ABSTRACT

4th Session of the IAG Working Group on Geomorphological Hazards (IAGEOMHAZ)

& INTERNATIONAL WORKSHOP ON GEOMORPHOLOGICAL HAZARDS

21-23 July 2010

ORGANIZERS

Venue

Sponsored by

Department of Science and Technology, Govt. of India

Ministry of Earth sciences, Govt. of India

Tamilnadu State Council for Science and Technology

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Name of the Department : CENTRE FOR GEOTECHNOLOGY

Establishment of the Dept : August 2005

Origin and Aim of the Centre

The Centre for GeoTechnology was established in August 2005. The Centre was emerged from the Centre for Marine Science and Technology, M.S. University, which offers an interdisciplinary course focusing on Marine/Coastal mining, natural hazards, Geophysical explorations for petroleum and mineral resources, exploration technology, environmental geoscience, Medical geology and generic research related to earth resources and GeoTechnology.

To develop human resources in the above said area, centre has started a Post Graduate course on M.Sc., Applied Geophysics with specialization on Environmental GeoTechnology & Marine Geophysics and M. Phil. Geo-Marine Technology. The students from the various disciplines such as Engineering, Geology, Physics, Environmental science, Chemistry, Zoology, have registered for Ph.D programme on different themes of GeoTechnology.

In addition to that the Centre also coordinates and promotes research on sustainable development, exploration & exploitation of earth resources including Medical geology.

Thrust Areas of Research

1. Marine Geology & Geophysics
    a. Marine Mineral Exploration
    b. Coastal Mining
    c. Marine Resource Processing for value addition
    d. Biogeo Chemistry
2. Natural Hazards
    a. Paleo Seismology
    b. Coastal Hazards
    c. Tectonics
3. Medical Geology
    a. Traditional Herbo mineral formulation for Tropical Diseases
4. Geo Environmental Studies
    a. Geomorphology
    b. Bio Geo Chemical Cycles
    c. Land cover changes
    d. Climate & Water

Memorandum of Understandings (MoU)

Signed MoU with Intergraph, USA for Recognition of Notable Research Activities in the field of Geospatial Technologies.

Signed MoU with Department of AYUSH for starting M.Tech in Ayurveda Sidha and medical biogeosciences during the academic year 2008-09.

Signed MoU with Tamilnadu Minerals Ltd., Chennai in the month of February 2009

Signing of MOU is under process with University of Malaysia Sabha, Malaysia, for the exchange of faculty members and students of both universities.

Research Projects:

Principal Investigator – Prof. N. Chandrasekar
#Co Principal Investigator – Dr. Y. Srinvas

Funding Organization	Project title	C	Total Cost
DST–NRDMS	Preparation of damage assessment maps of tsunamis affected areas in Kanyakumari **(No: ES/11/936(5)/05, Dated: 27.01.2005)**	C	Rs.10,00,000
DST – SERC	Mapping of areas of Inundation –Kanyakumari **(No: SR/S4/ES-135-5.1/2005, Dated: 03/03/05)**	C	Rs 4,60,000
UGC	Evolution of 550 Ma Southern granulite Terrain, South of Kodaikanal Ranges, possible linkages to beach Placer deposits of Southern Tamil Nadu	C	Rs.5, 59,600
CSIR	Mining Environment management in Tamil Nadu. **(CSIR/CMM/22.1/192. Dated: 04th August, 2003)**	C	Rs. 40,50,000
DST – SERC	Sedimentology,Geochemistry and evolution of Certain coral islands of the Gulf of Mannar. **(SR/S4/ES-44/2003, dated: 01/11/2004)**	C	Rs.22,00,000
DST-NRDMS	Environmental Impact Assessment of Beach Placer Mining along the Coast between Tiruchendur and Kanyakumari (AIBMBTAK). **(ES/11/526/2000, dated: 09/12/2004)**	C	Rs.13,00,000
#TNSLUB	Evaluation of Agricultural Land and Water Bodies Changes due to Urban Expansion in and around Tirunelveli Corporation **(No: 3951/SLUB/SPC/2006, dated: 01/11/2006).**	C	Rs. 3,25,000
Intergraph, U.S.A.	GIS and Remote sensing softwares were provided by Intergraph, USA for validating the software application in Geoscience – **MOU available**	C	Rs.1,25,00,000

On Going Projects :

Funding Organization	Project title	C	Total Cost
DST	Scientific Evaluation of safety and efficacy analysis Anti malarial drugs from marine Herbs for the management of Malaria – (Geomicrobiology) **(DST No: VII-PRDSF/53/05-06/TDT)**	O	Rs.1,07,00,000
#DST-SLUB	Establishment of NRDMS Database Center in three districts of Tamil Nadu **(100/IFD/130/2006-2007, dated: 17/04/2006)**	O	Rs. 5,00,000
#DST	Kanyakumari School Observatory Programme in Earthquakes - Setting up of School Level Seismological Observatories in Tamilnadu **(DST/23(577)/SU/2005 dated: 19/12/2006)**	O	Rs. 67,00,000
TNSLUB	Evaluating Tamiraparani river water quality through land use analysis in the two catchments (Papanasam & Manimuthar): impacts of wetlands on stream nitrogen concentration **(Proce No: 550/SLUB/SPC/2009, dated: 26/03/2009)**	O	Rs. 4,50,000
DST-NRDMS	An Operational Marine GIS Expert system for Mapping of Non-living Resources	O	Rs. 19,00,000

List of Ph.D Scholars:

Guide: Prof. N. Chandrasekar

Name	Topic	Year	C/S/U
D. Vetha Roy	Geochemistry of deltaic sediments of Tambraparani delta	2002	C
Anil Cherian	Shoreline changes and Morphodynamic control on placer deposits in the beaches between Tuticorin and Valinokkam	2003	C
Jeya Sekar	A Study on Ambient Heavy Metal Distribution in the Atmospheric Environment of Tuticorin Coast	2003	C
J. Dajkumar Sahayam	Genesis of Beach Rock Formation along the Southeastern Coast, Tamil Nadu and its Significance to Sea Level Variation	2004	C
Mrs. M.Subbu lakshmi	Industrialization and Urbanizatiion Impacts in the Aquatic Environments of Tuticorin coast	2006	C
M. Rajamanickam	Remote sensing and GIS application in beach placer evaluation and shoreline dynamics along the Tuticorin Coast	2007	C
Mrs.Glory	Geo-chemical accumulation in salt marsh area of Tuticorin and Punnaikayal	2008	C
L. Ramakrishna	Developing suitable Eco-friendly excavation techniques for limestone mining from complex metamorphic structures and lithology of Thalaiyuthu limestone terrain	2010	C
P. Sheik Mujabar	Quantitative analysis of coastal land form dynamics between Tuticorin and Kanyakumari using Remote sensing and GIS	2010	C
S. Saravanan	A Study on Beach Morphodynamics and Heavy mineral distribution in the beaches between Ovari and Vattakottai, Tamil Nadu		U
J. Loveson Immanuel	Regional Assessment on spatial and temporal trends on Beach profile changes and Heavy mineral variability in the beaches between Periyathalai and Tuticorin, Tamil Nadu – GIS Analysis		U
C. Hentry	Spatial Characterisation and coastal zone assessment between Midalam and Kanyakumari coast, K.K. District, Tamil Nadu through Remote Sensing and GIS		U
N. Prince	Urban development through Remote Sensing and GIS in Tuticorin Coast		U
S. Krishna Kumar	Sedimentology and Geochemistry study on Coral Reef, Gulf of Mannar		U

Prince. S. Godson	Evaluating the impact of beach placer mining on sandy beach macro and meiofaunal community along the Southern Tamilnadu coast		U
A. Ponniah Raj	Texture, Distribution and Provenance of Alluvial Garnet Placer in the Major Ephemeral Streams Between Kollimalai and Thalamalai, Tiruchi District, Tamilnadu		U
N.S.Magesh	Prediction of Spatial Variability of Water Quality and LandUse Pattern along the TamiraParani River Bank between Cheranmahadevi and Vallanadu, Tirunelveli District, Tamilnadu		U
Ram Anand Bheeroo	Coastal dynamics of Mauritius island		U
Joe Vivek	Remote Sensing and GIS application for validity of beach placer minerals		U

C – Completed, U – Under Progress

Guide : Dr.Y.Srinivas

Name	Topic	Year	C/S/U
D.Muthuraj	Integrated Geophysical studies for Structural analysis near Abishekapatti, Tirunelveli District, Tamilnadu.		U
D.Hudson Oliver	Geo electrical and Geo chemical Assessment of Groundwater in parts of Kanniya Kumari District, Tamilnadu.		U
A. Stanley Raj	Applications of Artificial Neural Networks for the Interpretation of Geophysical Data.		U

C – Completed, U – Under Progress

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Fluvial Geomorphology and Hazards

Coastal/SubMarine Geomorphology and Hazards

Landslide/Tectonic/Earthquake/Volcanic/Mountain Geomorphology and Hazards

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Hazard Zonation Mapping/Anthropogenic impacts

Remote sensing/GIS in Geomorphological Hazards

Part – I

A MANUAL FOR COASTAL RISK ASSESSMENT IN BAY OF BENGAL COAST

Dr. Ashis Kr. Paul & Dr. Soumendu Chatterjee

Department of Geography & Environment Management, Vidyasagar University, Midnapore-721102, West Bengal

The coastal zones are exposed to variety of hazards due to interactions between marine and terrestrial systems with respect to hazardous processes and complexities of coastal areas (in terms of geology, geomorphology, hydrology, ecology, economy, sociology etc.) in responding to those processes. In the context of increasing concerns about those hazards, the growing importance of the coastal zones because of high productivity of the ecosystems, concentration of population, industrial development, resource exploitation, recreational activities etc.- demands effective coastal management. The Swaminathan committee has recommended vulnerability as the important criteria in costal zone management. Assessment of the physical sensitivity and exposure of coasts to hazards is an essential component for any comprehensive coastal vulnerability study.

During the last few decades, a plethora of coastal risk assessment methods have been proposed consequent upon the recognition of global climate change and resultant sea level rise which is expected to put the coastal habitats and coastal communities into real threats. Many of such methods have been developed adopting purpose oriented approaches which fail to address the whole gamut of the coastal risks/problems in entirety. This often leads the costal managers to confusions in choosing between the alternative methods of coastal risk assessment on which planning and management exercises largely depend. In some other cases, different methods have been devised for different coastal situations to achieve similar goals. Furthermore, the economic and social structure that characterizes a coastal community are required to be more emphasized considering their higher significance in defining the vulnerability and unsafe conditions of the coastal dwellers exposed to natural hazards. Therefore, in many cases socio-economic agendas of vulnerability and risks stands before their physical considerations. Hence, there is a need to formulate a methodology that may allow a nearly self sufficient assessment of coastal risks which is almost complete in all practical senses. Moreover, there is a need to prepare a manual for acquisition of survey based field data required for the assessment. The treatise is a humble attempt in that direction.

The human occupancies of geomorphologically hazard prone lands of the coastal belt are not avoided at present around the Bay of Bengal shores due to increased population pressure and available economic options in the sea and adjacent lands. The dramatic increase in losses and casualties due to natural disasters like wind, storms surge induced flooding, seismic hazards and tsunami incidence of Bay of Bengal coasts during the previous decades has prompted a major national scientific initiative into the probable causes and possible mitigation strategies. However, the immediate attention of geomorphologists is demanded to analyze the coastal hazards and distress of the country after anticipating the changes and impacts of extreme weather hazards of the Bay of Bengal coasts as a result of global climate change and local sea level change.

This paper is aimed at developing a conceptual framework for coastal risk assessment and discusses how to collect and analyze the database for mapping risk zones. This method has been adopted in case of Bay of Bengal coast.

RATIONALE OF COASTAL RISK ASSESSMENT:

Attractiveness of coastal locations as the place for settlement, urbanization, trade and commerce, industrialization etc. is gradually increasing. Thus the importance of coastal areas has gone up significantly. Here lies the essence of coastal risk assessment.

- About 50% of the population in the industrialized world lives within 1 km. and 50% of the global total population live within 60 km of the coast. At the end of this Century the coastal areas are expected to house more than three-fourth of the global population (Viles and Spencer, 1995)
- ⅔ of the world's cities (with population over 2.5 million) enjoys a coastal locations. Thirteen of the world's twenty largest cities are located on coasts.
- Unprecedented growth of population in the coastal areas is orchestrated with increasing pressure of tourists.
- As a result of high population pressure coastal ecosystem resources are subjected to unsustainable utilization which has perturbed the critical balance within and between the coastal subsystems.
- Coastal environment exhibits wide diversity not only in its natural setting but also in terms of community, livelihoods and resilience.
- Coasts play an important role in global transportation and trade and commerce, and thus the coastal cities have become key component of globalization.
- The greatest threat to the coastal areas arises out of the strong likelihood of global sea level rise which is projected to be 0.49 m at the end of this Century relative to the base level in 1990 (Church et al., 2001). This will lead to displacement of huge population.
- The coastal risk assessment is an essential task for disaster risk reduction and a step towards a safer future.

CONCEPTUAL FRAMEWORK:

For the risk assessment a semi-quantitative approach has been adopted. Several input parameters are used in this numerical model. The success of risk assessment virtually depends on perception about the risk. Strong judgment and wide experience about the complex natural and human behavioural mechanisms are the most important preconditions to realistic assessment of risks.

Risk refers to the exposure of people to a hazardous event. It incorporates potentiality of the threat to people and their possessions, including buildings and structures. People may consciously place themselves at risk due to lack of alternatives, or economic benefits that overweigh the risks involved, or turning of a once safe place into unsafe one under a new threat. The mathematical definition of risk is the probability of harmful consequences or expected loss as an outcome of mutual interaction between hazardous and vulnerable/ capable situations. This can be expressed(Shaw et al ; 2009) as:

Hence, risk associated with a disaster defines that part of the concerned hazard which has probability or potentiality to cause loss of lives and properties of the socially vulnerable/capable people who are physically exposed to the hazardous situation. It is evident that three major constituents of risk are: i) **hazard-** its type, frequency and severity; ii) **exposure** of human activities to the hazard as a function of location specific sensitivity of the concerned geographical unit to the hazard process; and iii) **vulnerability** of people (and their properties) as the manifestation of their ability and inability to cope with the hazardous situation in a given socio-economic structure. Hence the task of risk assessment involves precise analysis of each of these three components.

1. HAZARD ANALYSIS:

The process of hazard analysis starts with identification and prioritization of hazard types followed by assessing probability of the occurrence of a hazard of given intensity (often associated with the physical level of damage) at a particular location. Well developed scientific methods can be used to analyze hazards which involve various steps like data collection, data analysis etc. Results of hazard data analysis are presented in the form of hazard maps. Such maps provide information on the probable extent of the hazards and their impacts in combination. Thus hazard analysis can be carried out in following steps.

a) Hazard Identification and Prioritization:

Coastal areas are threatened by number of hazards driven by different hazardous geophysical events or extreme physical phenomena like tropical cyclone, earthquake, tsunami etc. The hazards generally observed in the Bay of Bengal coasts are listed in the following:

Table 1: Hazard Types and their Prioritization

Hazard Type	Hazard Priority Score (HPS)
Strong Wind (Cyclone)	
Coastal Flood	
Storm Surge	
Wave Action	
Beach (coastal) erosion and beach ridge breaching	
Inland (stream) erosion and embankment breaching	
Salt water incursion	
Drought	

For a particular coastal region the hazards are required to be weighted from 1 – 8 to generate a hazard Priority Score (HPS). These score values are to be utilized in the overall risk estimation.

b) Hazard Assessment and Impact Assessment:

This phase of hazard analysis involves calculation of **Hazard Score** which measures the impact of different identified hazard types in a region. The Hazard Score is a function of the geography and the natural recurrence of hazards over several regions. A hazard Score is to be computed for each hazard type. These scores can refer to the probability and intensity or strength of disasters. The Hazard Score (H) for a coastal region can be calculated using the following formula:

$$H_{it}^{k} = (\text{Probability}_{it}^{k} \times \text{Intensity}_{it}^{k})$$

Where the subscript 'k' refers to hazard type and 't' takes into the time involved in measurement which can be suitably fixed according to the hazard type. Here probability is defined as frequency of events per year and intensity is referred to such as seismic intensity of an earthquake, wind speed of a cyclone, inundated area and depth of water in case of a flood, duration without rainfall in the event of a drought etc.

i) Strong Wind (Cyclone):

Time series data on cyclones have to be utilized to map and zone the areas prone to the hazards associated with strong winds. Such maps can also be produced in digital formats to facilitate integration of various spatial data with socio-economic, housing, infrastructure and other variables for assessment of cyclone risks. In this context, satellite imageries provide considerable volume of supplementary data on topography, vegetation, hydrology, land use and land cover etc. The Saffir-Simpson cyclone disaster-potential scale can be used as a basis for assessment of cyclone hazard and its impacts.

Table 2: Variables and Calculations of Cyclone Hazard Assessment

Scale No. Col. 1	Central Pressure (mb) Col. 2	Wind Speed (kmh^{-1}) Col. 3	Damage Col. 4	Intensity Score Col. 5	Frequency (n) Col. 6	No. of years considered in frequency measurement (m) Col. 7	Interval (r)= (n+1)/m Col. 8	Probability (p)=1/r Col. 9	Cyclone Hazard Score (CHS) = Intensity Score X Probability (Col.5 X Col.9) Col. 10
1	> 980	120 – 150		2.7					
2	965 – 979	151 – 179		7.4					
3	945 – 964	180 – 210		20.0					
4	920 – 944	211 – 250		54.6					
5	< 920	> 250		148.4					

ii) Coastal Flood:

Coastal flood hazard can be caused by tropical cyclone and tsunami. The degree of flooding depends upon scale of the storm, height of storm surge and the tide level at the time of the event. Global sea level rise will be an increasingly important factor if predicted rise in sea level do occur. River estuaries may witness severe estuarine flooding with combined effects of a storm surge and river flood caused by rain storm inland. Coastal flooding is the most severe hazard in many coastal locations around the Bay of Bengal.

Assessment of the flood hazard includes identification of flood hazards, characterization of the flooding in terms of depth, duration of inundated condition, extent and velocity etc. Furthermore, the height of storm surge in low lying coastal areas is another important criterion for evaluating flood hazards. Damage to human life, properties and infrastructure caused by flood hazard is another easily measurable component of the flood hazard intensity. Field data sheets can be prepared in the following format to generate database for flood intensity assessment. One has to take substantial number of samples within the study area considering each mouza (village) or Gram Panchayat as sample unit, depending on the scale of study. Secondary data of past flood events are available with Gram Panchayat and Block Development offices which are to be supplemented by primary data acquired through questionnaire survey. Several indicators can also be used to determine landward extent of coastal flooding. These indicators include the highest level of beach material deposits, debris, scars on trees, plants originally flattened by floods and then grew upwards from a horizontal position etc.

All the data on damage impacts are to be standardized by calculating z-scores for making them dimensionless and scale-free then those z-sores are to be locally and regionally averaged for a particular flood event. Hence,

z-score of flood impact (Local) (FI_L) = $$\frac{\sum_{j=1}^{k} Z_j}{k}$$

Where j = hazard parameters and k = no. of parameters

On the basis of above local flood impact z-scores spatial variation of flooding damage character within the study area can be mapped subjectively. The damage impacts of a flood event for a region can be calculated by simply averaging the local level scores.

Table 3: Calculations for Flood Impact Assessment

Observation Station (Village)	Fully damaged houses		Partially damaged houses		Population affected		Cattle died		Fishery damage		Crop damage		Road damage		Locally averaged z-score of flood impact
	No.	z-score	No.	z-score	%	z-score	No.	z-score	Value in Rs.	z-score	Value in Rs.	z-score	Length in km	z-score	
1.															
2.															
3.															
.															
.															
Regionally averaged z-score of flood impact															

z-score of flood impact (Regional) (FI_R) = $\dfrac{\sum_{i=1}^{n} FI_{L\,i}}{n}$

Where i = sampling stations and n = number of sampling stations.

