil of sandy and silty nature. Gangtok town famous for its tourist industry attracts a huge population of about 1, 00,000 during tourist season (May to Oct.). To accommodate such huge tourists population many multistoried hotels, lodges, guest-houses have been built, increasing the instability factors of slopes, endangering the local ecological balance resulting in frequent landslides,

Thus the incidence of landslides has become a recurring phenomenon in Gangtok town and along different sectors of NH-31A, endangering the lives and properties of the local inhabitants during monsoon. Geotechnical investigations were undertaken to prepare Landslide Hazard Zonation (LHZ) maps, stability map and risk zonation maps.

The risk zonation map in the general sense is to classify the earth surface into different areas (slope facets) according to the magnitudes of actual or potential hazards from landslides and vulnerability to cause damage. A slope facet map has been prepared from the topographical sheet. The landslide micro hazard zonation map has also been drawn through BIS guideline and vulnerability study has been conducted through GPS survey, ground survey and socio-economic survey from door to door. On the basis of the equation (R = H + V) the risk zonation maps of Gangtok town and Municipality have been generated. This risk zone map have been classified into three broad classes - viz. (a) high risk zone, (b) moderate risk zone and (c) low risk zone.

This paper attempts to find out with the help of modern techniques like RS and GIS, the Magnitudes of risk and vulnerability. Finally, it is also concerned that which areas are relatively stable or unstable of the town and surroundings. This paper is highly useful and rational for urban planning regarding construction purpose mainly hilly or mountainous part of the Himalayas.

Image Classification by Clustering Method for Landform Analysis: Its Merits and Demerits

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Clustering is a very common unsupervised method in remote sensing for land classification. It is actually an automatic soft computing technique on the basis of DN distribution in the image. In this study I attempted landform classification of a part of Baromura hill, Tripura by clustering. For clustering I experimented with various spectral resolutions. First I selected the red band for its highest extension of upper DN value and then did a clustering with 2 classes. I also attempted multi-spectral resolution with different combinations like R-G-B, R-G-G, R-B-B etc. The real world domain was compared with the classified images for determining the computational errors of land classification by clustering in various spectral levels.

Key words: Clustering, unsupervised classification, Baromura hill, R-G-B, landform, spectral level.

Use of Digital Elevation Model for Visualization of Landforms: A Case Study from Guwahati Metropolitan Area

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The term Digital Elevation Model (DEM) denotes digital representation of the continuous variation of relief over space that helps in visualizing the landscape. Most geo-scientific applications need a good knowledge and visualization of the topography of the Earth's surface. This paper elucidates with example, the potential of satellite derived DEM and high resolution remote sensing imageries for visualization of landforms. A preliminary virtual tour to any terrain can be made using DEM and remote sensing data before carrying out actual mapping.

Two forms of visualization are exemplified: overview visualization showing regional set up and individual site visualization. Remote sensing data draped on the DEM gives the most realistic portrayal of the terrain. Geologic substrate is frequently a control on slope morphology, which in turn influences slope gradient, drainage, weathering conditions etc. Computer visualizations allow the inter-relationships between these conditions to be easily portrayed compared with the use of traditional maps, field photos etc. In addition, the use of high resolution DEM facilitates calculation of site descriptive statistics, and forms a suitable base for spatial analyses in combination with a GIS whenever required.

Guwahati, the capital of Assam is the main hub for political, administrative, industrial, educational, commercial and many other activities in the entire North East India. The city began to expand in all fronts at a tremendous rate when the capital of Assam was shifted from Shillong to Dispur in 1974. Afterwards because of rapid urbanization, many places natural slopes/landforms are being altered by anthropogenic activities. This subsequently has caused various social problems and man-made disasters along with many other good things. The city is facing problems like, shortage of proper dwelling areas, drainage congestion, landslide, flash flood etc. This paper for example attempts to visualize the present landform condition of Guwahati metropolitan area from a different perspective in relation to bedrock conditions, slope morphology and geomorphic processes and present ways to visualize site conditions in and around Guwahati city.

Key words: DEM, remote sensing, geomorphology.