For a particular flood episode, FI_L and FI_R z-score values can be ranked in a ten-point scale to get the Flood Impact Ranks.

Table 4: Ranking Flood Impact from z-scores

z-score Range	Flood Impact Rank (**FIR**)
< -3	1
-3 to -2	2
-2 to -1	3
-1 to 0	4
0 to 1	5
1 to 2	6
2 to 3	8
> 3	10

Characterization of a flood event at the regional level in terms of its magnitude can be done in simplified manner using time series data collected in the following format.

Table 5: Calculation of Flood Magnitude rank (FMR) and Flood Intensity Score (FIS)

Sl. No.	Year of occurrence	Depth of flood water		Flood Velocity		Area Inundated		Landward extension of flood from shoreline		Average of z-scores	Flood Magnitude Rank (FMR)	FMR X FIR	Flood Intensity Score (FIS)
		in m.	z-score	in m/sec	z-score	in km^2	z-score	in km	z-score				
1.													
2.													

Probability of the occurrence of a flood of given magnitude is calculated from Return Period. Flood return period should ideally be calculated on the basis of at least 30 years worth of data. A simple formula is used to assess the return period in years.

T = n+1/ m, where T= return period in years; n = rank, m = no. of years in record.

The probability of occurrence of flood of a given magnitude is expressed by taking the inverse of the return period (T) i.e P = 1/T.

Finally, the Flood Hazard Score (FHS) is calculated by multiplying the Flood Intensity Score (FIS) and probability.

FHS = P X FIS

c) <u>*Storm Surge*</u>:

Storm surge flooding can be also considered for assessment of risk. To identify the risk, the depth and extent of storm surge flooding for different probabilities of occurrence can be predicted and also that can be expressed as a hazard index. The coastal belts can be categorized into five major land uses: Industrial areas, commercial areas, urban built-up areas, rural housing areas and agricultural areas. For each area, population density and economic importance of the area have been considered and are expressed as an importance index. Finally, using the hazard index and the importance index, the risk index for each area is calculated. On the basis of such analysis the whole region can also be classified into four categories of risk: the low risk area, the moderate risk area, the high risk area and severe risk area.

According to Abdullah and Haque, M.M (1997) the risk of a storm surge for a particular area depends mainly upon depth of inundation, population densities and land use. The method of assessment of risk from such diasaster is expressed by the risk index:

RI (Risk Index)= HF X VF (hazard factor and vulnerability factor)

HF= 10 X hazard index of an area / highest hazard index

(hazard index is the depth of the storm surge)

VF= 10 X importance index of an area / highest importance index

(land use type is the importance index)

'Aila' cyclone with associated storm surge is considered in this work for assessment of risk by the application of above method. On the basis of the importance of land use, the whole area of Indian Sunderban and other low lying coastal belt is divided into five zones A,B,C,D and E. the tourism industrial area belongs to A, commercial fishery sector and whole sale market belong to B, urban areas belong to C, unplanned rural settlements belong to D and others including agricultural lands belong to E. the areas under A and B get the highest importance index as 5 score and areas under E get the lowest importance as 1 score. Areas occupied by C and D are given as 3 and 4 scores as importance index respectively. Finally the vulnerability factors can be calculated using the above equation: (table-3).

The depth of inundation is categorized and scaled as 2.5 is 5, 2.0 is 4, 1.5 is 3, 1.0 is 2 and 0.5 is 1 for estimation of hazard factor. The risk index values are finally calculated by estimating the hazard factor and vulnerability factors of the study area.

Table 6: Estimated risk index values and associated risk categorization of the Aila storm surge affected areas

Vulnerability factor	Hazard factor	Risk Index Value(HF X VF)	Degree of risk
10 X 5 /5 =10	10 X 2.5 / 5 =5	50	Severe risk
10 X 4 /5 =8	10 X 2.0 / 5 =4	32	High risk
10 X 3 /5 =6	10 X 1.5/ 5 =3	18	Moderate risk
10 X 2 /5 =4	10 X 1.0 / 5 =2	08	Low risk
10 X 1/5 =2	10 X 0.5/ 5 =2	02	Low risk

The population density is above 200 persons per sq km in the urban parts of the study area, and the overall density ranges from 700 to 800 persons per sq km in the other parts of the low line coasts.

In Bay of Bengal coast storm surges are primarily associated with tropical cyclones. Magnitude of tropical cyclones often corresponds to a range of storm surge height. Hence, magnitude of a tropical cyclone, (assessed from wind speed) can be taken as a measure of storm surge intensity and recurrence interval (probability) of tropical cyclone of a given magnitude in a particular coastal section is assessed from time series climatic data (as has been calculated in Table 2). The storm surge hazard scores calculated from the intensity and recurrence interval of storm surges of different intensity can be averaged for characterization a coastal region in terms of storm surge hazard.

Table 7: Calculation of Storm Surge Hazard Score (SSHS)

Scale No.	Wind Speed (kmh^{-1})	Height of Storm Surge (m)	Intensity Score	Probability Score	Storm Surge Hazard Score (SSHS) = Intensity Score X Probability
1	120 – 150		2.7		
2	151 – 179		7.4		
3	180 – 210		20.0		
4	211 – 250		54.6		
5	> 250		148.4		

d) *Wave Action*:

The risk level involved in wave action depends on number of waves that reach or overtop the structure and thus on run up of the waves. The run up on beaches and structure has been an object of much experience and substantial information is available for the shapes of dykes and breakwaters. Many of such information have been analyzed to model run up length as a function of significant wave height and beach morphology, shallow water bathymetry etc. According to a simplified method (Van der Meer, 1994), the run up R_u as a function of significant wave height H_s and breaking parameter ξ,

$$R_u = 1.6 \text{ X } Hs \text{ X } \xi$$

The breaking parameter in turn is given by-

$$\xi = \tan \alpha \, / \, \sqrt{2 \pi Hs / T_p^2}$$

Where α is beach slope and T_p the spectral peak time.

The bottom slope and depths needed to perform these calculations are obtained either from bathymetric map or from field measurements. Following this simple procedures large scale maps of potential hazard can be produced in short time.

The data collection table is given below in which D_1 and D_2 refer to the first and second depth datum available from maps of field data, L_1 and L_2 are the respective distances from shoreline, H_1 is the elevation of the first obstacle and L_S its shoreward distance from the shoreline. The beach slope needed for empirical formula is obtained by interpolation.

Table 8: Data Collection Shhet for Run Up Calculation

Locality	D_1 (m)	D_2 (m)	L_1 (m)	L_2 (m)	L_S (m)	H_1 (m)

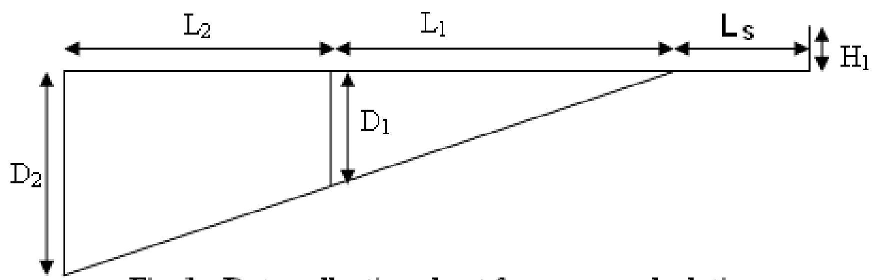

Fig. 1- Data collection sheet for run up calculation

The wave height Hs, associated with a coastal area can be assessed using the concept of significant wave (H⅓), which is defined as the average height of the highest one-third of all waves observed over a period. This can be used for spatio-temporal comparisons between coastal sections. Coastal sections with mean annual significant wave height exceeding 2m are defined as high energy coast while coasts with significant wave height of 1 – 2m and < 1 are referred to as moderate energy and low energy coasts respectively. Wave Hazard score for a coastal section can be calculated as follows:

Table 9: Calculation of Wave energy intensity score

Mean Annual Significant Wave Height range (m)	Coastal type in wave energy term	Wave Energy Intensity Score
< 1	Low energy coast	1
1 – 2	Moderate energy coast	2
> 2	High energy coast	3

Table 10: Calculation of Wave Action Intensity Score

Wave energy Intensity Score	Calculated Run up (m)	Estimated area under flood (km^2)	Rank for Flood Area	Wave Action Intensity Score =
Col. 1	*Col. 2*	*Col. 3*	*Col. 4*	*Col. 1 X Col. 4*
1				
2				

Probability of high intensity wave episode can be obtained from wave height records associate with cyclone etc. and thus Wave Action Hazard Score (WAHS) for a coastal section can be achieved.

e) *Beach Erosion*:

Beach erosion is associated only to those coastal areas where more sediment is lost alongshore or offshore than is received from various sources. Destructive wind action in stormy periods is the most important process of beach erosion in the context of risk assessment though there are many other caused of beach erosion. As the volume of beach material diminishes the beach face is lowered and cut back. The rate of retreat of the high tide line can be measured by comparing dated sequences of maps and charts, aerial photographs and satellite imageries. The volume of beach material lost can be estimated by superimposing series of beach profiles taken at different periods. Losses of material along two successive profiles are averaged and multiplied by the area between profile lines to determine volume of material lost.

Table 11: Calculation of Beach Erosion Hazard Score

Rate of Beach Erosion	Rank for beach erosion	Average loss of beach materials per year (m^3)	Rank for beach material loss	Beach Erosion Hazard Score = Col. 2 X Col, 4
Col. 1	*Col. 2*	*Col. 3*	*Col. 4*	*Col. 5*

Similarly, hazard scores for a coastal region with respect to stream erosion inland and drought can be calculated using suitable variables. Finally the hazard scores are to be multiplied by their corresponding Hazard Priority Score (HPS) and those products will have to be added up to get the Hazard value for the concerned region.

2. ANALYSIS OF EXPOSURE:

The definition of risk incorporates exposure to the hazard as part of the vulnerability. It refers to the level of danger that people and property face in the event of any natural hazard. Therefore, assessment of the physical sensitivity and exposure of coast to hazard is an essential component of any properly comprehensive coastal vulnerability study. Such an analysis can be carried out within a conceptual framework that involves three logical levels of assessment. The first level (national level) comprises the identification of shores likely to be physically sensitive to coastal hazard like flooding, sea level rise etc. This involves geomorphic and topographic mapping to identify soft (erosion prone) and low lying (flood prone) coasts. Such maps are generally prepared for long coast which provide useful information for coastal risk assessment.

Several risk variables are identified for the coasts of Bay of Bengal to develop the ranking of coastal vulnerability index. Particularly to develop a database for a national scale assessment of coastal vulnerability, relevant data have been gathered from local, state level agencies, as well as govt. institution of the country. The compilation of the data set is integral to accurately mapping potential coastal changes due to predicted sea level rise.

The second level or regional level involves identification of regional variation in the energies or processes impacting on the potentially sensitive coast identified at the first level the assessment. This phase identifies those sensitive shores most exposed to physical impacts using regionally variable exposure factors such as - sea level rise; wave climate (wave energy, height, direction); storm climate (storm surge frequency, direction, and magnitude); tidal ranges; vertical land movement (subsidence, tectonic uplift) and potentially other climatic changes such as precipitation and wind. This stage of second level of assessment needs to be integrated with fist level geomorphic sensitivity data to be of practical use in coastal risk assessment. A good example of such an integrated regional level assessment is provided by Coastal Vulnerability Index.

Ten physical variables are used here (Table-12), and each variable is assigned a relative risk value based on the potential magnitude of its contribution to physical changes on the coast as sea level rises in the Bay of Bengal.

For local level, CVI data can be generated on monitoring the form and processes of the coast.

Table 12: Ranking of coastal vulnerability index variables for the coast of Bay of Bengal

	Ranking of coastal vulnerability index				
Variable	*Very low (1)*	*Low (2)*	*Moderate (3)*	*High (4)*	*Very High (5)*
Geomorphology (relative erodibility of different landform types)	Rocky, cliffed coast with coves bays and embayment	Deltaic Chenier coast with beach ridges	Non deltaic sandy coast with barrier beaches, lagoons	Island coast with coral reef, mangroves	Deltaic coast with estuaries, mud flat, mangroves
Surface elevation in metre					
Coastal slope in %					
Relative sea level change(mm/y)					
Shore line erosion, accretion (m/yr)					
Mean tide range (m)					
Mean wave height (m)					
Wave run up length in the Tsunamies					
Frequency of cyclones (landfall)					
Maximum inland penetration of storm surges (in Km)					

At the third level, site specific assessment would be necessary to identify and evaluate critical local variations in shoreline sensitivity and exposure. The factors which influence the sensitivity and exposure of a coast at the local level are bed materials, topography, shoreline planform and bathymetry, dune height, local sediment budget, longshore drift and other local coastal processes such as river discharge and tidal channel processes. As all these processes find expression in the coastal landforms, vulnerability of individual coastal landforms can be considered to include local processes in the assessment of risk.

According to IPCC vulnerability is defined as "the extent to which climate change may damage or harm a system; it depends not only on system sensitivity but also the ability to adopt to new climatic condition (IPCC, 1996). The coastal system always adjusts with environmental changes within the available time, space and materials. Thus, the system must be given sufficient time, space and materials or sediments to adjust to a new equilibrium state.

Pethick (2000) estimated the ratio between relaxation time and return interval for threshold time events that referred to here as the vulnerability index, and provide an important measure of the manner in which coastal landforms respond to impose changes and can allow assessment of the potential for long term progressive change in the system:

Vulnerability Index = Relaxation time/ return interval

Construction of such vulnerability index for site specific coast regions will need locally specific data with monitoring records. The vulnerability indices may be constructed for small scale coastal landforms (sand dunes, salt marshes, sea beaches, mud flat and Spits etc.) and large scale coastal landform (estuaries, open coast, deltaic island etc.)

Table 13: Example of vulnerability indices for Bay of Bengal coasts

Shoreline	Event frequency (yr)…1	Relaxation time (yr)…2	Vulnerability index 1/2
Sand dune			
Sea beaches			
Salt marshes			
Mud flats			
Sand spits			
Estuaries			
Island			
Rocky cliffed coast line			

The period of recovery from the effects of extreme events is referred to as the relaxation time of the coastal system. However, the threshold coastal strength is considered as a direct response to environmental inputs. The high energy Bay of Bengal cyclones may, however, exceed the threshold strength and cause changes in the coastal morphology.

3. VULNERABILITY ANALYSIS:

Vulnerability is a term that is essential to the full understanding and efficient management of risk and vulnerability analysis is an important stage of risk assessment. Vulnerability is defined as the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards. Vulnerability is understood as the combination of societal, economic and environmental issues which give way to the natural hazards to become a disaster. Social characteristics like gender, age, occupation, marital status, race, ethnicity, religion of the people exposed to a hazard determine their loss, injury sufferings, life chances etc. Different types of vulnerability have been recognized by Aysan (1993) viz. economic vulnerability (poor access to resources); social vulnerability (weak social structure and deterioration of social relations); ecological vulnerability (degradation of environmental quality); organizational vulnerability (lack of national and local institution); attitudinal vulnerability (lack of awareness); political vulnerability (lack of political power); cultural vulnerability (some orthodox beliefs and customs) and physical vulnerability (weak buildings and structures). The poorest and marginal people in a society to live with perpetual indebtedness, malnutrition, ill health, unhygienic living environment and violence are highly vulnerable in the face of a hazard. Therefore, any additional stress like loss of land, shelter, occupation, assets caused by hazard place those people in catastrophe.

The operational model that helps in assessing risk as well vulnerability is as under.

Risk = f_1 {Hazard (H), Vulnerability (V), Exposure (Ex)}
V = f_2 {Social (S), Economic (E)}
S = f_3 {Poverty (P), Education (Ed), Health quality (Q), Population (P)}
E = f_4 {GDP, Income Level (IL), Indebtedness (ID)}

Information required for vulnerability analysis is summarized in the Table- 14. It emphasises on five groups that are likely to have least protection against hazard. Nature and composition of such highly vulnerable groups may vary from place to place and situation to situation. The disparities among the vulnerable groups in accessing four types of resources in the wake of a disaster event helps in assessing socio-economic vulnerability of a community. The symbols are used to signify whether a particular group is likely to experience enhanced (+), reduced (-) or no change (0) in its situation in accessing the resources. But the 0s are not considered because they are not significant with respect to vulnerability. If the researcher understands that there is really no change in any variable at the face of hazards then he can put o in calculating vulnerability.

Obvious that, the data are ordinal scaled and not normally distributed. Hence, one can use the principle of binomial test (as applied in sign test) for determining the probability of positive or negative changes between pre- and post-event situations with respect to each of the selected variables. The probability for the k number of positive (or negative) observations is given by-

$$f(X \geq k/n) = \sum_{j=k}^{n} \binom{n}{j} . p^{j} . q^{n-j}$$

Where n = number of observations, p = 0.05 probability of positive changes = 0.5 and q = 0.5 probability of negative changes. Thus calculated probabilities may be expressed in percentages or may be multiplied by 10. The test is to be conducted for each of the variables under every resource type and values obtained are to be added to get the vulnerability of a particular group. Vulnerability of the region can be determined by adding up the product of vulnerability value for the group and their percentage in the total population.

Table 14: Variables and Calculations for determining Vulnerability (Modified from Wisener Et al. ;2004)

Resource type	Access to	Potentially vulnerable Groups	Respondent's perception in regard to change in condition between pre- and post- disaster event					Total No. of '+'s	Total No. of '-'s
			1	2	3	.	.		
Material Resources	**Land**	Poorest 33%	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -		
		Middle 33%	.	.	.	.	.		
		Richest 33%	.	.	.	.	.		
		Women	.	.	.	.	.		
		Children	.	.	.	.	.		
		Elderly	.	.	.	.	.		
		Minority class	.	.	.	.	.		
	Water	Poorest 33%	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -		
		Middle 33%	.	.	.	.	.		
		Richest 33%	.	.	.	.	.		
		Women	.	.	.	.	.		
		Children	.	.	.	.	.		
		Elderly	.	.	.	.	.		
		Minority class	.	.	.	.	.		
	Local resources	Poorest 33%	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -		
		Middle 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Livestock	Poorest 33%	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -		
		Middle 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Tools and Equipments	Poorest 33%	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -		
		Middle 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Capital and Stock	Poorest 33%	.	.	.	.	.		
		Middle 33%	.	.	.	.	.		
		.	.	.	.	.	.		

	Food reserve	Poorest 33%	.	.	.	.	.		
		Middle 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	House/Shelter	Poorest 33%	.	.	.	.	.		
		Middle 33%							
		.	.	.	.	.	.		
	Transport	Poorest 33%	.	.	.	.	.		
		.							
	Sanitary	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
Physiological and social Resources	**Nutrition and health**	Poorest 33%	.	.	.	.	.		
		.							
	Education	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Technology	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Information	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Social links	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Livelihoods	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Safety and Security	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
Financial Resources	**Income**	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Market	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Banking and Credit	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
Environmental Resources	**Workplace Environment**	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Home Environment	Poorest 33%	.	.	.	.	.		
		.							
	Pollution	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		
	Aesthetics	Poorest 33%	.	.	.	.	.		
		.	.	.	.	.	.		

Scores/ Index values for Exposure and Vulnerability are to be added to get weighted Vulnerability value of a coastal region.

4. CAPACITY ANALYSIS:

The following table shows the variables selected for assessing the capacity. In a particular coastal region the variables are given a weightage value according to importance and a rank according to their status. Then the capacity score for the region concerned is calculated by adding up the products of weight and rank of each of the variables.

Table 15: Variables and Calculations for Capacity Analysis

Capacity Component	Weight	Rank	Weight X Rank
Regulations			
Planning			
Rescue operation			
Insurance			
Alarming system & its reliability			
Compensation against losses			
Awareness			
Institutional Co-operations			
Healthcare			
Capacity Score for the coastal region in consideration			∑ Row values

CONCLUSION:

Finally, the values of scores and indices associated with hazard, vulnerability and capacity are put in the risk equation to get the risk value for a particular coastal region which can be used to map risk zones at the national level.

The method can be applied for national level mapping and state level mapping for ranking vulnerabilities under the impact of sea level rise along the coasts of geomorphological diversity. Most of the deltas, estuaries, back water, embayments, island and coral fringe shore lines are highly vulnerable to the predicted sea level rise in Bay of Bengal. Occurrences of storm surge flooding and recorded tsunami wave run up lengths in the coasts proved the vulnerabilities of the same areas in the previous decades. The study also shows that relatively higher areas, rocky coasts with cliffs and barriers coastal area are less vulnerable than the other parts of Bay of Bengal coast. The coastal cities like Chennai, Kakinara, Puri and Digha are remarkably vulnerable to sea level rise for their low surface elevations, alluvium materials, and high population densities.

The geomorphic perspective of vulnerability index is applied for assessing risk of site specific geomorphic units along the coast. The return interval of threshold events and sensitivity of range of coastal features have been considered here for the assessment of vulnerability index. This method is used for measuring vulnerability index of shore line features of West Bengal and Orissa as the local specific monitoring data is available here (Neyogi, 1965, 1970)(Chakroborty 1965) and (Paul 1985, 2002). Now the base line research is needed to identify the precise limits of tolerances of alluvial coastal features to the major environmental changes caused by extreme weather events and predicted sea level rise to utilize our coastal resources in sustainable manner over the long period of time.

The method of risk categorization is conducted in the low lying coast of deltaic and non-deltaic parts using the impact analysis of 'Aila' storm surge depth and inundation area. Temporal Remote sensing data and location specific monitoring data have been provided for estimation of hazard factors and vulnerability factor of the low lying coasts of West Bengal.

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Part - II

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Fluvial Geomorphology and Hazards

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FLUVIAL GEOMORPHOLOGICAL HAZARDS OF THE BRAHMAPUTRA BASIN, INDIA AND ADJACENT AREAS - A CASE STUDY

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Present paper concerns a study on the fluvial geomorphological hazards of the Brahmaputra- a case study. The Brahmaputra rises from the tongue of the Chema Yungdung glacier of the Kailas Range, Tibet, and is known by the name of Tsangpo throughout its eastward course for. 1500 km. before entering Arunachal Pradesh across the Sadiya frontier, where it is called the Dihong. Two other tributaries, the Dibang and the Lohit, join from the cast, and the combined rivers are known as the Brahmaputra. The total catchment of the river is 580,000 km2 of which about one-third lies in India. This river valley is synonymous with the Assam Valley, and is subject to morphological changes, annual floods, migration of channels, erosion of land, disruption of river and rail communications, disastrous earthquakes which occur frequently in the valley.

This author has adopted the modern method (including Remote Sensing and G.I.S software i.e. Eradus, Geometica V-10, Map Info etc) and intensive field work especially in some selected areas with particular Applied Hydro-Geomorphological interests of the Brahmaputra Basin particularly the later one as a case study. The methods adopted relate broadly to the three major stages- (a) Pre-field,(b) Field work, and (c) Post-field methods with an application of advanced techniques of measurement and analysis.

The meteorological cause of flood relates to -

Very high rainfall (700 mm and more) in a short period i. c. in the South-West Monsoon period (June to Sept.) where monthly rainfall at places cross 1150 mm with records of maximum above 400 nun and more of rainfall in 24 hours. 2) Rain storms (cyclones, local severe storms) of one to three or more days duration arc quite common over the entire BBM basin area c. g. average storm distribution is 1 in May, 26 in June, 29 in July, 9 In August, 19 in September and 3 in October in an average.

The major causes of floods especially the geomorphological causes –

3) The river valleys especially the tributary rivers appear to be 'misfit' in that sense as they lack the proper sediment-transfer zone i. c. gcomorphologically no intermediate stage. 4) The marked variations in the river valley gradient of the Brahmaputra river, especially for the stretch of about 500 km in Dibrugarh to Gauhati with a fall of only 2m. In Assam the valley-gradient is very low in comparison to its distance from the base level of erosion or the sediment sink Zone i. e. its delta downstream. This valley gradient of about 16 m/km in the upper-near the gorge-valley section (above Karko 28°32'N, 95°1'E and Moling at 3075 m. a. s. 1.) along the Dihang (Siang) - Tsang Po valley (with restricted width and great depth), the boat hook bend near Nanicha Barwa, 7755m, a. s. I.) changes abruptly into 0.5 and less m/km beyond the piedmont plain near basighat, and becomes about 0.1, in average in the lower braided (greater width of 4 to 6 km and shallow depth) part e. g. Guwahati downstream. 5) The Brahmaputra (with its braided course) - a notable tectonically active river basin having very narrow valley section (width and depth factors), alluvial gap (flood plain) especially between Garo hills in the South and Bhutam Himalaya in the North, for example. 6). The Brahmaputra flood plain is being shaped by seismic and tectonic movements along its southern and northern margins which are still very active even today. 7) The occurrences of subsidence of Brahmaputra valley in a comparative sense in respect of the rapid upliftment of its surroundings- e. g. (i) the Himalaya in the north (at the rate of 5 to 9 nun in a year), (ii) the Mishmi Massif in the cast (at the rate of 9 to 12 mm in a year), and (iii) the Meghalaya Plateau in the south (at the rate of 3 to 5 min in a year). This author has already presented an interpretative fluvial geomorphological account of the

drainage basins of the NorthEastem part of the Indian Subcontinent i. c. the Brahmaputra, Ganga, Irradwaddy etc. and their tributary rivers (Sub-basins like the Tista, the Torsa, the Ravi, the Bagman, the Manipur etc.) through his earlier publications (Mukhopadhyay 1982, 1987, 1988, 1989, 1993, 1996, 2006.2007,and 2008).

In this connection, it seems reasonable to refer to the design flood of one of the important tributaries to the lower Brahmaputra, Sikkim and West Bengal i. e. the Tista river. The given illustrations like Discharge and Stage hydrographs, 1970, 1986 Rating curves at Chungthang, Coronation bridge, Darjeeling District 1985, and rating curves including Looping type rating curve at Domhani, Jalpaiguri District, 1983, 1985, Discharge vs chance percent curve 1972 to 1986 etc. applying the standard methods – California, tumble's etc relating to peak discharge by probability method for near and remote future, and other methods like peak discharge by empirical formulae c. g. Dicken's Formula, Inglis formula, Nawab Jung Bahadur's formula etc. (vbrshney 1979), Fuller's formula (Fuller 1957) etc. are also presented. The main findings and observation of the paper relates to the importance of surface configuration and the drainage pattern other than the climatic factors as discussed quantitatively and qualitatively both.This author has further added some relevant points also suggesting the remedial measures of the flood hazards as presented in the text.

FLUVIAL HAZARDS AND ITS IMPACT ON LAND USE PATTERN OF HARIDWAR DISTRICT, UTTARAKHAND

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The present paper is concerned with Fluvial Hazards and its impact on land use pattern of Haridwar District, Uttarakhand. It extends from 29º35'37"N to30º13'29"N latitude and 77º52' 52"E to78º 21' 57"E longitude covering an area of 1850 sq.km. The present study is based on the application of modern methodology including GIS and Remote Sensing as well as intensive fieldwork with an integrated approach. After procurement of these materials, etc an analysis of these data are made adopting the advanced technique of measurement especially in terms of 1) Prefield work 2) Field work and 3) Post fieldwork (Mukhopadhyay 1980,1982). Haridwar city located at the foothill of Shiwalik is facing various physical and as well as man made problems. There is a great impact of landforms on the land use of the area. Recently the land use patterns are being rapidly changed by anthropogenic effect. The area consists of forestland, irrigated arable land and unirrigated land, built up area, wetland, wasteland and other types of land use pattern. In the northeastern and northern part of the district Shiwalik range is situated, where landslide is a major problem.

During monsoon numerous torrents are formed from Shiwalik range. That is why excessive soil erosions are occurred. This eroded materials transported into river and in the southern part due to sudden change of slope of relief, river velocity suddenly decreases. That is why transported materials are deposited on river channel reducing its water bearing capacity. These whole mechanisms are responsible for seasonal flood at the southern part of the district. The eroded materials from Shiwalik also hamper soil productivity. Beside these physical problems, there are some man made problems also. So some major physical problems and as well as man made problems are degrading various land resources of the area. Through time series analysis it has been found that deforestation, contamination of ground water and as well as surface water, poaching of forest resources, increasing pressure of population are some major man made problems. On the other hand landslide, seasonal flood, water logging problem and huge soil erosion are some major physical hazards which have a great influence on degradation of various land resources like forest, soil, surface water, transport system and agricultural production. So geographers have a significant role to preserve the area from the various environmental problems through scientific land use planning and sustainable development strategies.

SPATIO TEMPORAL MORPHOLOGICAL CHANGES OF THE BRAIDED BRAHMAPUTRA RIVER IN INDIA

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The Brahmaputra River is one of the biggest rivers in the world. This mighty trans-boundary river runs for 2880 kms through China, India and Bangladesh with a drainage area of 580,000 sq. km. (50.5% in China, 33.6% in India, 8.1% in Bangladesh and 7.8% in Bhutan). In India, its basin is shared by Arunachal Pradesh (41.9%), Assam (36.3%), Meghalaya (6.1%), Nagaland (5.6%), Sikkim (3.8%) and West Bengal (6.3%). Any alluvial river of such magnitude has problems of sediment erosion-deposition attached with it; the Brahmaputra is no exception. Relentless stream-bank erosion along with flooding in the densely populated riverine region of the Brahmaputra basin in the Indian province of Assam has become one of the causative factors for impoverishing a large segment of agrarian population every year. Significant areas of prime inhabited land are lost every year to river erosion in the Brahmaputra basin thereby pauperizing the affected people due to sudden loss of home and hearth. Furthermore, bank erosion process has caused channel widening which creates navigation bottleneck zones in the Brahmaputra due to inadequate draught during non-monsoon. An imperative need persists to formulate appropriate parameters to describe braiding phenomenon and fluvial landform pattern of large alluvial rivers like the Brahmaputra with highly intricate channel configurations. In order to understand morphological changes of the Brahmaputra river a study of river channel changes of the Brahmaputra River has been carried out by the authors. The paper also presents quantitative assessment of temporal behavior of channel braiding process of the Brahmaputra River by using Plan Form Index (PFI) formulated by Nayan Sharma (1995) along with its threshold values. The index is compared for different discrete years to understand the morphological behavior of the highly braided Brahmaputra River. The present paper briefly describes a study of the Brahmaputra river - its entire course in Assam from Kobo u/s of Dibrugarh up to the town Dhubri near Bangladesh border for a stretch of around 620 kms using an integrated approach of Remote Sensing and Geographical Information System (GIS). The channel configuration of the Brahmaputra river has been mapped for the years 1990 and 2008 using IRS 1A LISS-I and IRS-P6 LISS-III satellite images respectively. Deployment of GIS technique has been made to extract the required parameters to derive Plan Form Indices for the entire study reach. Temporal and spatial variations of PFIs have been analyzed considering the threshold values categorizing the braiding intensity for the river flow domain. The foregoing study implicates substantial as well as persistent changes in the river flow domain with increasing braid intensities in recent years. This unabated channel process warrants immediate erosion control measures to prevent prime inhabited land loss. The results provide latest and reliable information on the dynamic fluvio-geomorphology of the Brahmaputra river for designing and implementation of drainage development programmes and erosion control schemes in the north eastern region of the country.

QUATERNARY GEOLOGY AND GEOMORPHOLOGY OF TERNA RIVER BASIN IN WEST CENTRAL, INDIA

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This paper presents the Quaternary Geology and geomorphology of Terna river basin in the Deccan Basaltic Province (DBP) of West central India. The Quaternary geological mapping was carried out in the area in order to generate the data on soil stratigraphy, morphostratigraphy and lithostratigraphy. A WNW-ESE and E-W regional structure, which has influenced the drainage network of the area and the tributaries of the Terna river shows the anomalous drainage pattern.

In the Deccan Peninsular India Quaternary deposits are primarily fluvial. They are confined to very narrow belts along rivers with not much recognizable landscape features. These deposits are often discontinuous, generally unfossiliferous and lack suitable material for radiometric dating, further more, the deposits lack proper preservation of pollen and proper sedimentological record. The lithology and faunal assemblage of the Terna and Manjra valley alluvium suggest that the Older Quaternary Alluvial deposits are of Upper Pleistocene age. Lithostratigraphically the Quaternary deposits of the Terna river basin have been divided into three informal formations including (i) dark grey silt formation – Youngest, (ii) Light grey silt formations - Upper Pleistocene, (iii) brown silt formation - Oldest. The Quaternary geomorphic units observed in the area are Present floodplain (To), Older floodplain (T1) and Pediplain (T2). The fine clay and silt formations in the lower reaches reflect that the streams are of low gradient and more sinuosity.

IRS P6 LISS III 2006 data was used to delineate Quaternary litho units of the Terna river. Active channels and floodplain features were mapped. The river shows the evidences of channel movement by avulsion and the lineaments largely control these. Older palaeo-levees exist in the form of ridges 4-5 m high in the Thair, Killari, Sastur and Makni villages along the Terna river floodplain. In the field these are marked by a curvilinear deposition of Paleolithic sites on the silty or sandy over bank deposits or on the surfaces. They occur as irregular patches and can be related to the older course of the river. Several lineaments run NE-SW, NW-SE, E-W and WNW-ESE directions, which control the basement structure in the study area. Sections were logged and sedimentary structures were studied.

BANK EROSION OF THE RIVER GANGA AND ITS CONSEQUENCES IN MALDA DISTRICT, WEST BENGAL

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Rivers of alluvium tracts face very low gradient, invariably which forces the river to flow slowly in meandering or zigzag path (Das & Dutta, 2007). Nature and intensity of such meandering significantly the over curvature of meandering scour is many a time governed by both the geologic and tectonic conditions. Similarly hydrological characters contribute a lot to turn the situation into a vigorous state. A change in any of the controlling variables or the imposition of an artificial change by the construction of structures along or across the stream will disturb it's equilibrium and the stream then aggrades or degrades(Ramshastri,2003).Construction of Farakka Barrage has initiated acceleration of bank erosion in case of river Ganga after 1971. Survey maps of 1922-23 & 1936-37 (sheet nos. 72P/13, 72O/13) show a straight course of almost zero sinuosity indices between Rajmahal and Farakka.Right from 1930s to 80s the river skirted east ward hugging it's left bank and the issue was generated extremely and now the river is facing intermittent phase of extreme leftward movement (I&W, Govt. of W.B, 2005). Now-a-days the bank erosion of the river Ganga in Malda district of the state of West Bengal has become a tremendous menace and unexpected fate of unfortunate local dwellers. General configuration of the country rock, general slope as well in channel hydraulics has contributed a lot towards the causation of this age old disaster. Year-wise records on erosion reveals that up to 1970 about 15,064 ha of lands had been washed away in the grasp of the mighty river which reached to 2,821 ha in 1980, again the increment level of erosion amounted to 1,305 ha in 1990& the figure became 1,057 ha in 1998 and the rate was increasing upto2007 (Malda Irrigation Division, Govt. of West Bengal 2000). As per available records total lives affected was about 340 in 1980s,which was 7,848 in 1990s, 4,717 in 1995 and the figure was tremendous in 1996 amounting to 50,000. In 2000, 13,550 houses were totally destroyed costing to 21.40 lakhs Rs., whereas crop damage was 1,480 lakhs Rs. for that year and more than of 2,000 lakhs Rs. till 2003.From methodological point of view intensive vediography of the east bank of the river Ganga for two periods i.e. wet & dry during 2005 to 2008 was done & which provided serious help to document the nature of erosion, bank–soil character, and detection of slump types, whereas secondary sources associated with empirical formulas provided estimations on river hydraulics like average depth, constant of gravity, discharge etc.Time series analysis on bank side soil/land loss in addition to crop loss(crops in danger -*aus ,aman ,kalai* pulses, sugarcane mango , maize, mustard, Boro etc.) and loss of both movable and immovable properties really focus the intolerable agony of local inhabitants. Here two simultaneous approaches have been taken, one, study the situation in general perspective using secondary records & two, using schedule method analysis of lost properties of selected villages taking100 family/households as study units. Analysis cum documentation of public loss to flash light on the destitute dwellers was the main aim behind result detection and also documenting the reasonable factors for erosion. Oscillatory shifting of the mighty river Ganga really has grasped the natural life line of the local inhabitants and hundreds of disaster refugees have created and here lies the validity of the paper.

BANK EROSION ALONG THE LOWER COURSE OF BALASON RIVER, WEST BENGAL

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Balason River with a total area of 254.59 sq. km is the most important right bank tributary of Mahananda River having its origin from Lepchajagat on Ghum-simana ridge at an altitude of 2361 m. The human induced activities of extracting bed materials for economic purposes, especially in its lower course are largely responsible for the changing fluvial environment of the Balason River as a whole. Such extraction activities from the river bed as well as adjoining terraces have led to progressive bed degradation both upstream and downstream and such situation is very much visible throughout the lower course. Mostly, extraction sites close to the bank are preferred as it reduces both labour and transportation costs. The effect of such near-bank extraction is the ultimate lowering of the bed and in many sites such extraction process has created scours which result into diversion of channel towards the bank during high discharge, hence increasing the bank recession. Among other effects of bed materials extraction from Balason river, the most immediate and alarming effect of bank erosion is endangering not only its fluvial characteristics but is also becoming a thread to the inhabitants who are residing close to the river bank and are dependent on river for their livelihood. The retreat of side banks are favouring the widening of the river, possessing threat to properties and civil works located near the river.

In this paper an attempt has been made to assess the extent of bank erosion considering the bed material extraction activities. Along the lower course of Balason River (24.13 km), the sites where bank recession is most visible and fresh retreat has occurred are taken into consideration. The cross profiles along the studied sites and exposed bank height and sketches were taken for detecting the recession frequency. The bank erosion rates were measured once in October, 2008 and again during monsoon period of 2009 with references to selected permanent structures along the bank line. In two of the sites, the bank height has increased to more than 5m along with recession of 2.5m and 4m from its actual position. With an average annual 20 cm bed lowering, the banks are well exposed resulting into removal of underlying materials accompanied by periodic collapse of overhanging top materials. During peak discharge, wearing away of the bank margins are letting loose gravel and sands from the bank slopes to be added to the river during the monsoon periods. Also, the extent of bank recession at some sites needs immediate protection works. Hence, the changes in river profile brought about by extraction of bed materials throughout the year and resultant bank erosion have left great impact on its behaviour which might result into severe geomorphic hazards endangering the surrounding environment.

CHANNEL INCISION, WIDENING AND RETREAT OF EXPOSED BANKS IN THE LOWER BALASON RIVER

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Balason River with a total length of 46.40 km is the most important right bank tributary of Mahananda River having its origin from Lepchajagat (with latitude of 27˚3´55″N and longitude of 88˚14´12″E) on Ghum-Simana ridge at an altitude of 2361 m. The human induced activities of extracting bed materials for economic purposes, especially in its lower course are largely responsible for the changing fluvial environment of the Balason River. Such extraction activities from the river bed as well as adjoining terraces have led to progressive bed degradation both upstream and downstream and such situation is very much visible throughout the lower course. Mostly, extraction sites close to the bank are preferred as it reduces both labour and transportation costs. The effect of such near-bank extraction is the ultimate lowering of the bed and in many sites such extraction process has created scours which result into diversion of channel towards the bank during high discharge, hence increasing the bank recession. Among other effects of bed materials extraction from Balason river, the most immediate and alarming effect of bank erosion is endangering not only its fluvial characteristics but is also becoming a threat to the inhabitants who are residing close to the river bank and are dependent on river for their livelihood. The retreat of side banks are favouring the widening of the river, possessing threat to properties and civil works located near the river.