Use of Remote Sensing and GIS in Morphometric Analysis of Sanjai River Basin

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The analysis is based on multi-temporal satellite imagery of Indian Remote Sensing Satellite 1A (IRS-1A &1B) and Linear Imaging Self Scanner (LISS-III). It also consulted Survey of India (SOI) toposheet nos. 73 J/1, 73 J/2, 73 F/5, 73 F/6, 73 F/7, 73 F/9, 73 F/10, 73 F/11,73 F/12, 73 F/13 of 1:50,000 scale. The Ground truth was collected with the help of False Colour Composite (FCC) hard copy -prints of study area, SOI toposheets, Global Positioning System (GPS) and magnetic compass.

The Sanjai River is the tributary of river Kharkai (latitude, 22º 44' 20" North to 22º 39' 23" North and longitude, 86º 19' 55 "East to 85º 17' 41" East). Kharkai is the major stream of Subarnarekha River and the Subarnarekha basin, covering larger part of the southeastern Chotanagpur plateau. Sanjai is the important

tertiary stream of Subarnarekha River. Administratively it mostly belongs to West Singhbhum district (Jharkhand State) but it also occupies a very small portion in East Singhbhum district (Jharkhand State). Its catchment area is about 2,154 km2.

The study area being dominated by the Dharwar formation and polycyclic topography has undergone the following geomorphological evolutionary phases in accordance with the aforesaid geological events:

i). The Dharwar sedimentation (Iron-ore series of rock) over the Precambrian Landscape subsequently experienced by the Archaean folding and faulting . ii). Planation by the Pre-Dalma subaerial denudation cycle causing denuded synclines of the oldest Archaean mountain and also the Dhanjori conglomerate with unconformities. iii). Volcanic effusion of Dhanjori and Dalma Lava over the said synclines . iv). Prolonged planation of the Post Dhanjori and Dalma i.e. Pre-Tertiary landscape . v). Development of the tertiary planation surface interrupted by the Tertiary upliftments. vi). The formation of the post-tertiary landscape within recent alluvium and laterites.

The existing morphology of the basin provides good reflections of the aforesaid geological structure and differential resistance of rocks to the process of weathering, mass movement, erosion and others in association with the morpho-climatic mechanisms. The evidences are granite tors and domes, hummocky boulders, pillars and upstanding rock masses, escarpment (Tebo Ghat) over the Singhbhum plains.

Palaeocourse of the Saraswati River, West Bengal: Evidences From Remote Sensing and Sediment Analysis

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The Bhagirathi-Hugli is the westernmost distributary of the Ganga. During 15th-17th century AD, the river used to get branched into three channels from the vicinity of Tribeni (88 24 E, 22 59 N), about 175 km downstream of its off-take from the Ganga: the western Saraswati, the central Bhagirathi and the eastern Bidyadhari. The Bhagirathi used to flow through its present channel up to the Garden Reach area of Kolkata (88 19 , 22 33) and then used to turn east and follow the now-moribund course of the Adi Ganga. The Saraswati used to flow through a 75-km meandering course sub-parallel to the Bhagirathi and then occupy the present course of lower Bhagirathi from Sankrail (88 14 , 22 33). It is widely believed that sometime in the mid-18th century, an artificial connection was made between the headwaters of the Adi Ganga and the lower Saraswati as a result of which both the upper Saraswati above Sankrail and the Adi Ganga below Garden Reach degenerated and the present course of the Bhagirathi-Hugli became established.

The mediaeval course of the Saraswati described above is still traceable by its prominent levee and riverbed, dried-up at places. The relative relief of the levee varies from 7 to 10 m from the palaeochannel and the surrounding countryside. Its width fluctuates between 1 and 5 km. Analysis of six sediment samples across the levee of the Saraswati north of Chanditala (88 16 , 22 42) showed that the high grounds are formed of silty loams and silty clay loams, the channel bed is formed of silty clay loam while the surrounding floodplains are dominated by clays. At places, deterioration of the channel has been hastened by human encroachment. IRS L3+Pan satellite images and DEMs prepared from SRTM data reveal continuance of two levee systems branched off from the Saraswati channel at Domjur (88 13 , 22 38). The first of these follows the trend of upper Saraswati and flows parallel to the Bhagirathi-Hugli for 20 km before meeting it at Phuleshwar (88 07 , 22 29). The second levee system is 44 km long and connects the lower Saraswati to lower Rupnarayan south of Bagnan (87 57 , 22 26). It is comparatively disjointed and at places is associated with distributaries of the Damodar system: Kana Damodar and Amta channel. The two levees indicate possible palaeocourses of the Saraswati prior to its late mediaeval position.