In this paper an attempt has been made to assess the extent of bank erosion considering the bed material extraction activities. Along the lower course of Balason River (24.13 km), the sites where bank recession is most visible and fresh retreat has occurred are taken into consideration. The cross profiles along the studied sites and exposed bank height and sketches were taken for detecting the recession frequency. The bank erosion rates were observed following the monsoon season and the recession or further erosion after monsoon flush are compared with the pre monsoon bank conditions in references to selected permanent structures along the bank line. In two of the sites, the bank height has increased to more than 5 m along with recession of 2.5 m and 4 m from its actual position. With an average of 20 cm bed lowering annually, the banks are well exposed resulting into removal of underlying materials accompanied by periodic collapse of overhanging top materials. During peak discharge, wearing away of the bank margins are letting loose gravel and sands from the bank slopes to be added to the river during the monsoon periods. Also, the extent of bank recession at some sites needs immediate protection works. Hence, the changes in river profile brought about by extraction of bed materials throughout the year and resultant bank erosion have left great impact on its behaviour which might result into severe geomorphic hazards endangering the surrounding environment.

Key words: Human induced activities, Bed material extraction, bank retreat and recession.

ENERGY DIFFERENTIAL AND ITS IMPACT ON RIVER BANK EROSION OF RIVER GANGA IN MALDA DISTRICT, WEST BENGAL, INDIA

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Flood and erosion have been seriously wondered the physical and socio-economic conditions of any riverine environ. The western part of Malda district has been designated as a linear boundary for the presence of mighty river Ganga. The study has been carried out in the district of Malda covering an areal extent of $24^0$42’20”N to $25^0$32’08”N and from $87^0$45’50”E to $88^0$28’ 28”E respectively. The river enters the district near Gaduri of Bhutnichar and flows upto Farakka in the district. Till 1931the reach was almost straight between Rajmahal and Farakka which afterwards experienced vigorous level of bank side slumping consequent upon erosion on time scale specially in the post Farakka periods. Time series analysis on channel shifting morphometry display a distinct and sharp bend towards Malda i.e. upstream the barrage from 1930s to till date. Three blocks namely Manikchak, Kaliachalk II & III and fewer parts of Englishbazar are worst affected in the grasp of mighty river Ganga. The mouzas like Panchanandapur, Jot Kasturi, Sakullapur, Khaskol Dharampur, Manikchak etc. are the so called and most severely devastated in the migratory morphogenesis of the river Ganga. On the other hand, downstream of the barrage the river has been found to be shifting towards west collapsing areas in Murshidabad. Here fluid studies have been carried out to estimate river energy and thereby computations of both the Potential and Kinetic energy are the major endeavor of the authors. Comparative study of both the energies have revealed precise reasoning to make out the steady and regular causation of bank side slumping. Parametric data collected from other sources on height difference (h), radius of the earth (R), mass of fluid (m), density of water (D), component of gravity (g) and site specific estimation of gravity (g″) discharge of fluid (Q) etc. helped to find out the quantification of empirical values of the energy equations. Calculation of both the energies in joule’s unit as well in comparative unit (%) attributed to the fact that location wise and composite value of potential energy is less than the location wise and composite value of Kinetic energy, which evident that the competency of the fluid to be moved is less than to be static as potential energy for a given time factor and in the specific segment of the channel under study. The inference can be drawn on the findings that because of almost stagnancy of in-channel water over a low country slope of 1in 21,000 (Valentine, 1992) creates bank saturation, hydrostatic water pressure, chemical reactions of bank soil dominated by sands of 80% and lower composition of silt and clay; with low velocity water etc. consequently result into bank failure processes. The situation would be of difference and the reach under study would be comparatively secured if fluid dynamism could be of considerable velocity (v) creating adequate channel discharge (Q). To study these phenomena and to validate the effect of such quantifications behind the hydro-geomorphologic occurrences are the prime objective of the authors and to open up new passages for further fluid study.

Key words: slumping, changes in morphometry and morphogenesis, Potential energy, Kinetic energy, empirical values, hydro-geomorphologic occurrences.

BANK EROSION AND SOIL CHARACTER ANALYSIS ALONG THE LEFT BANK OF THE RIVER GANGA IN MALDA DISTRICT, WEST BENGAL, INDIA

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Shifting and time series channel oscillation along the left bank of the river Ganga in the district of Malda, West Bengal since 1930s has become a vigorous natural calamity and has been enormously effected by the loose sandy and silty character of the bank. The effect of correlation between soil mechanical properties i.e. presence of proportion of sand, silt and clay and age old problem of bank erosion of the left bank of the river Ganga, were studied. Identification of soil profile spots alongside the virgin and exposed bank profiles standing almost like a wall with a view to selection of sites having no human interference results a deep causal relationship between soil characters (mechanical) and consequent bank erosion. 14 nos. spot level data (SLD) from the laboratory records of office of the Soil Conservation Officer, Soil Survey, Malda, Govt. of West Bengal, both of 'off bank spots' (OBS) and 'near bank spots' (NBS) accompanied by on field profile analysis, were attempted i.e. total 20 spot profiles were studied starting from ground level to a subsurface depth of 160 to 180 cm taking on an average 7 to 8 horizons. Horizon-wise estimation of percentage of sand, silt and clay evident that over dominance of sand in the subsoil horizons (3,4,5) below the top soil horizons (1,2) with dominance of silt and clay within a large zone of unsaturated entisols resulted subsurface undermining because of lower the presence of cementing material like organic carbon, higher the pH and excessive base saturation, which is attributed to aerial liquefaction, collapsing of overridden top soil and slumping of non cohesive bank by hydraulic action consequent upon heavy bank erosion.

Key words: bank erosion, slumping, profile, horizon, subsurface undermining, organic carbon, base saturation.

PROBLEM OF FLOOD & BANK EROSION OF DOWNSTREAM R PANCHNOI, SUKNA, DUARS

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Flood is nothing but one of the important cumulative atmospheric hazards which are caused due to cumulative effects of weather events and it is found as the acute environmental hazard of north Bengal. The studied area, Bandijot and Dagapur Nadipar village, sukna, Darjeeling are such villages which are nearer to Siliguri township area, situated at the bank of R Panchnoi downstream (tributary of R Mahananda). Almost the yearly occurrence of flood as well as river bank erosion makes a real measurable condition for the inhabitants of the tea estate.

A considerable number of people become homeless some of them lose their only crop practicing land or their vegetable garden due to the enormous bank erosion. Not only that a number of cattles even villagers died in last flood occurred on October, 2007. Now the Dagapur tea estate factory, the only source of income for the slum villagers, will be severely affected in future flood occurrence, if no serious measures are taken immediately.

Methodology

The present study is based on the collection of data from topographical map no 73B/5 and 73B/6 and the extensive field survey by the traditional instruments, like – dumpy level, prismatic compass, as well as by the modern technology, like GPS etc. At the same time we give emphasis on the perception of the local inhabitant. The satellite image 73B5 grid B3 and 73B6 grid 73B1 is digitized to measure the temporal fluvio-dynamics of that particular downstream reach of R Panchnoi, near the villages, named Dagapur Nadipar and Bandijot. The collected primary and secondary data are analyzed to understand the status or the magnitude of flood and bank erosion in that particular fluvio-geomorphic region.

Cause

We try to find out the probable causes of this type of flood in this region. We find that the heavy downpour in a very short span of time, the high rate of sedimentation in the river bed and mostly the human interference play the major role for the execution of such an devastating event. Not only that the increasing tendency of deforestation at the sight of river bank of R Panchnoi, has been accelerated the rate of bank erosion. It passively increases the rate of surface run off which also accelerates the rate of soil erosion and passively the amount of bed load.

Result

It is very important to follow some mitigation measures to prevent the future damages. So suitable river training measures should be taken to save the inhabitants. Though a number of measures have already been taken by the government, such as- embankment has made, revetment concept has also been introduced. But still the situation is not under control .A huge damage has done at the bottom of the pillar of Toy train Panchnoi River Bridge due to high rate of scouring mainly in rainy season or at the time of high water level.

- It is so important to make a artificial diversion or a flood wall in the channel bed to get down the velocity.
- The wire- crating spur will be a useful measure to reduce the flow velocity .
- At the same time it is also to be said that the anthropogenic effects on Panchnoi river course should be reduced to allow it to flow freely in its own course, otherwise it is quite impossible to make success by adopting a scientific river training management system.
- A mass awareness should be made to reduce the tendency of deforestation, agricultural practices in river bed etc.

EXPLORING THE RELATION BETWEEN BASIN MORPHOMETRY AND CHANNEL CHARACTERISTICS — A CASE STUDY OF THE CHEL NADI BASIN, WEST BENGAL

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A drainage basin is often considered the basic unit of geomorphic investigation since it is a clearly defined and unambiguous topographic unit, is available in a nested hierarchy of sizes on the basis of any considered classification scheme and is an open physical system in terms of inputs of precipitation and solar radiation with outputs of discharge, evaporation and re-radiation. The drainage of any area has a marked influence in shaping the spatial geometry of that landscape. The channel pattern represents a mode of channel form adjustment in the horizontal plane, comprised of several transverse and longitudinal components all influenced by the underlying terrain. The basin geo-materials induce resistance to flow and the working and re-working of the sediments lead to changes in the channel morphology which are further controlled by parameters like channel gradient, valley slope, discharge and load characteristics. Thus knowledge of the morphometric attributes of a basin and how they influence the trunk and tributary streams' morphology and behaviour is crucial towards understanding the basin dynamics in operation and the nature of any fluvial-induced hazards affecting that landscape.

The present study focuses on the Chel N. basin, a fifth order (according to Strahler's scheme) left bank tributary of the Tista River in the Jalpaiguri district of northern West Bengal. The Chel basin (27º 05′ N – 26 º 42′ N and 88 º 45′ E – 88 º 40′ E) straddles the foothills of the Himalayas to the north and the broad alluvial plain to the south, the entire topography being criss-crossed with rivulets, rivers and residual ridges. The major objectives of the present study are — ddelineation of the Chel basin and extraction of its drainage network, enumeration of the stream network properties of the extracted network, mapping of the morphometric attributes of the Chel basin, demarcation of probable distinct basin physiographic regions on the basis of the above morphometric attributes, aanalysis of channel characteristics and patterns within each of the above demarcated physiographic divisions, and iidentifying the natural and anthropogenic stresses on the channels within the basin area and outlining probable corrective measures to stop possible environmental degradation.

The study uses SRTM (Shuttle Radar Topographic Mission) DEM (Digital Elevation Model) data to extract the drainage network, delineate water divides and generate contours at a greater density than that available from existent topographic to enumerate the various basin morphometric parameters. Channel patterns are mapped from high resolution Google Earth images while channel-shifting and changes in the channel plan-form over time have been analysed by overlaying available satellite images from the Landsat archives.

The study reveals the impact of surface slope on the streams' erosive capacity - it being directly proportional to terrain dissection. The Chel N. behaves markedly different in the three demarcated basin physiographic units of steep northern foothills, central piedmont zone and gentle southern broad alluvial plain. Sudden change of slope from the foothills to the piedmont causes channel instability. This zone is a prime target for channel siltation, rapid bank erosion and channel avulsion especially in high-discharge states as the streams change from confined boulder-choked single channels to multi-thread courses. The impact of the above on the livelihoods of the local inhabitants is often devastating and possible remedial measures have been suggested.

BANK EROSIONS AND SILTING OF INLAND WATERWAYS AND LOW COST RECOVERY STRATEGIES

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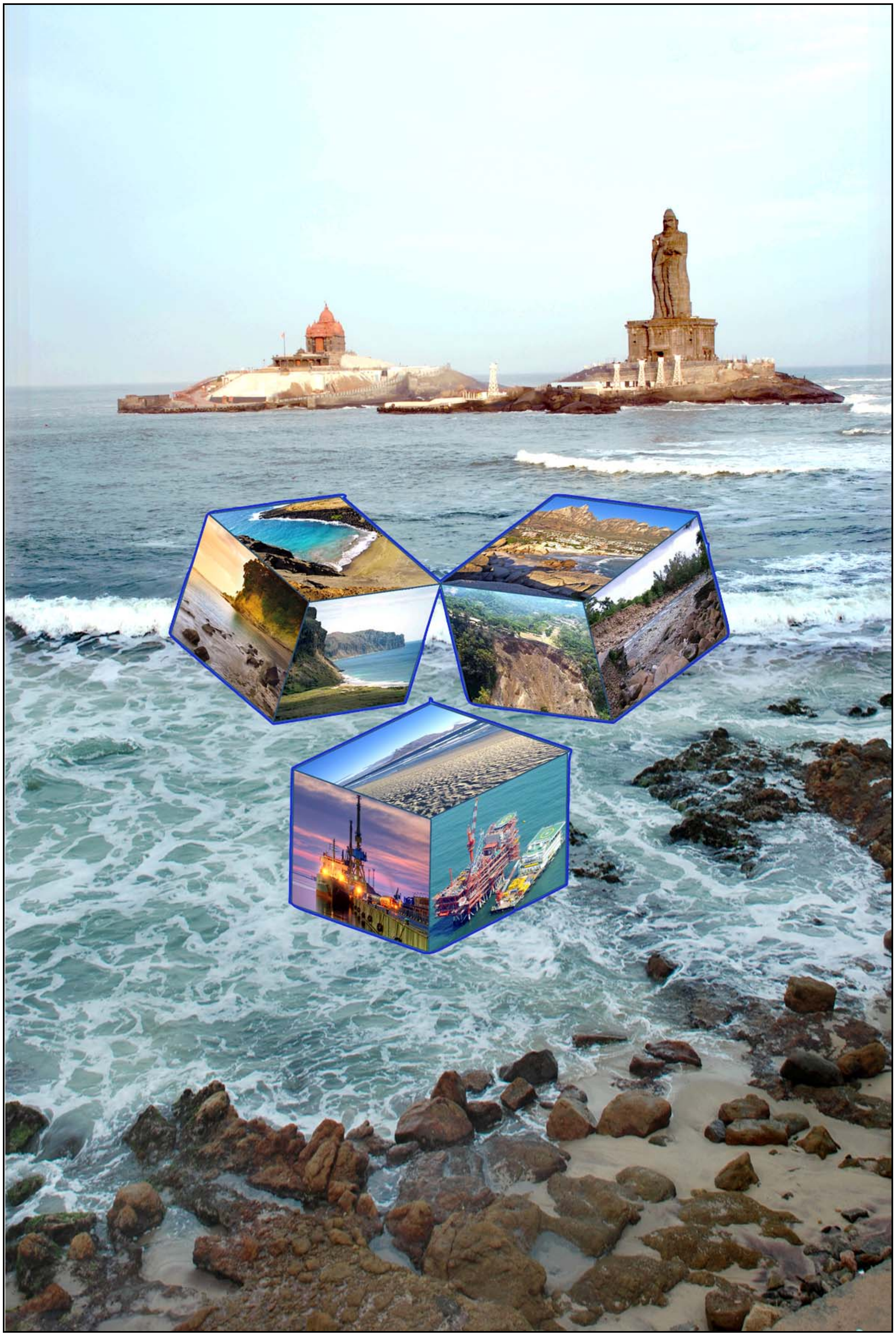
The Vembanadu wetlands, which is the largest wetland system on the west-coast of India is facing environment degradation due to lack of civic sense, poor living standards and unawareness of best and alternate practices in water quality control. The encroachment, mining and reclamation has lead to the decrease in the depth of water courses in many stretches which has badly affected the water transport in many places Excessive weed growth due to eutrophication leads to high rate of siltation resulting in shallowing of a wetland, preventing the smooth functioning of water transport system and had increased pressure on road transport, especially in the Kuttanadu wetlands . Many stretches of the waterways did not have the required flow due to neglect, which leads to environment degradation. The canal bank erosions and silting have reduced the draft, which has resulted in the gradual reduction of flow. The water quality in one of the canals of upper Vembanadu was monitored in 2007-2009 and trials of low cost water purification and canal recovery with herbs and other low cost materials available in the region were performed. During the pre-monsoon months, only 43.17% was moderately suitable and 56.83% was unsuitable for life. As per BIS guidelines, the water in the canal during monsoon months is classified as Category A and in post monsoon season it is classified as B. During the entire year, the water in the canal is in class C. The perennial grass vetiveria zizanioides was tested to have high sediment holding capacity to control canal bank erosion with high root growth and has high medicinal and economic values. The oxygenating device fabricated from locally available materials and working with wind was found to be suitable for "Rejuvenation of canal" with improved water quality and it provided trained manpower on water resources management.

Keywords: oxygenating device, Rejuvenation of canal, Vembanadu wetlands



Coastal/SubMarine Geomorphology and Hazards

CLOSURE OF TIDAL INLETS IN A WAVE- DOMINATED, MICRO –TIDAL COASTAL ENVIRONMENT ALONG KONKAN COAST OF MAHARASHTRA

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The seasonal closure of tidal inlets is a common and important coastal phenomenon along the Konkan coast of Maharashtra. The closure of tidal inlets or estuaries usually starts at the beginning of the fair weather or dry season, when the average river flow drops down significantly. Hereafter persistence in wave direction and wave conditions remain more or less uniform for several days. River generated flood currents decline at the end of the rainy season and wave energy is reinstated as the dominant sedimentary process. Sediment from offshore sand bars is transported alongshore and landward resulting in gradual narrowing and shallowing of tidal inlets.

The river floods only occur in monsoons but they exert a strong control on the form and evolution of inlets. Under flood conditions, flood currents cut through the sand-spits bordering the tidal inlet mouths. The flood currents also erode accumulated sediment and start deepening the channel. An abundant supply of sediment is always available for ready redistribution in monsoons.

In all tidal inlets on this coast the existence and persistence of an entrance is dependent on the relative strength of tidal currents and flood-generated currents which maintain the inlet entrance as well as close the entrance by depositing marine sediment. The balance between these processes determines the nature and the persistence of an inlet or a river mouth. Thus two main mechanisms of inlet evolution are involved in the process.

These inlets are partially closed to the ocean for a number of months every year due to the formation of sand bars and sand lenses across their entrances. The annual closure of these inlets inhibits ocean access for boats and could also cause deterioration of water quality in the estuary connected to the inlet. Lagoons like conditions are created in the lower sectors of the estuaries. As these estuaries are commonly used as harbors or for recreational facilities there is increased interest in keeping the inlets permanently open.

This paper documents the features related to seasonal opening and closure of tidal inlets and river mouths in a wave-dominated, micro-tidal environment along the South Konkan coast of Maharashtra. The sedimentary forms developed and temporal morphological changes in such forms under typical conditions dominant in the dry and the wet season respectively are discussed. The interpretations are based on aerial photographs, satellite images and field observations. This study of the mechanism of gradual, seasonal closure of inlets on konkan coast also considers the role of long shore and cross shore sediment transport. It also includes the parameters like wave steepness, wave approach, inlet cross section, tidal prism and inlet plan form.

The study suggests that the alongshore processes are not the cause of inlet closure. The onshore sediment transport due to wave conditions in fair weather appears to govern seasonal closure of the inlets.

APPLICATION OF MODERN TECHNIQUES ON COASTAL AQUIFERS OF CENTRAL KERALA

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Land use/landform changes play a significant role in the quality and quantity of groundwater especially in densely populated areas. Consequently, the study of land use/landform patterns assumes significance in any attempt at water resources management. In addition, anthropogenic activities have exerted large-scale changes on terrestrial ecosystems in the last century, primarily through agricultural activities. Application of modern techniques is essential for the proper utilization and management of groundwater resources. Remote sensing, GIS (Geographic Information System) and GPS (Global Positioning System) have proved to be effective tools in the management of water resources especially in the groundwater sector. The unconfined aquifer of the coastal tract of Central Kerala comprises mainly of fine sand and clayey silt. The area is conspicuous with the prevalence of backwaters that directly influence the quality of the groundwater in the coastal areas. The region is densely populated and people here mostly rely on the coastal aquifers for their water needs. In the present study, an attempt has been made to assess the impact of land use/landform changes on the groundwater scenario in the coastal tract of Central Kerala. Thematic maps of aquifer resistivity and thickness were analyzed in a GIS environment to delineate groundwater potential zones. Land use/landform change studies in the delineated high potential zones using satellite imageries further help in identifying groundwater potential zones on a micro level. The integrated study undertook by applying Remote Sensing, GIS and GPS in the above coastal have proved to be an effective tool for the groundwater management.

INLET BEHAVIOUR INDUCED CHANGES IN THE BEACH-DUNE COMPLEX AT VALVATI, MAHARASHTRA, INDIA

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Inlet systems represent a primary natural boundary or sink for transport of littoral and nearshore sediment. These are the systems in dynamic equilibrium wherein tides and waves, along with their associated effects, form a locally unique balance that determines the morphological characteristics of each inlet. With the seasonal variations in the tides, waves and sand transport, the inlet morphology may also change. As an effect of this balance, sand often accumulates in two shoal areas – on the bay side and on the seaward side. These shoals are referred to as flood and ebb delta, respectively. Depending on the dominance of the wave processes versus the tidal currents, sediment deposition from cross shore and longshore varies spatially. Behaviour of inlets can have extremely significant environmental, social and economic impacts. Inlet migration and ebb channel shift causes erosion/accretion of sediments along and across the shore which may drastically change the beach profile temporarily or even permanently.

The present paper examines the inlet behaviour, in terms of the shifts in the inlet location over a span of last ten years, and its impact on the adjacent beach-dune complex. Valvati tidal inlet is observed to exhibit a strong instability in its location and is characterized by seasonal shifts in the ebb channel across the beach with a history of inlet migration. The zone of inlet shifts was demarcated and profiles were superimposed for three periods in order to understand the erosion/fill of the beach-dune complex. It was observed that the Beach-dune complex in the north was more stable and recorded less of variations whereas, the southern section of this complex (closer to the inlet) exhibited maximum variations. These variations were in terms of lowering of the dune crest and erosion on either side as well as formation of an extensive berm. The inlet throat deepened (in 2008) than the previous survey period (2004) by 3m and the channel appeared to have got stabilized temporarily. 2008 condition exhibited a tidal prism of $1.4 * 10^6$ m^3 as against a tidal prism of $1.2 * 10^6$ m^3 in 2002.

Keywords: Inlet, ebb channel, beach-dune, inlet migration

GULLY EROSION AND THEIR SPATIAL PATTERN ANALYSIS FOR GEOMORPHIC HAZARD EVALUATION USING GEO-INFORMATION TECHNIQUES

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The present study is aimed at evaluating geomorphic hazards in a famous ravenous tract of Lower Chambal Valley using remote sensing and GIS. A serious threat to marginal agricultural lands and constructed sites such as roads, bridges and settlements in Chambal Valley is due to the gully erosion. Gully erosion is amongst one of the major indicator for the evaluation of geomorphic hazards. Areal extent of gully erosion was measured using Indian Remote Sensing satellite images. Large-scale land degradation and the advancement of gully heads are clearly visible in the digital satellite images and the gully pixels are observed carefully for the study. Delineation of ravines and their spatial distribution was done by enhancing the images with that of PCA, histogram equalization and other image enhancing techniques. A visual classification was used in order to delineate the intensity of gully erosion on the satellite images. Areas with similar intensity of gully erosion process were delineated, distinguishing between areas with no visible signs of erosion and areas affected by gully erosion. It was observed that the areas affected initially by rill erosion have gradually become deep gullies. This increase in gully density is related to natural degradation of the soil. The characteristic features for gully development such as spatial patterns of ephemeral gullies, head-ward erosion and channel deepening etc have been considered. It is observed that the development of sharp edge and rounded edge ravenous lands are connected to slope steepness. The sharp edge ravines are formed due to the parallel retreat whereas the rounded edges gradually decrease the steepness. The intensity of erosion is observed more in rounded type ravenous areas. However the final result of the study is evaluation of the hazards in the area in the form of a risk map which clearly depicts the intensity of the erosion taking place in the area and The moderately eroded areas are more prone to become ravines in the near future. It is concluded from the study that Geo-information techniques helps adequately in the study of ephemeral gully and their spatial pattern for the evaluation of geomorphic hazards.

Keywords: Gully erosion, Geomorphic hazard, Histogram equlisation, ephemeral

HABITAT DYNAMICS OF COASTAL VEGETATIONS IN RESPONSE TO GEOMORPHOLOGICAL HAZARDS- A STUDY AT NORTHERN BAY OF BENGAL SHORELINES

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Habitat destruction caused by geomorphological hazards will alter the prospects of a wild range of highly valued resources including fisheries, open spaces, wildlife areas, nutrient cycling, buffering against the storms and flooding, and pollution trapping activities, aesthetic significance, and recreational opportunities along the coastal belts of the Bay of Bengal. The coastal landscapes that provide the various habitats for colony development of plants are affected by the endogenic (tectonic) and the exogenic (climate-driven) processes. The external parameters of the coastal landscapes changed by these two processes are supposed to be in equilibrium over a time span through the re-establishment of coastal system by a corresponding continuous change of the other parameters with process response signatures of morphology along the coast.

The tectonics and climate-driven processes are simply part and parcel of geomorphic systems that disturb the coastal habitats with their size and frequency of events in the coast. The present study shows that characterization diversity of habitats is produced by normal geomorphic evolution induced by hazard events over spatial and temporal scales.

The four study areas of the Bay of Bengal (Sandy shorelines of Orissa And West Bengal, Estuarine marsh of Nayachar island, Mangrove swamps of the Sundarban, Subarnarekha Delta, Bhitorkanika, and Hukitola Bay, and Andaman & Nicobar islands) are selected for the analysis of habitat dynamics of coastal vegetations in response to earthquakes, tsunamis, cyclones and storm surges. Some habitats are destroyed by erosion and repeated flooding, and others are modified by sudden changes of geomorphic systems with limited opportunities of plants to recolonise or limited capacities of plants to compete with other tolerant species in the changing environment under stress.

The true succession and zonation patterns of coastal vegetations are also absent in many habitats due to above reason. The study will provide the knowledge about how the physical aspects of coastal hazards can be used by man to formulate adjustments to the events in the coastal belt. The spatial aspects of vulnerability can also be approached by evaluating change in the position of coastal habitats through time.

COASTAL GEOMORPHIC SETUP OF KACHCHH COAST, WESTERN INDIA: IMPLICATIONS IN 'HUNTING' SITES FOR PALAEO-TSUNAMI DEPOSITS

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Geomorphology and coastal configuration plays a vital role during tsunami events as different coastal geomorphic units respond differently to a tsunami hazard. The study of ability of different coastal landforms to respond tsunami surge is equally important for Palaeo-tsunami studies. The Kachchh coast that runs for about more than 400 km has conspicuous presence of both, wave as well as tide influenced landforms. Based on their response to possible tsunami event and depending upon its action as facilitator, conveyor or accommodator, the geomorphic units could be short listed for a detailed investigation of geological material related to any palaeo-tsunami event. Based on its geomorphic assemblage three distinct segments have been identified along the Kachchh coast and are described for their possible response to tsunami event.

GEOHAZARD OF SAND STORMS IN SISTAN REGION OF IRAN

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Each year, several billion tons of soil dust is entrained from arid and semiarid regions and are causing economical, social and geological hazard. Sistan region in the south east of Iran is affected by the high wind velocity Bad-e-sad-o-bist roze that always blows from one direction and reaches a velocity over 120 Km an hour . Severe droughts in the past decades have caused drying of Hamun lakes and when Hamun lakes is dry, their beds become the source of atmospheric dust and seasonal winds blow fine sands off the exposed lake bed. The sand is swirled into huge dunes that may cover a hundred or more villages along the former lake shore. The satellite images and Ground measurement data was used to evaluate the effects of Dust storms Afghanistan, Pakistan and especially in the Sistan region of Iran. This study shows that the origin of dust storm is dry bed of Hamun Lake in Iran and Afghanistan and influence Iran, Afghanistan and Pakistan. The numbers of dusty days reach form 23 in 1997 that was wet year to 74 in 2000(dry year). The mean area affected by dust storms was 9000Km2 in normal years and 165000Km2 in drought years. Also this paper investigate the effect of sandstorm on agricultural land, roads and villages.

CHEMICAL HAZARDS IN THE COASTAL WATERS AT BAKKHALI, WEST BENGAL

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Luxuriant casuarinas bordered Bakkhali beach, an almost lonely beach round the year stood at the bosom of the Bay of Bengal in the extreme southern portion of South 24 Parganas district of West Bengal suffers water pollution as the analyzed Chemical Oxygen Demand (COD) value and Total dissolve solid (TDS) of the coastal water samples cross the permissible limit of water quality index. Spatial variations of some physicochemical properties of the coastal waters of Bay of Bengal at Bakkhali were measured. The mixing of river waters from Hugli flowing through Haldia industrial belt (basically Chemical detergents, batteries, petrochemicals and plastics) in coastal areas are the primary causes of nutrient enrichment, hypoxia, harmful algal blooms, toxic contamination, sedimentation and other problems that plague coastal waters of Bakkhali Beach.

GEOMORPHIC CONSEQUENCES DUE TO RISE IN SEA LEVEL ALONG THE .INDIAN COAST

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The coastal plains and deltaic coasts of India consist of a variety of landforms such as cliffs, bluffs, beaches, dunes, barrier islands, spits, estuaries, lagoons, deltas, salt marshes, mangroves, coral reefs and associated low lying islands. Most of these landforms have formed during periods of relatively stable sea level (the Holocene still stand) that came as a sequel to the world wide Late Quaternary marine transgression The shaping of the present coastal landforms are influenced by a range of morphogenic factors such as geology, coastal processes, human effects, and sea level rise. The sea level rise has been considered as the major cause for coastal retreat in the recent time (Zhang 1988, Vellinga and Leatherman, 1989). The impact of sea level rise on coastal geomorphology, which is felt world over, is phenomenal in the form of beach and dune erosion, barrier erosion and or translation on to back barrier morphology, widening and deepening of tidal inlets and estuaries and elimination several transitional morphologies.

Several segments of the Indian coast, which runs over 7500 km, are found to be eroding or getting modified in accordance with the rising sea level condition. Due to rise in sea level the foreshore beach becomes very steep or resembles like a vertical cliff, the nearshore water depth and wave height increase, waves plunges more close to the beach causing sever erosion of the beach Thus a dissipative beach sooner or latter transforms into a reflective beach (coasts of Mumbai, Cochin, Kanyakumari, Cuddalore, Pondicherry etc). As a result the entire beach is subjected to severe erosion and at times total loss of beach sediments and the associated morphology as witnessed along the Cochin coast. In barrier coasts, breaching may convert the barriers into spits with the formation of intervening tidal entrance. Along wave dominated coasts large scale transport of sediments alongshore lead migration of the spit upcurrent side (eg. The Chilka lagoon spit). Narrowing of the tidal inlet may clog the tidal entrance of the lagoon. Rising sea level leads to the frequent formation of overwash deposits which may fill the back barrier lagoon or estuary (Kodiyampalayam lagoon, north of Coleroon, northern Vembanad estuary) or may encroach onto the fringing mangrove swamps behind the barriers. Along tide dominated coast the intertidal flats and the associated fauna and flora may be submerged. The tidally occupied area in Sunderban comprises of 4267 km^2 of which the tidal and inter tidal mangrove forest is estimated as 2300 km^2, the water area 1750 km^2 and the rest are river banks, beaches and open forest land. Sea level rise will erode many of the islands and submergence of low lying intertidal flats which means that the water spread area will be increased at the expense of tidal landforms. Dune migration landward in another geomorphic impact where agricultural activities are practiced.

ASSESSMENT OF COASTAL CHANGE HAZARDS AND THEIR MAPPING AT MAINLAND COAST OF TALSARI AND BARRIER SPIT COAST OF MONDERMONI, W.B., INDIA.

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The beach – dune morphology of sandy alluvium coast along the Bay of Bengal shoreline is rapidly changing due to storm characteristics, elevation of the shoreline and various human activities at present. The wide sea beach and beach-fringed dune belt of Talsari barrier & mainland coast and Mondermoni-Silampur barrier coast had acted as natural barrier against the tidal waves and storm surges in the past. By considering the magnitude of wave run-up, the highest reach of the waves on the beach, relative to coastal elevation, a new scale has been developed that categorizes net erosion and accretion during storms. Different impact regimes (swash regime, collision regime, over wash regime, and inundation regime), their morphologic responses and greater potential hazards have been estimated for mapping geomorphological changes along the coastline.

Reclamation of pre-mature tidal floodplains of the low lying coastal plain (behind the dune belt), reduction of tidal prisms and temporary flood spill grounds, and recreational uses of shore fringed sand dunes are major human activities that influences the magnitude of coastal changes along the Bay of Bengal shoreline at present. The older records of the shoreline characters are also compared with satellite images (IRS-1D LISS-III (2002) and (LANDSAT-TM & ETM+ of temporal variations) of the same area to record the present day coastal change.

COASTAL TSUNAMI GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL IMPRINTS ON KANYAKUMARI COASTS, TAMIL NADU

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Coastal geomorphology of Kanyakumari has revealed the geomorphology consistent with tsunami inundation. It is consisting of dune pedestals, parabolic dune systems, hummoclay topography and changes in nearshore sediment budget. The most prominent features are erosion and boulders/gravels. They are well marked in the affected area. This type of features formed by a tsunami, has indicated the ability to understand and detect the tsunami geomorphology, hinges on the interaction between sand availability, nature of the coast, accumulation space and landward environmental conditions. At most locations, the destruction is mainly attributable to the shipping away of the soil surface as well as to the effects of saline water. Significant and widespread change in the coastal land landscapes are prominent an include destruction properties. Most affected areas of the coastline were flooded up tsunami run up values between 1.5 M and 3 M where as the run up was 10 meters coastal retreat, multiple sets of ephemeral erosional cliffs and lowered dark sandy soil ground surface due to erosion were observable.

IMPACT OF 26TH DECEMBER 2004 TSUNAMI ON THE PICHAVARAM MANGROVE ECOSYSTEM, SOUTHEASTERN INDIA

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The 26 December 2004-Tsunami has deposited sediments in the Pichavaram mangrove ecosystem (latitude 11°23 - 11°30 N and longitude 79°45 - 79°50' E), east coast of India. Twelve water samples, ten surface and three core sediment samples were collected within thirty days of the event to evaluate the impact of tsunami on nutrients and heavy metal distribution in Pichavaram mangrove ecosystem. The sampling locations were divided in three parts; Vellar estuary region, dense mangrove forest region and Coleroon estuary region. The chemical analyses of water and sediments samples were carried out by various standard protocols. The retreating water of tsunami played an important role in changing the nutrient concentration in water as well as in the sediment. An increase in the concentration of various nutrients namely nitrate and phosphate was observed in mangrove water. Further the sediment column was disturbed due to energetic tsunami waves, which has caused a sheer increase in the dissolved oxygen in water. As a result, the change in the redox potential has resulted in change in the nutrients absorbed/associated with the sediments. The high concentrations of Cd, Cu, Cr, Pb, and Ni were observed in the tsunamigenic sediments. With respect to Fe, Zn, and Mn, there was little variation as compared to pre-tsunami values. The geo accumulation index was calculated in order to assess the contamination of heavy metals in the sediments. The sediments were extremely contaminated with respect to Cd and they showed moderate to strong contamination with respect to Cr, Pb and Ni. The study highlighted the risk of metal pollution in the ecosystem in the mangrove ecosystem with due course of time.

DETERMINATION OF SEAWATER INTRUSION HAZARDS BY GEO-CHEMICAL ANALYSIS OF GROUNDWATER

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A nonlinear three-dimensional model is developed to simulate the effect of groundwater pumping along west coasts of Peninsular Malaysia. A geo-chemical analysis is performed based on the hypothesis developed in the research to identify seawater intrusion hazards. These results are then compared with that of numerical simulation of groundwater flow in the region. Numerical simulations based on a natural river channel indicate that explicitly modeling local obstructions/boundaries can significantly impact predicted flow parameters. If the abstraction of groundwater is continued and become over-exploited, groundwater level would get lower, and finally the interface between fresh and saltwater could gradually move inland. The hazard is not only in movement of the interface, but also in baneful influence on crops predicted and hence affecting the groundwater quality. A numerical model is developed for different steady state scenarios and for each scenario the effect of ground water flow is observed. A case study on historical groundwater levels at confined and semi-confined aquifers of river basin situated along west coast of Malaysia, showing a long-term fluctuation is chosen for study. The presence of obstruction creates velocity gradients, transverse flow and other hydro-geologically important flow features that are not reproduced by incorporating the geometry of the basin into the hydrologic model. The most effective form of flow model resulted when the data are fit to the model systematically. The calibrated model can be used to predict future groundwater heads in the confined aquifer in the year 2020 with an estimated increase in pumping. These type of studies are useful for better hazard identification for seawater intrusion and for better water resource management. Further the hypothesis developed can extended to test with other coastal regions.

Keywords: Groundwater resource, coastal hazards, numerical equations, hydraulic simulation, groundwater pumping, seawater intrusion and groundwater aquifers.

DEVELOPMENT OF COASTAL WEB-GIS FOR SOUTHERN COASTAL TAMIL NADU OF INDIA BY USING ARCIMS SERVER TECHNOLOGY

P. Sheik Mujabar and N. Chandrasekar

There is a need for a wider dissemination of knowledge relevant to the importance of coastal and marine areas to the world's well-being, sustainable development, environmental safety and a reevaluation of societies. There are multi-interest groups in the coastal zone and each group has its own area of interest and aspects of coastal environment, be it the shipping and harbors facilities, fisheries, developmental projects, sand and mineral mining, military maneuvers, recreation and conservation. The web based coastal GIS can provide all these specific requirements required by these multi-interest groups.

This paper presents the information on the implication and development of web-based coastal GIS (STNCOAST-GIS, www.geotechmsu.co.cc**)** for analysing the dynamics of coastal landform features along the southern coastal Tamil Nadu of India by using ArcIMS server technology. It also deals with the concept, architecture and advantages of ArcIMS technology. The integration of spatial and non-spatial database for the study area has been discussed. The effective dissemination of geospatial information and the findings of the recent researches on the southern coastal Tamil Nadu have been visualised through the web based coastal-GIS developed by using the ArcIMS. The web-GIS for the study area have wide applications in the field of geology, coastal zone management and developmental projects. It provides the up-to date information and dynamics of the various coastal landform features. It also provides the land-use and land-cover mapping of the study area. Thus the developed web based coastal GIS is very useful for the coastal planers, engineers and policy makers to plan various developmental projects in sustainable environmental way.

Key Words: WebGIS, Server GIS, Shoreline changes, Coastal erosion, STNCOAST-GIS.

Landslide/Tectonic/ Earthquake/Volcanic/ Mountain Geomorphology and Hazards

GEOMORPHIC HAZARDS OF UTTARKASHI TOWN- A CASE STUDY OF VARUNAVAT MOUNTAIN

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Present paper is concerned with the Geomorphic Hazards of Uttarkashi town- A Case Study of Varunavat hills. The Central Himalayan belt of Garhwal is geologically very young and seismically highly active. The diverse ecosystems, that it supports, are fragile and even small disturbance can trigger changes that rapidly assume dimensions of a disaster.Commonly occurring landslides, earthquakes, flash floods, forest fires, avalanche and other natural hazards have been causing extensive damage in the Himalayan region during the past few decades.This author has adopted the modern methodology and intensive fieldwork and the work has dependent on the advanced techniques of application of geomorphic tools particularly topographical maps (53 J/6), air photographs, landsat imagery (LISS III and LISS IV Images), and geographical softwares like Erdas, Arc View, Arc GIS, Map Info, Surfer and other related softwares.

The Uttarkashi town (30°43'N-30°45'N and 78°25' – 78°30'E) has a long history of witnessing various types of disasters. The lower portion of town was severely damaged in the year 1978 due to formation of a temporary lake in Kanaudiya Gad (a tributary of Bhagirathi river) and subsequently breaching of the lake which lead to sudden surge of flash flood in the Bhagirathi River. In October 1991 an earthquake rocked the town and caused colossal loss to life and property, subsequently 1999 Chamoli earthquake also effect the town.The Varunavat landslide has been classified as a classical example of debris slide (debris slide in the crown portion, and rockfall and rockslide in the middle part). Both natural and human-induced factors are responsible for this slide.This landslide complex was triggered due to the incessant rainfall prior to the event, and its occurrence led to the blockage of the pilgrim route to Gangotri.This landslide has affected more than 5000 people, damaged buildings, and roads, chocked up sewage and drainage line, disrupted transport or communications network and affected drinking water, electricity supply etc.