The Domjur-Bagnan levee connotes connection between the Rupnarayan and Saraswati sometime in the past. The disposition of the lower Rupnarayan at its confluence with the Hugli estuary (88 03 , 22 12) suggests that the estuary used to continue through the lower Rupnarayan rather than the Hugli, which joins it at an angle. The famous 4th century BC-7th century AD port of Tamralipta (87 55 , 22 17) was situated in the lower Rupnarayan. This supports the fact that it was connected with the Bhagirathi, and thereby with the Ganga and northern India, along the Domjur-Bagnan link and the Saraswati.

Geo-Ecological Signatures for Assessing Rudrasagar Lake Basin Morphology: Multi Sources Spatial Data Analysis

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This paper deals with geo-ecological signatures by multi sources spatial data for the assessment of lake basin morphology of Rudrasagar area in Tripura, North-East India. In this work an attempt has been made to understand the different ecological domains and their relationship with landform. Here natural vegetation was considered as the ecological signatures of geomorphic expression since I observed that different plants grow on different types of slopes and land conditions in this area. For that purpose both field observation and application of remote sensing methods were used by the present author. For mapping I consulted topographical sheets of SOI (Scale 1: 500000), Geological Survey of India Maps (Scale 1: 500000) and several other maps from different sources along with SPOT data (radiometric spectra and 10m resolution).The maps were prepared on the basis of DN value. All these works show that human interventions also play vital role for the change of lake morphology and thus I also consider the human activities as one of the important signatures of present land classification. Not only it indicates the present land condition but also future trend of morphological changes can be assessed by human activities.

Hydrographic Network Mapping of Rudrasagar Lake Basin from Popular Google Earth and GPS Derived Data

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Though Google Earth images are very popular today to the common people but it is not easy to use those images for systematic wide area mapping due to their variations of spectral and spatial resolutions. Thus they are not much popular as raw cartographic material to the geo-scientists, cartographers and remote sensing experts. In this study I attempted to prepare a drainage network map of Rudrasagar lake basin from Google Earth image. For that purpose I used very simple GIS based software Easy Trace Pro 7.95. I vectorised the rivers from downloaded images of the study area and then exported the vector data to DXF (AutoCAD) format for using the image processing software. I imported the vector data to ILWIS 3.3 (Integrated Land and Water Interpretation System) Academic version as general raster and then geo-referenced that. Here I used GPS derived data for ground control points. Finally I created a map layout and prepared the map in a very general "jpeg" format which is a very user friendly format. This study shows that there is a probability to use the Google Earth images for wide area assessment and even spatio-temporal analysis if it is compared with SOI toposheets.

ABSTRACTS FOR

YOUNG GEOMORPHOLOGISTS COMPETITION

Abstract - 1

Role of Remote Sensing and GIS in Detecting Land-use / Land-cover Change of Srinagar City in Kashmir Valley

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Rapid urbanization Land use and land cover change has been one of the most obvious drivers of global change over the last few centuries. Geographic Information Systems (GIS) and Remote Sensing (RS) technologies provide very efficient tools to collect and analyze the information necessary to detect changes in urban areas as well as find out the geomorphologic changes that conventional surveying technology can't deliver in a timely and cost effective manner. Changes in land use and land cover can have significant ecosystem consequences such as impacts on global and regional climate and biogeochemical cycles. In this paper, we report changes in land use and land cover and find out the new locations for Urban Expansion of the region over 31-year period (1976-2007) in the Srinagar city in Kashmir Valley. We used Landsat MSS 1976, ETM 2001, 1990 and IKONOS 2007 (Google earth) images, to identify urbanized areas and to quantify urban expansion in the above mentioned city i.e., Srinagar. The results showed that over the 31-year period, the land use and land cover in the study area experienced significant changes. The urban area of the city has increased 58% since the year 1990 till 2007. Since 1976 the built up in the Srinagar city has increased from 8.065 sq. kms. to 29.23 sq. kms. in the year 2007. Further analysis showed that there were significant changes in ecological functions and biodiversity of the region.
Our findings conclude that an abrupt shift in land use from ecologically important Dal lake to large-scale built up environment, besides Srinagar city became overcrowded and some how need to control it. Using buffering and proximity analysis in GIS for the Srinagar city some new centers were identified on the basis of road accessibility and other amenities and facilities in the area.
Keywords: urbanization, remote sensing, GIS, land use, land cover change.