The rocks found in the landslide-affected area of Varunavat Parvat comprise thinly bedded quartzites and phyllites which are highly weathered, jointed and fractured. Varunavat Parvat along three transportation tracts and accumulated in three different accumulation zones respectively. These zones are locally named as Tambakhani zone, Ramlila ground zone and Horticultural and Jal Nigam zone.Out of these 3 accumulation zones, the Ramlila ground zone is the most prominent.The landslide has deposited at the foothill, a huge quantity of debris, which caused a huge loss of property. A large number of buildings were severely damaged. Recently constructed hotels and tourist lodges, which existed even after the landslide was triggered, were completely buried later under the debris. The debris has also buried the Uttarkashi–Gangotri National Highway-108, affecting about a kilometre stretch. It was reported by the district administration that about 362 dwelling houses were completely ruined by this landslide. Landslides are one of the most common natural hazards in the Himalayan terrain, causing widespread damage to property and infrastructure, besides loss of human lives almost every year. Appropriate management measures taken at the right time will reduce the risk from potential landslides.

GEOMORPHOLOGICAL HAZARDS IN RESPONSE TO TECTONICALLY ACTIVE PARE (DIKRONG) BASIN, ARUNACHAL PRADESH, INDIA

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The Pare (Dikrong) basin is bounded by the two regional thrust faults the Main Boundary Fault (MBF) and the Himalayan Frontal Fault (HFF). The Pare (Dikrong) river flows in the E-W orientation its course is deflected at MBT and then it follows NNE-SSW orientation. The Pare (Dikrong) river and its tributaries, Pachin, Senkhi, Chimpu and Dokhoso form the main network of the Pare (Dikrong) basin. The total basin area (A) is 1279.48 sq.km. The drainage density (Cd) is 2.957 km /sq.km.. The SL Index (▲H/▲L) * L) shows high SL values in the areas covered by the proterozoic gneisses and schists and anomalously low SLvalues in the area covered by gondwanas and the siwaliks lying south of the Main Boundary Fault (MBF). The longitudinal profile of Pare (Dikrong) however indicates long term balance between uplift and incision but the profiles of Senkhi, Dokhoso and Papu indicates dominance of incision over uplift while Dete and Niorchi show profile convexity suggesting rock uplift is dominant. Geomorphic indices of active tectonics such as Basin elongation ratio (Re) is 0.44, Topographic symmetry factor (T) ranges from 0.43 -0.51and the Asymmetry factor (AF) in the Pare (Dikrong) basin is 62. Further, the Ratio of valley floor width to valley height parameter (Vf) is 0.0055 – 0.4152 and Mountain Front Sinuosity (Smf) in the two segments is 1.38 and 1.53 points to active tectonic activity in the basin. The imprints of valley incision and uplift are well preserved by the disposition of terraces with respect to brahmaputra alluvium in the present landscape. Movements along fault caused ponding of a first order stream of budhibeta locally known as Gekar-Sinyi or Ganga Lake. Due to rapid urbanization in the senkhi, chimpu, pachin and pare (Dikrong) valley, drainages are blocked for construction of buildings etc. Further, the situation is worsened as natural slopes are being intercepted and many buildings are being constructed. This human interference is causing frequent landslides during rainy seasons in the tectonically active Pare (Dikrong) basin. The present paper discusses the active tectonic indices and geomorphic hazards in the Pare (Dikrong) basin.

Keywords: Geomorphic indices, active tectonics, valley incision, uplift, geomorphic hazards.

CAUSATIVE FACTORS FOR HIGH MOUNTAIN HAZARDS: CASE STUDY FROM ZANSKAR VALLEY, LADAKH, INDIA

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Zanskar valley covers an area of some 7000 km^2 and spreads between the altitudinal range of 3500 and 7000 m amsl. Zanskar valley is drained by two major tributaries of Zanskar river, namely Doda river and Lungnak river. Zanskar river flows northeast to join Indus river near Leh. Zanskar valley is studded with eleven major glaciers, namely Durung Drung, Haptal, Haskira, Kange, Hagshu, Sumcha, Lechan, Denya, Mulang, Yaranchu, and Gompi covering an area of 1098 km^2 . The summer snowline (ELA) rises transversely from SW to NE but is slightly lower on NE than on SW side. Accordingly, the ELA is above 5800m on the south but at 5500m on the north.The present-day climate of Zanskar valley is arid to semi-arid. The mean temperature during summer ranges between 32.0^{o}C and 16.0 ^{o}C, whereas the mean temperature during winters ranges between -17.5 ^{o}C and -40.0^{o}C. The seasonal precipitation between November and April ranges between 793cm and 1055cm.

Zanskar valley represents dominance of glacial landforms suggesting that the entire valley in geological past was under the cover of glacier and present day glaciers are remnant of the erstwhile glaciers. The Zanskar valley commences from Pensi La pass situated on an altitude of 4400m asl. The valley is enclosed on three sides by lofty ridges, Pensi La pass and Durung Drung glacier in the northwest; Mulung, Haptal, Shimling glaciers and Umasila Pass in the west, south and southwest; and Tanglangla Pass in the east and Stod river in the north. The relative relief of main valley is rarely less than 2500m, even the tributaries have an elevation difference of 2000m in a horizontal distance of 2 to 4 kms.

Walls of the Zanskar valley are covered with rills, gullies and mud channels. Massive debris slope covered with scree gradually merge with fans, low terraces, valley fills and channel gravels on the floor of valley. The magnitude of relief, steepness of slopes and debris accumulation causes the instability of slope, mass movement and thus trigger catastrophic events that are accentuated by the arid environment of the region.

The solar and gravitational energy are responsible to major exogenic processes related to glacier sliding, processes of permafrost and mass movement, fluvial, glacio-nival processes. The processes occur at varying rate at various level of spatial resolution. On account of this, much of the present character of the topography is polygenetic composed of elements produced by glacial, periglacial and glacio-fluvial in geological past. The glacial and periglacial agencies produce frost shattering and frost heaving processes that supply the raw material to glacier for erosion and subsequent deposition. Nival processes play a major role in shaping the landscape by way of generating certain micro-climatic processes leading to the weathering. Majority of high altitude zone along with the valley slopes are subjected to extreme low temperature for the major part of the year. The water freezes in the cracks and also within the soils of valley walls and are subjected to intense stress due to high diurnal temperature. This results in cryostatic pressure that increases as temperature falls below -25^{0}C. Mass wasting is the major degradation category found along the valley slopes. It is primarily an outcome of slope failure and slope gullies. The mass wasting move rapidly to river channels as mud flow and debris flow that contribute to siltation problem.

The intense climatic conditions are largely responsible for the degradation of landscape in Zanskar region.

SOIL EROSION AND ITS MANAGEMENT: A CASE STUDY OF GARHBETA BADLAND, WEST BENGAL

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Soil erosion is one of the major hazards in the countries located in humid tropics. The present case-study deals with the causes, consequences and mitigation practices in a badland area of West Bengal, India. The principal objectives of the study is to find out the rate of erosion and badland extension, to identify the causes and processes of soil erosion and to suggest some effective management practices.

The methodology includes collection of data and information on physiographic characteristics from existing maps, photographs and literatures; collection of meteorological data; field survey by abney's level, clinometer and GPS as well as soil sample collection and analysis. Monitoring the rate or status of erosion of the study area is attempted by comparing maps and images of 1930–2005 apart from measuring annual gully headwall retreat and gully fan extension rates during 2001–2009

The studied badland area, locally known as *Ganganir Danga*, is located in West Medinipur district of West Bengal, India. The badland covers an area of 1.66 km^2 in a Pleistocene laterite upland having a thick mantle of duricrust, experiencing sub-humid monsoon type climate with temperature range of and 9°C–45°C and average rainfall of 140 cm. The surface soil is loose and dry, with the presence of pisoliths and has no fertility. Vegetation type of the area is mixed deciduous.

The study area is suffering soil erosion problem due to rapid growth and development of gully network and extension of badland. Causes of soil erosion include: presence of easily erodible materials in the surface and low infiltration rate; soil unsuitable for vegetation growth besides presence of wide and deep gully network with high slope. Geomorphic processes responsible for erosion include *surface processes* like slumping and rainsplash, sheet, rill and gully erosion, and *sub-surface processes* like piping.

To prevent soil erosion from the area, local self government and soil conservation department launched afforestation programmes but they failed due to unscientific plantation. Recently the forest department started constructing check dams in some selected gully channels on trial basis. A large dam with reservoir was constructed here on the main gully channel of the western gully network. Various field trials were conducted for soil erosion control and establishment of vegetation cover using jute-geo-textiles since1999. The jute fabric was seen to reduce the velocity of runoff, moderate soil temperature and conserve moisture in the soil. It also stimulated rapid root development, lead to development of soil and contributed to good soil health through decomposing mulch. All these promoted vegetation cover which, in turn, prevent soil loss.

A STUDY ON LANDSLIDE HAZARD PRONE AREAS IN GUWAHATI CITY, ASSAM, INDIA

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The incidence of hazard caused by landslide has been on the increase in recent times. It stands in the path of wholesome sustainable development of a region. In order to fulfill the objective of new development and other urban facilities and efficient use of resources there is need for zoning of activities compatible with geological formations, land use, geomorphic and geotechnical factor etc. A study undertaken to investigate the impact of these factors on landslide prone areas Guwahati city revealed that with the growth of population from 1, 23,799 persons in 1971 to more than 20 lakh in 2010, there has been acute shortage of suitable area for settlement in the plain region. Guwahati, the capital city of Assam, dotted with 18 hills composed of highly weathered Precambrian Granite & Gneissic rocks is expanding in an unplanned manner with the rapid growth of population. The settlement areas expanded to the hilly terrains irrespective of its vulnerability are getting prone to landslide hazards. It has become a recurring and menacing problem, as the thick weathered mantle overlying the massive crystalline rocks are highly susceptible to pore water pressure during rainy season. Further, toe cutting on the steep hill slopes for construction of dwelling houses, roads and resultant loss of the vegetation cover and seismicity, rock quarrying etc aggravate the situation. The hazard caused by landslide in the city area although not alarming may lead to disastrous situation if present scenario of slope instability continues. For the measures of mitigation of the problem landslide, it can be suggested that instead of adopting single measure or two, a package of landslide adoption technique will protect the hill slopes to a great extent.

Key Words: Landslide, hazard, slope instability, mitigation.

THE STUDY OF DEVASTATING LANDSLIDES OCCURRED ON MAY 26 AND 27, 2009 FOLLOWING THE CYCLONE AILA IN THE DARJEELING TOWN, WEST BENGAL, INDIA.

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A heavy downpour of 465 mm within 48 hours (which is equivalent to nearly 12 days' rainfall in the rainiest month i.e. July) was the cause for several ruinous landslides claiming 7 lives and huge property in the Darjeeling town on 26th and 27th May, 2009 triggered by the cyclone Aila. The present paper deals with the detailed investigation of two such most destructive ones occurred at Frimal Village and Haridas Hatta in the Darjeeling town.

In the Frimal Village landslide recurred five times on a single spot within a period of 18 hours completely demolishing 22 houses below and three safety tanks within the slide itself. No casualty was recorded except huge loss of property. But in the Haridas Hatta landslide occurred only one time with high vigor partially damaging a house at the lower level and claimed seven lives.

It has been found that reckless construction of multi storied buildings, unmanaged building and community outlets, bare soil surface on the steep slopes and the old tea plants incapable of holding soil were the prime causes of such devastation.

EARTHQUAKE POTENTIAL REGIONS IN NORTHEASTERN INDIA USING PATTERN INFORMATICS METHOD

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Northeastern India is seismically one of the most active regions of the world. The study region is demarcated as zone V, highest level of earthquake hazard potential in the seismic zoning map of India and high seismic risk with peak ground acceleration of 0.35-0.4. About 20 large earthquakes (M > 7.0) including two great earthquakes 1897 Shillong Earthquake and 1950 Assam Earthquake (M > 8.7) occurred in this region during the last 112 years from 1897 to 2009. A uniform earthquake catalog from various sources is prepared for the period 1897 to 2009 for the seismicity analysis of the study region (20ºN-31ºN latitudes and 80ºE-97ºE longitudes). Out of the most devastating natural hazards Hurricanes can be tracked, floods develop gradually, and volcanic eruptions are preceded by variety phenomena. However, earthquakes are the most destructive natural phenomena occur without any warning. It is impossible to prevent earthquakes from occurring. However, it is possible to make probabilistic seismic hazard assessments for earthquake risk: to reduce loss of life, injuries and damages.

In the present study we applied a new approach for the forecasting of major earthquakes based on pattern informatics method in the Northeastern India, which quantifies temporal variations in sesismicity. This technique does not predict the exact time and location of earthquakes, but it does forecast the regions (hotspots) where earthquakes are mostly like to occur in the relative near future. The main objective of this paper is to analyze the historical seismicity for anomalous behavior, which would provide information on the occurrence of future earthquakes and reduce the earthquake risk areas relative to these given by long term hazard assessment. This method has been successfully applied to California, to Japan and on a worldwide basis. We have constructed two type of retrospective binary forecasting for Northeastern India. The first one is Pattern informatics (PI) method and other one is relative intensity (RI) method. The PI method performs better than the RI method under more circumstances. Our approach divides the seismogenic region to be studied into a grid of square boxes whose size is related to the magnitude of the earthquakes to be forecast. The result gives a regional seismogenic map where earthquakes are likely to occur during a specified period in the future.

Key Words: Pattern Informatics, Seismic Hazard Assessment, Relative Intensity, Northeastern India

LANDSLIDES ANALYSIS USING SCAR GEOMETRY IN WESTERN GHAT REGION OF AHMEDNAGAR DISTRICT, MAHARARASHTRA

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Landslides play role in weathering and transport processes on the slope faces. They cause exposure of subsurface material to various sub-aerial processes. They also provide enormous loose debris material in the sediment flux system. In many cases landslide geometry is studied to understand various aspects of landslide hazard but after landslide events, data related to landslide geometry does not become available. To overcome such problems, it was thought to study the geometry of landslide scar. With the help of geometry of original slope and geometry of landslide scar, the volume of detached debris material from the original slope is calculated. Geometry of scar is also used to know the input of material in sediment flux. Based on landslide scar geometry an attempt is made to understand the landsliding process and to identify similar such sites where huge amount of debris material will be formed after landslide event. This information will be helpful to understand the intensity of landslide hazards and hazard mitigation in landslide prone areas. After study it was found that in the study area most of the landslides are triggered by heavy rainfall in monsoon season. It is also said that highly weathered rock and particular angle of slope with sufficient amount of water supply through streams are the factors which favour the movement of material. This generates enormous amount of material to be carried out through surface wash process.

LANDSLIDE SUSEPTABILITY MAPPING IN HIGH LAND REGION USING SPATIAL DATA ANALYSIS TECHNIQUES

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Landslides occur in large variety of forms depending on the type and speed of movements, the material involved and the triggering mechanism. The study area is Idukki District of Kerala with highly undulating terrain along with steep slopes. A spatial database was constructed from topographic maps, geology and land cover. The factors that influence landslide occurrence, such as slope, aspect, curvature, distance from drainage and terrain mapping unit were calculated from the topographic database. Lithology was calculated from the geology database. Land cover was classified from IRS LISS III satellite imagery. Weighted and frequency ratio models are done for the preparation of landslide hazard zonation mapping and the two methods are compared statistically. Numerical weights for different categories of these factors were determined based on a statistical approach and then integrated in GIS environment to arrive at landslide susceptibility map of the area. The landslide susceptibility map classifies the area into five classes of landslide susceptible zones viz. very high, high, moderate, low and very low. An attempt was also made to validate the map with the existing landslides of the area. The final result is used for the planning and implementation of land resource conservation strategies in the area.

LANDSLIDES ALONG WESTERN HIMALAYAS: AN ENVIRONMENTAL PERSPECTIVE

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Mountains play catalystic role in the whole range of denudation processes. The geology, climate, Undulating topography, steep slope, and anthropogenic impact contribute to the prevalence of landslides. The ubiquitous steep slopes resulting from tectonic forces provide abundant locations for landslide occurrence. Landslides are an integrate of relief, climate, nature's turbulence, calm and quite processes and sources of rivers.

The landslides represent spontaneous rapid mass movements on the slopes. This phenomenon evidently involves three distinct processes: The triggering the motion itself and the long range end, which can be landscape forming. In the possible mechanical causes of landslides, one has to distinguish between the long range and immediate effects. These are the part and parcel of the normal long ranges landscape development: The ongoing endogenic uplift has to be compensated by down hill mass movements.

Landslides are part and parcel of the normal long range landscape development: "the ongoing endogenic uplift has to be compensated by down hill mass –movements. Furthermore, the neo-tectonic forces redesign the future failure surfaces, so that the orientation of the slides is quite in conformity with the orientation of the neo-tectonic stress filed (Scheidegger and Ai 1986, Ire and Mio 1987).

Nevertheless, the fact remains the slides occur on the slopes have been stable for the long time, sometimes for many thousand of years. Thus, if a slide occurs, there must have been an agent, which caused a decreased of the stability of the slope, so as to make it collapse. In every landslide there must therefore be a direct mechanical cause. A good review of the possible mechanical causes has been given by Tezoghi (1950).

The present paper is an attempt to distinguish between external and internal causes of slides. The external causes create an increase of the shearing stresses in the slope, which include the undercutting of the slope by a river, the effect of an earthquake shock and the deposition of the material at the upper edge of the slope due to anthropogenic influences.

LANDSLIDE HAZARD ZONATION MAPPING IN PINDAR BASIN, UTTARAKHAND HIMALAYA

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Pindar Basin which extends form 29^0 59'N to 30^0 21′ N Latitude and 79^0 29'E to 80^0 5'E Longitude covering the area of 1856.56 $Km^{2.}$ Feeding Population of 24554, residing in different Land form of glacial, glacio fluvial and fluvial. It represents the eastern past of the Garhwal Himalaya with elevation ranging between 800 m to 6800 m. River Pindar originates from the 'Pindari Glacier' in district Bageshwar (32 Km) and flowing an approximate 124 Km with its numerous tributaries. Confluences in to the Alaknanda River at Karnprayag in district Chamoli. The watersheds of the Ram Ganga in the South, the Saryu in the east, the Nandakini in the North and the Alaknanda in the North West delimit it giving it a distinct Socio-geographical identity.

The study area comprises part of Chamoli & Bageshwar District covering from block Karnparyaga, Tharali, Dewal, Narayan Bagar, Kapkot only (22) villages and Gairsain only (72) villages. The Pinder Basin covers a variety of physical Landscape develop under the complex action of denudation processes guided by varied lithological complexes.

Landslide is the most universal mass wasting geomorphic process in the mountain region. Isolated cases of landslide of varying dimension usually reported in Pindar basin during the monsoon rain every year. Such landslide activities normally interrupt vehicular traffic along Karnparyag to Deval road at least 4-6 times each year. The Paper is an attempt to describe various aspects of landslide in the valley including vulnerability related to transformed topography, sliding material, structural features, and anthropogenic activity. Pindar River originates from the Pindari Glacier in district Bageshwar and traverses almost 124 km before meeting with Alaknanda at Karanprayag in Chamoli district. It represents the eastern part of the Garhwal Himalaya with elevation ranging between 800 m to 6800 m. The watershed of the Ram Ganga in the South, the Saryu in the east, the Nandakini in the North and the Alaknanda in the North West delimit it and gives it a distinct socio-geographical identity. The nature of slope is very steep ranging from 20^0 to 60^0. Mostly the landslides are caused either by Natural Phenomenon or Human Induced activities

A landslide database is completed during the fieldwork. The database contain a record of landslide events covering site characteristics, estimated dimensions, predominant type of materials and movement, damage caused by the slide and landuse characteristic. Landslide analysis includes distribution density, exposure, landslide loss and landslide susceptibility.