Abstract - 2

Study of Ground Water Potential Zones in the Hardrock Area Applying RS, GIS & ERS Techniques, Gangtok, Sikkim Himalayas

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Ground water occurs in largely disconnected localized bodies under favorable geological conditions, such as jointed-fractured zones in various lithological units, weathered zones in the phyllite, schist gneisses and quartzite. The ground water is available from some perennial springs and also from nalas [small streams] present in all geological formations in the area and in the borehole wells constructed by the CGWB.
Due to higher relief and steeper gradient of the area, ground water comes out as seepages and springs, wherever the land surface intersects local ground water table. The area is characterized by high rainfall and as a result, the primary source of ground water is from natural precipitation. The yearly and monthly precipi-

tation in Gangtok is relatively high with an annual average of 3539 mm. for the peak of months i.e. June and July. The 'normals' are found to be 603.1 and 649.6 mm. The data indicates that in a 15 year period, there were only three months when the precipitation had been above 1000 mm e.g. in April 2002 it was 1440 mm, in May 2003-1226 mm and in June 1997 it was recorded 1280 mm. But the average annual rainfall was 3546 mm. The data also shows that there were only six days when the precipitation had been above 200 mm. This happened in April and May 2003 with 203 and 362 mm precipitation and April 2004 and June 1997 the rainfall recorded were 434 and 224 mm respectively.
Due to higher slopes, most of the precipitation in the area flows off as surface runoff through streams, kholas, [spring] and through intermittent springs. Only a minor fraction of total precipitation percolates down through the thickly vegetated permeable soil cover and through highly fractured rocks. Relatively flat areas like those on tops of hills and ridges, saddles, spurs form the potential recharge area, while the steeper hill slope dominantly form the areas of spring discharge zone through seepages. Perennial streams make important contributions to discharge of springs, especially those located on valley sides. The catchments area is always situated in the higher altitude. The movement of ground water is mainly controlled by the structural set up of the area and physiography. Gangtok, the capital of Sikkim, is situated at an elevation of 1780 m. above m s l on a NNE-SSW extending ridge covering an area of 30 km2. Lithologically, a major part of this area is covered by highly crushed and fractured meta-sedimentary rock of Daling series with a patch of high-grade gneissic exposure. Due to deep weathering accompanied by high rainfall, the rock has been transformed into thick soil of sandy and silty in nature. This is highly capable of storing sub-soil water.
This paper attempts to find out with the help of modern techniques like RS, GIS and ERS (Remote Sensing, Geographical Information System and Electrical Resistivity Survey) together with the water bearing and holding capacity of porous, permeable, saturated geological formation in the hard rock area. Here underlying geological structures have a good storage potentiality and this is mainly unconfined or semi-confined in nature. This low cost technique is highly useful without involving costly, time consuming and hazardous profiling, sounding and logging in highly inclined hard rock surface of Gangtok town and surroundings and hence very useful for tapping vast under ground water resource for the over all benefit of the local people as well as tourists.

Abstract - 3

Characteristics of Late Holocene Sediment Depositions of Rudrasagar Lake and Their Influences on Micromorphology: A Study by Digital Image Analysis

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Studies on PIA are very relevant to the earth scientists for understanding the paleo-environmental conditions. Recent development of digital technology plays very important role for analysis of physico-cheminal and mineralogical compositions of the sediment depositions. In this study the present author discusses the characteristics and mineralogical influences on micromorphology of lake depositions. For that purpose Rudrasagar lake of Tripura was selected for field work and sample collection. In laboratory thick sections were prepared for micro-photography under reflected light. For image analysis two microcopy software GSA 3.2.3 and ZISS LSM IMAGE BROWSER were used. Identification of minerals was done by ZISS LSM IMAGE BROWSER in RGB combination. The micromorphology was analyzed by preparing 3D images from the processed digital data by Helicon Focus and Helicon 3D viewer software.