The basin is tectonically active and falls under the severe seismic zone V. The situation is grim in the area and it has repeated history of huge lose of life and property due to landslide, This paper also describes the ground situation permanent landslide prone area along karnprayag – Deval road to drive home, the necessity, usefulness and economics of long term solution to a vexed problem.

LANDSLIDE SUSCEPTIBILITY ZONATION OF THE KURSEONG SUBDIVISION OF DARJILING HIMALAYAS USING RS AND GIS TECHNIQUES

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Landslide and soil erosion are the most disastrous phenomena in the Kurseong subdivision of Darjeeling Himalayas. Landslide Susceptibility Zonation is important to take quick and safe mitigation measures and to make strategic planning for the future. The main objective of the present paper is to prepare landslide susceptibility of the study area using RS and GIS techniques. For preparing such map various thematic 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. Different classes of thematic layers were assigned the corresponding rating value as attribute information in the GIS and an ‘‘attribute map’’ was generated for each data layer. Each class within a thematic layer was assigned an ordinal rating from 0 to 9. Summation of these attribute maps were then multiplied by the corresponding weights to yield the Landslide Susceptibility Index (LHI) for each cell. Finally a LSZ map was prepared showing the five zones, namely, very low hazard, low hazard, moderate hazard, high hazard and very high hazard zones. The ‘moderate susceptibility zone’ possesses the highest number of landslide events (35).

Key Words: Landslide, attribute map, LSZ

ACTIVE VOLCANOES GUIDED TSUNAMI GENERATIONS IN ISLAND ARC REGIONS OF ANDAMAN – INDONESIA : A TECTONIC TSUNAMIGENIC MODEL

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The Indian Ocean Tsunami of Northern Sumatra Great Earthquake disastrous event (Mw 9.3) on 26th December 2004, had initiated release of trains of aftershocks in different directions. The above events resulted in explosions of series of Volcanoes of Andaman and Indonesian Island Arc Belt. After the Tsunamigenic Northern Sumatra Great Earthquake of 2004, consecutive many Tsunamigenerations were formed from the following regions viz

1. West coast of Northern Sumatra (M 8.7) at quadruplicate junction of Australia, India, Burma and Sunda plates on 28th March 2005;
2. South of Jakarta, Indonesia between Australian plate and Sunda Plate on 17th July 2006; and
3. South Sumatra M 8.2 on 12th September 2007.

Similarly, the Great Indian Ocean Tsunami event of 2004 and its aftershocks have also resulted in an additional pressure at specific locations in Andaman-Indonesian Island Arc system and finally a series of Volcanoes were erupted as follows viz

1. Barren Volcano of Andaman on May 2005;
2. Talong Volcano of Northwestern Sumatra on 12th April 2005;
3. Merpai Volcano of Jawa on 14th April 2006 and

Batutara Volcano of East Indies on 1st July 2006. On considering the near past seismic and volcanic active scenario of Andaman and Indonesia Arc region it look more possible for earthquake triggered volcanoes and eruptive volcanoes controlled tsunmigenic earthquakes. Based on the sites of Tsunamigenic earthquakes, locations of activated Volcanoes, Movement directions of harmonic seismic tremors of each Tsunaigenic earthquakes, Migrations of Magma and fluctuations in the levels of Curie Isotherm Depths of the Island Arc-regions are utilized to bring out a tectonic tsunamigenic model.

Hazard Zonation Mapping/ Anthropogenic Impacts

ANTHROPOGENIC IMPACT ON GEOMORPHIC HAZARDS AND ITS PREVENTION THROUGH – ECO SOLUTIONS

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Geomorphic hazards such as Volcanic eruptions, Earthquakes, tsunamis, Landslides, avalanches, Floods, Desertification and Droughts which is being experienced at many locations, is a problem of global scale. These changes will significantly increasing the level of uncertainty of ecological and economical conditions, undermining the forecasts for growth and development and thereby threatening global prosperity. Recent climate models and results from extensive scientific research show that the impacts of climate change are likely to be serious. It is extremely probable that the anthropogenic greenhouse gas emissions play a significant role in this process. In the course of the last two decades, it has become clear from the measured evidence that the carbon dioxide concentration in the atmosphere has significantly increased since the early nineteenth century. There is strong evidence that increase in carbon dioxide concentration could be, due to the greenhouse gas effect, a cause for the significant global warming and in the coming decades. The Rio Earth Summit in 1992 witnessed the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) which agreed to stabilize emissions of Greenhouse gases at 1990 levels by the year 2000, in an attempt to mitigate the threat of Global warming. Following this, a historic agreement to actually cut Green House Gas (GHG) emissions was arrived in December 1997 in Kyoto, Japan, at the third Conference of Parties to the UNFCCC. Industrialized nations agreed to reduce their collective emissions of greenhouse gases by 5.2% from 1990 levels in the period 2008 to 2012. Crucially, the Kyoto Protocol committed developed countries in their GHG emissions. The Clean Development Mechanism (CDM), one of the cooperative mechanisms established under the Kyoto Protocol, has the potential to assist developing countries in achieving sustainable development and reduce the impact of geomorphic hazards by promoting environmentally friendly investment. This paper describes an Overview of the CDM's background, structure, and project cycle, and examines the potential value and benefits for reducing anthropogenic impact on geomorphic hazards. It also suggests steps for developing a national CDM strategy and provides examples of CDM projects. This paper also deals with the efforts in this direction and status of CDM in India

Keywords: Disaster, Clean Development Mechanisms, Climate change, Geomorphic hazard, Sustainability.

HUMAN ADJUSTMENT TO SAND DRIFT AND SAND DUNES MOVEMENTS IN THE EASTERN PROVINCE OF SAUDI ARABIA

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Sand dunes and sand sheets cover extensive areas of the eastern province of Saudi Arabia. The northern part of the study area is the main source of sand that forms the sand sheets and sand dunes in rest of the region. The wind regime, local topography, and geological structures play a major role in Aeolian sand dynamic in the region. Sand drift and sand dunes movement is one of the serious natural hazards which cause damage for human property. For this reason Sand drift and Sand dunes movements are one of the main problems facing the human activities in the eastern province of Saudi Arabia. Most of human properties (cultivated land, cities, industrial cities, villages, road construction, railroad, and oil plants, irrigation and drainage canal) in the area are threatened by sand drift and sand dunes movements. In Saudi Arabia adjustment to this hazard is usually the work of both individuals, and government. The Saudi Arabia government has spent large sums of money to reduce the impact of this hazard.

The main purpose of this study is to evaluate the human adjustments methods to sand drift and sand dunes movement hazard in the eastern province of Saudi Arabia.

HAZARD ZONATION MAPPING OF VILLAGE DEVBAG, COASTAL MAHARASHTRA (INDIA)

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India is most severely affected by natural disasters particularly floods and storm surges. The frequency and intensity of these disasters will further increase due to climate change. About 20% of the Indian population living along its coastline of over 7500 km. are highly vulnerable to these disasters.

Devbag (15°57' to 16°1' N latitude and 73°29' to 73°31' E longitude) is a 6 km. long sand spit about 16 km. South of Malvan on Maharashtra Coast. The spit bar is connected to main land near Tarkarli. Southern end of the bar abruptly ends in sea near Mobarwadi. The eastern edge of the spit is bordered by tidal stretch of river Karli. The western margin faces Arabian Sea.

Storm surges produced due to low atmospheric pressure and coincident with onshore south-west monsoon are frequent in the area. Episodic inundation due to storm surges is being experienced since 1990 in every monsoon. The problem of beach erosion at Devbag is however not recent, the area is showing a tendency of severe breaching and erosion of shorefront since 1952. It is one of the classic example of 'Chronic Erosion' (long term coastal hazard) Tarkarli and Devbag have emerged as one of the 'hot spot' regarding tourism activity in the recent past. Many villagers are switching livelihood to tourism from traditional fishing. In village Devbag (Population 2912, 640 houses) constructional activity in the form of Hotels, Motels, Jetties is making the situation more hazardous than before, especially in monsoon.

Objectives of Paper :-

The shifts in paradigm in both Disaster Management (DM) and coastal Zone Management (CZM) from relief-centric to risk reduction in the case of DM and from regulation to management in the case of CZM, are throwing new challenges. With the new challenges come the new demands. One such is mapping areas which are regularly vulnerable in monsoon season.

An attempt is made here to map -

i) Spatio - temporal changes at Devbag, and

ii) To prepare a map of hazardous zones of Village Devbag.

Method of Investigation :-

Data Sources	Field Component	Laboratory Component
Formaline map of study area published by Survey of India in 1894	Field visits, field measurements	Preparation of base map.
S.O.I. Toposheet 1:50000 scale (Index No.47 H/8, 48 E/8 and E/9)	Surveying and field mapping	Geo-referencing and joining to obtain the map of study area
Cadastral map of village Devbag obtained from Land Records Office, housed at Oras, Sindhudurg.	Interviews with locals	Mapping of history and events. Superimposition on cadastral map to detect changes and know spatial distribution of different land facets and delimit the boundaries of features.
Satellite imageries IRS IC LISS III image acquired on 22nd Sept., 1997 Google, Wiki Mapia.	Newspapers and other media reports.	

ASSESSMENT OF COASTAL CHANGE HAZARDS AND THEIR MAPPING AT MAINLAND COAST OF TALSARI AND BARRIER SPIT COAST OF MONDERMONI, W.B., INDIA.

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The beach – dune morphology of sandy alluvium coast along the Bay of Bengal shoreline is rapidly changing due to storm characteristics, elevation of the shoreline and various human activities at present. The wide sea beach and beach-fringed dune belt of Talsari barrier & mainland coast and Mondermoni-Silampur barrier coast had acted as natural barrier against the tidal waves and storm surges in the past. By considering the magnitude of wave run-up, the highest reach of the waves on the beach, relative to coastal elevation, a new scale has been developed that categorizes net erosion and accretion during storms. Different impact regimes (swash regime, collision regime, over wash regime, and inundation regime), their morphologic responses and greater potential hazards have been estimated for mapping geomorphological changes along the coastline.

Reclamation of pre-mature tidal floodplains of the low lying coastal plain (behind the dune belt), reduction of tidal prisms and temporary flood spill grounds, and recreational uses of shore fringed sand dunes are major human activities that influences the magnitude of coastal changes along the Bay of Bengal shoreline at present. The older records of the shoreline characters are also compared with satellite images (IRS-1D LISS-III (2002) and (LANDSAT-TM & ETM+ of temporal variations) of the same area to record the present day coastal change.

SHORELINE CHANGE ANALYSIS USING SPATIAL TECHNOLOGY ALONG THE COAST BETWEEN TROU AUX BICHES AND MONT CHOISY – MAURITIUS ISLAND

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Mauritius, a small island state with a total land surface area of 2,040 km^2, is situated at North latitude: 10° S / South: 21° S and East Longitude: 64° E / West: 55° E in the Indian Ocean and culminates at its highest point at 828 m. The coastline of Mauritius is 177 km in length and is almost completely surrounded by fringing coral reefs (except opposite river mouths, estuaries and cliff areas) enclosing a lagoon area of 243 km^2. Coastal and marine resources are of vital importance to the national economy. Over the past years, the coastal zone has experienced very rapid development and is coming under severe stress through anthropogenic impacts. Natural calamities such as cyclones further exacerbate physical impacts on the coast. Previous studies on Coastal Erosion around Mauritius, suggests that there are signs of wide spread erosion around the island. Whereas some of the erosion patterns are short-lived and repair themselves, there is evidence of sustainable erosion. The present paper is the study of a popular shore on the northwest coast of Mauritius; Trou aux Biches –Mont Choisy. Intense pressure of development on this coast as well as the lagoon has contributed towards sustainable coastal and beach degradation with areas considered as “hot spots”. The main objective of this study is to detect and establish trend in erosion/accretion patterns along the coastal zone using multi-temporal aerial photographs, satellite images for the past 40 years (1967 to 2010) and also different time periods (1967-1975, 1975-1991, 1991-1998, 1998-2003 and 2006-2010). Methods used to detect shore line changes for the present study involved the use of GIS tools to classify such landmarks as the Coastline (vegetation line) and the low water line. Other methods used for this study were Total station survey for producing topography and nearshore bathymetry map as well as in-situ Snorkeling and SCUBA Diving for the study of lagoon-Reef ecosystem. A GIS integrated coastal hazard map was prepared as an output. Detail survey carried out within identified hot spot zones revealed the followings: (1) Retreat of an average of 25m of beach over the last 40 years; (2) Intense changes in coastal morphology through the construction of solid jetties, concrete walls in the dynamic zone and (3) poor set back to contain elevated water levels, especially during cyclonic conditions (4) General degradation of coral reef ecosystem. The Paper proposes technical solutions as well as an integrated management plan to address coastal related problems in the study area.

Keywords: Aerial photographs, Satellite Images, Coastal Geomorphology, Coastal Erosion, GIS, Ecosystem, Coastal Hazards, Coastal Zone Management

GEOMORPHIC HAZARDS DUE TO ANTHROPOGENIC PROCESS -A STUDY BETWEEN THRISSUR AND ERNAKULAM DISTRICTS OF KERALA

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Kerala is one of the states in India where landforms are produced by fluvial, marine and denudational processes. Kerala state falls in the tropical geomorphic regions of the world. South west monsoon rainfall influence fluvial process and produced landforms of erosion and deposition. Kerala is one of the coastal States in India. The landforms produced by the marine process are coastal plain, spit, lagoon (backwater) and strandlines. Anthropogenic activities like sand mining in the river beds, clay mining in the paddy fields, reclamation of flood plain areas, valley fills for residential purposes, deforestation for plantation and other purposes have produced environmental hazards. Impact of these anthropogenic activities caused geomorphic hazards like landslides, flood, river bank erosion and slides, coastal erosion and water logging. This paper attempts to study the geomorphic hazards between Thrissur and Ernakulam districts of Kerala. Data collected from Topographic maps and satellite remote sensing was integrated in GIS environment using MapInfo GIS software and hazard maps were produced. Hazard areas were verified by the field checking. Kochi Corporation is one of the fast growing urban centres in Kerala situated in the study area is also vulnerable for geomorphic hazards. If proper measures are not taken to arrest anthropogenic activities, it would be difficult to face the hazards in future.

HAZARD ZONATION MAPPING OF VALAPATTANAM RIVER BASIN IN KANNUR DISTRICT OF KERALA, USING GIS AND REMOTE SENSING

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Geomorphic hazards are naturally occurring incidents on the earth. No area on the earth surface is free from hazards. Accurate, efficient and reliable information of hazards are must for the Planners and Govt. authorities to take appropriate action for prevention and mitigation so that the people and properties can be saved from the incidents. In this paper, an attempt is made for hazard zonation mapping in Valapattanam River basin using satellite remote sensing data and other data in GIS environment. Valapattanam River originates from the Brahmagiri Ghat Reserve Forest in Karnataka at an altitude 900-1350m above mean sea level and drains into Kannur district of Kerala State. Major tributaries of this river are the Sreekantapuram River, Bavalipuzha, Venipuzha, and the Aralam Puzha. The total drainage area of this river basin is 1867 sq.km. Of which 546 sq.km area is outside Kerala state. The basin is nearly level surface near the coast, undulating in the midland and steep sided hills and mountain in the east. Relief, landform, slope, aspect, soil, drainage density, landuse/land cover, agriculturally drought prone areas, flood prone areas are parameters considered for the hazard zonation. Main geomorphic hazards envisaged in the river basin are landslide, flood, agricultural drought, soil erosion and sea erosion. These areas are delineated by GIS analysis. Vulnerable watersheds and Panchayats are listed out for taking necessary precautionary measures.

RIVER SYSTEM MANAGEMENT IN AN URBAN ENVIRONMENT: A CASE OF MUSI RIVER IN AN ANTHROPOGENICALLY AFFECTED HYDERABAD ENVIRONS

S.Padmaja, N.Vijaya Sarathy

Rivers left to themselves might well be creating well distinguished fluvial landscapes (land forms) in their own right. However, in an altered and interfering environment like in an urban scape, rivers can well be constricted and morphologically changed to result in mammoth urban floods disrupting the urban life. Therefore the rivers in an urban environment need special attention in terms of their form process monitoring so that the remedial checks can be adopted without much delay. Some of the major cities of the world are synonymous with the rivers that flow in them like Thames & London, Irrawaddy & Rangoon, Seine & Paris, Rhine & Bonn, Nile & Cairo and Moscow & Moskva. Musi river, a tributary of Krishna in South India too is synonymous with Hyderabad. The river was at its pristine best 4½ centuries back but with the passing times, due to urban growth and industrialization in and around Hyderabad the river has transformed into a sewerage nala. River Course of Musi has undergone transformation in Bank & Bed forms due to anthropogenic encroachments resulting in constricted channel. Musi floods in the year 2000 are due to this cause only. In the light of these observations a study is attempted to highlight the impact of human induced changes on Musi River and the possible means of river management to maintain and sustain the water resources in Hyderabad environment.

The study is attempted through geo-informatics to identify not only the changes in the river morphology but also LU characters on the adjoining banks over a period of 30 years.

Keywords: River system management, urban environment, anthropogeny, geoinfromatics, channel geometry, landuse.

IMPACT OF BANK EROSION HAZARD ON HUMAN OCCUPANCE IN THE JIA DHANSIRI RIVER BASIN, INDIA

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Impact of river bank erosion hazard in the Indian part of the Jia Dhansiri river basin is studied through superimposition of village maps, bank line layers of the river for the years 2000 and 2006 in GIS environment and the spatial change therein is examined.

It is found that 74 villages out of 302 villages comprising three revenue circles were affected by bank erosion during the period and in some villages the erosion is so severe that it takes the form of hazard. The river has engulfed 21.43 km^2 (8%) area of the erosion affected villages which are basically intensively cropped agricultural lands and homestead areas. The erosion affected villages of the study area are categorized into three hazard categories on the basis of landed area lost due to bank erosion as high, medium and low. It is revealed in this study that out of the 74 erosion affected villages 5 (7%) villages falls in the high, 15 (20%) villages falls under medium and 54 (73%) villages fall under low erosion category.

Household survey done on sample basis reveal that over 15% families give up primary occupation, 69% increase in number of families in secondary occupation and 2000% increase in number of families in tertiary occupation after shifted their household due to bank erosion. This study also reveals that over 48% families shifted their houses due to bank erosion and resettled acquiring government land within 2 km distance.

Examination of the causes/processes of bank erosion reveal that channel and banks morphology, low river bed gradient, bed aggradation, and development of braids, floods, gully development, course bank material texture are principal causes/processes of bank erosion. Three vulnerable bank erosion hazard zones viz. high, medium and low are demarcated here. Some measures for mitigation of hazard and protection of local resources are also made.

URBAN GEOMORPHIC HAZARDS: SOME EXAMPLES FROM KOLKATA

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In urban environment the interaction between man and land is more intense and intricate in comparison with that of rural areas. Here the forms of land instead of landforms play considerable role to affect the day to day activities of the urban population. Geomorphic aspects in an urban system thus include various types and conditions of land, as they exist, under different time-scale frame. Sometimes the very form of land with its micro-relief variations, if not properly planned, implemented and maintained, pose serious threats to the citizens, causing hardships especially on the children and elderly people. Lack of coordination among the various government and civic agencies very often makes things worse and the problems related to micro-geomorphic changes becomes a hazard. This paper is an attempt to highlight some of these problems taking into account examples from Kolkata.

The methodology of this exercise comprises consultation of relevant literatures including government/ civic reports, observations at micro-level, interviewing the concerned people. It is found that the geomorphic problems of Kolkata have started with unplanned urban extension and defective implementation of urban renewal projects like roads, sub-surface drainage networks and other land use changes.