Abstract - 4

Identifying Tectonic Signatures on Geomorphology at Mono-Spectral Resolution from a Spatial Data Reference of Udaipur Fault Zone, Tripura

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This work deals with a multi-sources spatial data analyses of tectonic signatures from geomorphic evidences near Udaipur, Tripura. For that purpose I used SPOT image (PAN), Toposheets, and field data generated by instrumentation. GPS was used for fixing the ground control point. The satellite image with 10m spatial resolution was classified by clustering and density slicing method. For classification of the image reflectance was considered as the basic parameter since it represents the emitted temperature domains at radiometry spectra. Soft computational techniques like clustering and slicing was compared on the basis logical computational error and functional error. A map of the fault line was prepared with the calculation of less probability of error from those two methods. Scanned Toposheets of 1:50,000 scales provide a pixel resolution of 5m which were redrawn and geo-referenced for the application in digital mood for verification of tectonic signatures. All the geomorphic signatures of tectonism marked by different techniques from different spectral resolutions were interpreted and a complete land form assessment of the study area was attempted.
Key words: Tectonism, Fault geomorphology, Spectral resolution, Spatial data, Soft computation

Abstract - 5

Flood, Erosion and Human Encroachment Problems of the Dibru Saikhowa National Park in Assam : A Study in Geomorphological Perspective

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The Dibru Saikhowa National Park is situated within the upper channel reach of the Brahmaputra River in Assam covering an area of 340 km2 . The river channels, swamps, wetlands and various types of vegetations in the park altogether form a unique ecological and habitat base for a wide variety of flora and fauna. The park region representing distinct physiography is an integral part of the floodplain of the Brahmaputra River. But in recent years, the park has been experiencing frequent floods of the Brahmaputra causing damages to its habitat environment. The Park area also fallen prey to severe erosion due to dynamic channel process of the Brahmaputra. Besides these, the growing human encroachment upon the park has also emerged as a serious problem. The alarmingly increasing flood and erosion hazards coupled with growing human impact have posed serious threats to the precious bio-resources and physical existence of the park. This paper using the modern techniques like remote sensing, GIS and GPS attempts to examine the gravity and dimensionality of the geo-environmental problems of the park and suggest some conservation measures based on analyzed data and results.
Key words: Habitat base, devastating floods, channel process, bio-resources, conservation measures.

Abstract - 6

Changing Flood Morphology as Hazard at Moribund Deltaic Zone of Kandi Block of West Bengal : A Hydrogeomorphological Analysis

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River floods represent the most common geomorphic hazard encompassing a wide range of events like largely unpredictable, highly localized, flash floods to anticipated and widespread floods. According to the geological history of the moribund delta formation of the Ganga system of West Bengal the Kandi block of Murshidabad district was formed by the gradual deposition of sand and silt and is experiencing floods almost in every year since time immemorial. But the character of this flood is gradually been changing due to the encroachment of the anthropogenic factors. In this present paper a temporal as well as spatial changing form of the flood with its influencing factors will be carried on.

The deltaic Kandi Block is endowed with deranged surface and subsurface drainage pattern made by the mesh of Mayurakshi, Dwarka, Kuya, Hizuli, Mor,Banki and aligned gully segments. Depressed Hizole beel, Kumarsanda, Gokarna beel landscapes(wet lands) along with such deranged drainage pattern have made the flood condition devastating.

Spatio temporal flood character has been analyzed with aid of some statistical techniques. In this regard data have been collected from the old literature, documents and also from the official data of Irrigation Department of West Bengal. To get an idea about the current changing situation empirical field survey has been conducted for acquiring the perception of the flood victims.

As per outcome, out of 37 miserable floods, since 1900 to 2007, 80% have concentrated after 1955 to 2007 and out of 14 most devastating one 28.56% occurrences are within the narrow ambit of 2000 to 2007. The hydrological On the basis of the hydrological analysis it may be proclaimed that the suddenness of floods have increased alarmingly, flood prone areas have increased many times, flood heights have increased 2 to 2.5 times and frequency of flood is progressively growing.

Spatial zonation maps of the floods have been prepared on the simple composite indices using basically three parameters viz flood frequency, flood stagnation period and flood water height. Flood recurrence study has been deployed to assess the progressive change of flood magnitude with frequent manner.

The probable causes of floods have been identified like (i) Constant deposition with the river courses and beel areas (natural storage unit) (ii) encroachment of human being toward flood catchment areas of the existing river systems as well as toward beels (iii) building of lofty embankment along river courses (iv) construction of dam and barrage across rivers (v) advancement of cultivated plots into the river beds (vi) presence of zomindari bund remnants (vii) extremely poor drainage condition etc.

For the intensification of flood, along with natural depressed alignment of the region interference of human being in shape of conceited Tilpara Barrage, Massanjore Dam, Farakka barrage, artificial embankments cumulatively have made cloud of flood threats denser.

Abstract - 7

Microgeomorphic Forms of High Angle Profile Under Tropical Monsoon Environment: A Conceptual Study on An Artificial Cut Slope

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This paper deals with the micro-geomorphic forms of an artificial cut slope on which no human intervention occurred after its formation. This small slope is only 50.65 m long and located on a highland of Suryamaninagar of Tripura under tropical-monsoon type of climatic condition. Data generation through instrument survey shows that this small slope has many morphological variations within very small space and marked by several micro-geomorphic characters. Studying micro-angles and micro-relief on six serial profiles, it has been detected that though by necked eye the morphology of the whole slope looks almost uniform, the morphology is very diverse at micro level and the activity of process varies even within a very small area which results variation of instability and micro-geomorphic form. The overhang angles (>90º) of the surface of the six serial profiles of the studied slope supports the instability of it which results the micro level failure and modification. It is also very evident from the micro-relief changes that affect of the environmental processes of this slope is diverse. Different types of small sculptures and designs also show that the small parts of landforms are not only the result of combination of different environmental processes, but also the variation of processes at micro level. Though these small sculptures or designs are the integral parts of landform, most of them have no terminological identity in Geomorphology. They vary in shape and size and also very significant to explain the combination of active environmental processes for developing the landform. From that stand point the landform is so complex, if it is studied detailed at micro level. Thus micro-geomorphology is a very helpful tool to the Geomorphologists for in-depth study of landform.
Key words: micro-geomorphology, artificial cut, overhang slopes, micro-relief, vertical tunnels, environmental processes.

Abstract - 8

Environmental Hazards Along the National Highway 53A: A Study from Banderdewa to Itanagar, Arunachal Pradesh

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This paper evaluates the environmental hazards caused by anthropogenic activities along the road from Banderdewa to Itanagar which falls under Lower Siwalik formation. The episodic upliftment has caused many structural deformations forming unique depositional and constructional landforms. As the study area falls within the highly fragile mountain region, the environmental condition and the ecological risks of resource utilization are intimately linked together. The rapid growth of population in the twin capital, Itanagar - Naharlagun, is corresponding increase in pressure on the natural resources and the consequent danger on environmental degradation. Due to unavailability of plain area, the increasing population pressure is leading to settlement expansion on the steep sided slopes with the earth cutting on the hill top. Therefore, the human intrusion often accelerates the rate of change in geomorphic processes in many instances and initiates new changes. Specifically, and increase in population pressure puts a greater number of people at risk from a natural event. The land transformations in the hills of the study area lead to slope failure which is followed by soil erosion. Accelerated soil erosion is considered to be one of the most common and hampers the developmental activities in the Himalayan ranges. Earth cutting for both roads and building construction is a serious threat to the environmental condition of the area. High intensity of rains for long duration causes soil and rock debris to move down slope in the plain areas, which not only hamper the fertility of soil rather it, has also changed the fluvial processes. In this paper an attempt has been made to highlight the environmental hazards as observed during the study.

Keywords: Slope failure, land transformation, earth cutting, fluvial processes