MAPPING OF SARALA BET: MID CHANNEL ISLANDS IN RIVER GODAVARI

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A River island is a landform, elevated above and surrounded by stream channel branches. Processes often interactive by which islands forms include avulsion channel incision channel migration change in sediment supply etc. Formation of bars and islands is a channel adjustment which is prominent feature of rivers. Frequency of mid-channel and lateral bars is more than the islands. “Sarala Bet is one such island in river Godavari which is observed and mapped in the present study. River Island is characteristic feature of river Brahmaputra (Majuli Island). It observed in river Godavari that there is sequence of small and large island developed in its channel. River Godavari has its source at Trimbak in Nashik district of Maharashtra. Height at source region is 920 m. Length of the channel till study area is 195.5 k m. Sarala Bet covers an area of 65 acres of land. It is said by the local people that the origin of the island and is of 450 years. Uncommon that one side of the island shows thick alluvial deposits and other bank shows the rocky bank and bed. Rocky channel is new and the alluvial channel is old informed by the people. Height of the island is 479 m. There are two assumptions regarding the origin of the island. 1) Channel is linked in one of the high flood condition on meandering limps. 2) Channel have carved the whole patch of rocky bed slowly in number of years which is permanently turned in to active channel. In the present study the shape of the island is more or less circular. Present paper aims to understand the formation of Sarala Bet Island. Formation of islands change the channel geometry on rapid rate because of erosion if they belongs to alluvial rivers but since it is Deccan trap it does not show rapid erosion.

Remote sensing/GIS in Geomorphological Hazards

DEGENERATION OF JALANGI RIVER IN NADIA DISTRICT, WEST BENGAL : AN INVESTIGATION BASED ON MAPS AND SATELLITE IMAGES

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Jalangi is a distributary of the Padma river which has opened up within the last few hundred years to flow actively in the southern and south-western direction through the districts of Murshidabad and Nadia in West Bengal. The exact age of Jalangi is not known. Initially, its source was the original Jalangi offtake located near Jalangi town, Murshidabad district. Earlier, it used to meet Bhairab river at two different points 5 km apart. But due to irregular flow of water, this part of the Jalangi river has become a palaeochannel and the flow of water through Jalangi river is now maintained by Bhairab river. Therefore, the lower part of the Bhairab river is actually the present Jalangi river. It flows into the Bhagirathi-Hugli river near Mayapur in Nadia district. The part of Jalangi river in Nadia district is considered for this study which is representing the lower course of the river. Jalangi is active during the monsoon season and Nadia district is quite susceptible to the flooding of Jalangi and Bhagirathi-Hugli rivers. Jalangi river is otherwise suffering from lack of supply of water to maintain its flow during the drier part of the year. This study is an endeavor to map the behavior of the Jalangi river in the past two hundred years and to predict the future changes especially in the lower course of the river.

The database for detecting the changes in the Jalangi river course consists of J. Rennell's 1778 *Bengal Atlas, Atlas of India* maps (1855-56), topographical maps of 1: 63,360 scale; satellite database includes Landsat 5TM images (1998-2010), LISS III – PAN merged images (2001-2006). Discharge data of different periods have been used for identifying the variation of water flow through the main channel and to carry out quantitative analyses. The main channel of Jalangi is characterized by intense meandering and the channel has shifted quite a few times in the recent past. This fact is confirmed by the presence of ox-bow lakes, meander scars etc. near the main channel. It can also be found from the old maps of the 18th and 19th century that width of the Jalangi river channel—which was at a par with the Bhagirathi-Hugli river until a couple of centuries back— has been decreasing.

The main factors disturbing the main channel are sediment quarrying from the river bank and dry river bed, land-use changes, contamination of river water through the release of effluents into the river, garbage dumping etc. The presence of water hyacinth is a common phenomenon in the lower course of the river indicating eutrophication. The anthropogenic impact is mostly visible in the areas near Krishnanagar city. Even though the flow of water through Jalangi is plenty during the monsoon season, there is a chance that the river could turn into an abandoned one in near future. Mitigation measures with proper planning should be implemented to regenerate the river environment.

DYNAMICS OF BEACH MORPHOLOGY OF TAMIL NADU COAST, INDIA-USING GEOSPATIAL TECHNOLOGY

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The coastal environment of the world is made up of a wide variety of landforms manifested in a spectrum of sizes and shapes ranging from gently sloping beaches to high cliffs, yet coastal landforms are best considered in two broad categories: erosional and depositional. In fact, the overall nature of any coast may be described in terms of one or the other of these categories. An attempt has been made in this paper to describe the areal extent of beach morphology in the entire Tamil Nadu coast. Infact, Tamil Nadu coast has now become a hot topic because of tsunami and other devastating processes prevailing in this area. About 107,110,114 beaches covering in the corresponding time of 1992,2003,2008, respectively an area of 57.764 km^2, 59.445 km^2, 58.517 km^2,spread over the length of 1117 km were identified and studied spatially and temporally to get their past and present status. Moreover, effect of tsunami on this feature was found and discussed elaborately.

Keywords: Geospatial Technology; Beach morphology; Digitization; Sedimentations; Tamil Nadu coast.

ROLE OF RS & GIS TECHNIQUES IN EVALUATING VARIOUS GEO-ENVIRONMENTAL PARAMETERS TRIGGERING LANDSLIDE IN PARTS OF MIZORAM

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Remote Sensing (RS) technique plays significant role in landslide investigation, in terms of evaluation and analysis of specific landslide event form local to regional scale. It greatly aid in the prediction of future landslide occurrences, which is very important to those who reside in unstable slopes. Without replacing fieldwork, interdisciplinary research strategies etc. it offers an additional tool from which one can extract information about causes and occurrences of landslides. Moreover, thorough understanding of landslide activities requires handling and analysis of large volume of database. Geographic Information System (GIS) is ideal tool in this stage of landslide investigation since it has the capability of data capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output generation etc.

Landslide or slope failure is one of the major geomorphic hazards in India, which causes loss of human lives and properties almost every year apart from disrupting communication links. Combined effect of various geo-environmental factors aided by anthropogenic activities trigger landslide in hilly terrain. Fragile hills of Northeast India because of heavy rainfall as well as rapidly growing developmental activities also experience landslides every year especially during monsoon.

The study area is approximately 35 km. in length along NH-54 between south of Varengte to Kolasib town in Mizoram. The State of Mizoram has rugged and highly immature topography dominated by N-S trending linear anticlinal ridges and synclinal valleys with steep slopes. Present study highlights that interbedded sandstone with shale are the main lithological units where the interplay of geological structures and topographic slopes play very significant role in causing landslides. Anthropogenic activities like road cutting, Jhum cultivation etc. are the main triggering factors in this area in addition to heavy rainfall.

Key words: Remote Sensing (RS) .Geographic Information System (GIS). Landslide. Jhum cultivation

APPLICATION OF REMOTE SENSING DATA TO EVALUATE AND MAP FLOODS INFLUENCING FACTORS IN WESTERN SAUDI ARABIA

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Floods are natural phenomenon irregularly occur in arid areas, and it is known from all ages. However as a result of the increasing habitation and development of flood prone areas, floods have become a major society disrupting disaster. For example, in November, 2009 Jeddah the second largest city in Saudi Arabia was hit hard due to an extreme flood event resulting into catastrophic damages. Floods in arid areas are mainly caused and influenced by natural factors, but the disastrous consequences of floods are increased by human activities within natural floodplains. A proper understanding of floods causing and influencing factors is critical for a successful flood management programme. Remote sensing of multi-spectral and multi-dates images is of immense value in evaluating and mapping the floods influencing geomorphological and land-use factors. The main aim of this study is to assess the effect of geomorphology and land-use on flood hazard in western Saudi Arabia, and to highlight remote sensing based approach for rapid geomorphological mapping and land-use mapping in areas with limited information.

A REMOTE SENSING AND GIS BASED HYDROMORPHOLOGICAL APPROACH FOR IDENTIFICATION OF PERCOLATION PONDS IN THE COASTAL CITY TUTICORIN, INDIA

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Tuticorin is the capital city of Tuticorin district and it has a sea port developed during 1980's. The presence of the sea port facilitates the development of several heavy industries like SPIC, Thermal Power station, Sterlite copper smelting industries etc and several other small industries. Because of the industrial development, the people are started migrating from peripheral villages in search of their fortune. The rapid and accelerated urbanisation and industrialisation caused the over exploitation of groundwater and leads to the sea water intrusion in the coastal aquifers of Tuticorin. Tuticorin usually receives very less annual rainfall and lack of water conservation practices. The treated drinking water comes from the River Thamirabharani which is flowing 50km west of Tuticorin. Because of the above reasons this coastal town is facing a severe shortage of water. The safe development of groundwater resource primarily depends upon the groundwater recharge. Artificial groundwater recharge is essential in terrains with low natural groundwater recharge. In this study, an attempt is made to identify zones favourable for artificial-recharge for augmentation of groundwater through remote sensing and Geographic Information System (GIS). A special emphasis is laid on the identification of percolation ponds based on geology, geomorphology, slope of the area, soil and landuse pattern to increase the groundwater recharge.

APPLICATION OF REMOTE SENSING AND GIS TECHNIQUES FOR GEOMORPHIC MAPPING OF LATERITIC TERRAIN IN SATARA DISTRICT OF MAHARASHTRA

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Geomorphic mapping is one of the most useful tools for geomorphic studies, resource appraisal, planning and development in any area. With this view, mapping of lateritic terrain in Satara District of Maharashtra is done by using remote sensing data and geographic information system. To map different aspects of geomorphology of this region, various geomorphic features, processes and material were classified with the help of digital image. These are mapped in particular thematic layers such as landforms of different scale, material and processes operating in this region. The information of land use and land cover of this region is combined with geomorphic map to understand the distribution of vegetation with respect to terrain, distribution of exposed lateritic rock, surface depressions with or without water. Distribution of agriculture and settlement on lateritic terrain are also mapped. After applying different queries in GIS environment, geomorphic maps and other thematic maps are prepared and geomorphic characteristics of this region are studied. This information will help to understand the geomorphic processes, features and resource distribution in this region. It will also help to identify the potential uses of this region such as proposed tiger reserves, biodiversity zone, wind mill power plants, tourism activities and its impact on the natural environment.

HAZARD ZONATION MAPPING OF VALAPATTANAM RIVER BASIN IN KANNUR DISTRICT OF KERALA, USING GIS AND REMOTE SENSING

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Geomorphic hazards are naturally occurring incidents on the earth. No area on the earth surface is free from hazards. Accurate, efficient and reliable information of hazards are must for the Planners and Govt. authorities to take appropriate action for prevention and mitigation so that the people and properties can be saved from the incidents. In this paper, an attempt is made for hazard zonation mapping in Valapattanam River basin using satellite remote sensing data and other data in GIS environment. Valapattanam River originates from the Brahmagiri Ghat Reserve Forest in Karnataka at an altitude 900-1350m above mean sea level and drains into Kannur district of Kerala State. Major tributaries of this river are the Sreekantapuram River, Bavalipuzha, Venipuzha, and the Aralam Puzha. The total drainage area of this river basin is 1867 sq.km. Of which 546 sq.km area is outside Kerala state. The basin is nearly level surface near the coast, undulating in the midland and steep sided hills and mountain in the east. Relief, landform, slope, aspect, soil, drainage density, landuse/land cover, agriculturally drought prone areas, flood prone areas are parameters considered for the hazard zonation. Main geomorphic hazards envisaged in the river basin are landslide, flood, agricultural drought, soil erosion and sea erosion. These areas are delineated by GIS analysis. Vulnerable watersheds and Panchayats are listed out for taking necessary precautionary measures.

HAZARD ZONATION MAPPING IN THE MADMAHESWAR GANGA BASIN FOR WATERSHED MANAGEMENT (GARHWAL HIMALAYA)

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Geologically the Himalayan belt is very young and complex. Rugged topography in combination with commonly occurring earthquake/natural hazards and occasional high intensity rainfall, area of weak earth materials and complex geological structure, contribute significantly to mountain hazards. It is important to locate the areas vulnerable to mass movement related phenomena, which may be hazardous in future for the safety of the inhabitants and the schemes to be launched in years to come.

The present study has been developed an approach by using a mass movement hazard assessment in Himalayan watershed hazard zonation mapping involves evolution of hazard into relative degrees of potential hazard by ranking of various causative factors operative in the study area based on their influence in initiation of hazard. In the present study an attempt has been made to prepare hazard zonation maps based on the synthesiszation of data acquired from various geo-environmental thematic mapping.

The present study area has been conducted into Madmaheswar Ganga Basin, a tributary of Mandakinin River in Garhwal Himalaya which drains 358 sq kms of the Rudraprayag District. The combination of several factors is responsible for the landslides of study area like tectonically disturbed and fractured litho logy of the MCT Zone, past and recent seismic events loose regolith, quaternary cover on steep slope, prominent seepage zone, increased anthropogenic activity and faulty land use practices. In addition ill-planned road construction and rapid infrastructure development activities added to the problems.

Objectives

The specific objectives include:

1. Developing a pragmatic heuristic, quartitative hazard zonation mapping for the Madmaheswar Ganga Basin.
2. To workout the hazard zonation and their classification caused and consequences on geo-environment.

Methodology

All the natural hazard causative factors in each fact have been given numerical weightage to evolve. The natural hazards (NHR) system. Numerical values have been assigned to each fact based on relationship between occurrence of landslide and its various controlling factors viz. litho logy, slope and slope angle, hydrological conditions, land use, drainage density, dissection index and finally anthropogenic activities.

The NHR values for different categories are determined on the basis of their strength of relationship with natural hazards. For generating the required data, the Madmaheswar Ganga Basin has been divided into the grids of one km^2 and the NHI values were computed in each grid to delineate the natural hazard zonation. After assigning the NHR, the natural hazard index (NHI) indication the probability of instability of a unit fact has been calculated by multiplying the rating of individual causative factors incorporated in that particular fact. The multiplication has facilitated to high light the role of dominant causative factors.

Thus the total NHI value for particular fact = weighted rating litho logy x structure x hydrological condition x slope angle x dissection index x relative relief x land use x anthropogenic activities has been calculated.

The whole basin is thus divided into four different hazard zones. Characterized by low, moderate, high and very high potential of natural hazard by drawing the Isohazard lines. The area lying in very high hazard zone is very active during rainy season. The moderately hazard zone is the state of critical equilibrium conditions and any natural disturbance may incept. The mass movement whereas low hazard zones appear to be relatively stable.

There are number of factors, such as thickness of scree on slope, quaternary material resting on moderate to steep slope, continuous percolation of water along upper slope, modification of natural slope by anthropogenic activity and to a major extent the impact of fault's which are responsible for natural hazard zone. The high hazard zone corresponds to the impact of human activities on unconsolidated material and in seepage localities.

GEOMORPHOLOGICAL MAPPING OF SWAMPY TRACT AND RECLAIMED TRACT OF THE SUNDARBAN, W.B., INDIA, USING REMOTE SENSING AND GIS TECHNIQUES

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Mapping geomorphological units is not an easy task particularly when the landscape is very low in surface elevation, tidally flooded twice daily, densely covered by mangroves, or the wilderness is heavily modified by man due to pre-mature land reclamation in the coastal parts of deltaic tract. However, geomorphological mapping is an essential task in case of low lying deltaic tract to identify the role of geomorphology in mangrove ecology, in restoration process of wet lands and particularly in risk analysis of flooding and erosion. Sundarban swampy tract and reclaimed tract of West Bengal are selected for such study with the help of Remote Sensing and GIS techniques.

IRS-ID LISS-III and IRS P4 CARTOSAT data are used to identify the different geomorphological units of the low lying deltaic tact through knowledge based classification by using pixel weightage values for each unit. Ground truth verification has been conducted for field measurements of many units in the deltaic tract with conventional surveying equipments and GPS hand sets.

Whatever the geomorphological units have been identified by above way, a unique pattern is developed that categorizes ecological factors, various risk factors and process response factors at the deltaic tract of Sundarban. The temporal changes of recorded geomorphological units reveal that shore line features and tidal flat features are more dynamic in compare to other group of geomorphological features in the deltaic tract.

APPLICATION OF WEB-BASED GIS FOR FLOOD DISASTER MANAGEMENT

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GIS has emerged as a very important tool for effective planning, communication, and training in the various stages of the flood disaster management cycle. The prime concern during flood disaster is the availability of spatial information, and the dissemination of this information to all concerned. Internet-based GIS can play a key role in this aspect by providing cost-effective information at various stages of the disaster cycle, with a much wider reach.

A new category of GIS called Web-based GIS has emerged which uses a spatial representation for displaying spatial data in web-based environment. Web-based GISs are increasingly becoming popular since these facilitate to work / analyse data from a remote place and make holistic decisions. Users can access web-based GIS and perform a query without having GIS system software through World Wide Web. GIS users use it as an IT tool to access and transmit remote data, conduct analysis and GIS presentation. Web-based GIS data can be viewed using Internet explorer or Netscape Navigator or any Internet Browser. Web technology enables the users to access data with almost no cost at client site. A web GIS should be designed to facilitate geospatial decision support via all popular web browsers, demanding minimal network bandwidth, and requiring no configuration or dependence on additional plug-ins. At the same time, they should be portable across major platforms and free of software licensing restrictions.

The main contribution of this paper is to present use of state-of-the-art web development technologies and open-source GIS tools for an efficient web-based GIS design without sacrificing application functionality. The following aspects have been covered: how web-based GIS can be used as a very effective tool for flood disaster management, in the various stages of the flood disaster management cycle.

IDENTIFICATION OF DROUGHT VULNERABLE AREA USING GEO INFORMATION TECHNOLOGY

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Drought is one of the climatic natural disasters, having an impact on both the economy and the society, with its long-standing problems. It can bring disastrous impacts to any large segment of the society. Drought by nature is a result of inter-related parameters. In the present study a Geographic Information Systems (GIS) - based tool for drought vulnerability assessment at a micro level has been developed. It was tested for efficacy in fostering drought awareness among rural families. The study is based on the concept that the severity of the drought is a function of rainfall, hydrological and physical aspects of the landscape, leading to meteorological, hydrological and physical drought. The present study identifies drought prone areas in Idukki District, Kerala contained in the rain shadow regions. The results of the study can be used by the farmers and public for the better management of water resources.

FOREST FIRE - A GLOBAL SCENARIO: IDENTIFICATION AND MAPPING USING GEO INFORMATION TECHNOLOGY

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A forest fire event is influenced by ecological, human and climatic conditions. Forest fire can directly cause biodiversity loss, forest degradation and climate change. It has direct ecological, economic and social impacts. Fire prone area modeling is done to have the most effective system of fire management and at the same time to reduce its deleterious effect on ecosystems, communities and landscapes. Geospatial techniques prove to be powerful tools in assessing the forest fire risk and its management. With the application of GIS and Remote sensing techniques, the present study deals with identification of fire prone areas and their management in Shendurney wildlife sanctuary, the mega biodiversity hot spot of the Western Ghats region of Kerala. Large extent of forest is affected by fire in every year in this region. Two types of data are used in the study viz., spatial and non-spatial. Spatial data mainly includes remote sensing data, forest block, GPS field data, settlement boundaries, road/trek path network and the most important existing water bodies in that area whereas the non-spatial data pertains to meteorological data on temperature and rainfall. The parameters in consideration for the analysis are vegetation type, forest fragmentation, vicinity to settlement, distance from road, slope, aspect, temperature, amount of litter and rainfall. All these parameters have direct/and indirect influence on the occurrence of fire and are integrated using GIS and a multi parametric weighted index model, which has been adopted to derive the 'fire-risk' zone/ fire prone area map. The final output shows forest fire risk area map of Shendurney wildlife Sanctuary in four categories viz. very high risk, high risk, moderate risk and low risk.

GIS MAPPING OF SALINE WATER ZONES IN A COASTAL UNCONFINED AQUIFER OF CENTRAL KERALA

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The coastal aquifers of Central Kerala, India experience severe degradation of water quality due to various anthropogenic activities and other natural processes. The region is densely populated and people here mostly rely on the coastal aquifers for their water needs. Amongst the natural processes, seawater intrusion is the dominant one. The coastal area in Kerala mainly comprises of fine sand and clayey silt and is conspicuous with the prevalence of backwaters that directly influence the quality of the groundwater.

Geographical Information System (GIS) is nowadays commonly used for the proper utilization and management of ground water resources. Hence, with the application of GIS, an attempt has been made to study saline water zones in the shallow unconfined aquifers of the coastal tract of central Kerala.

Vertical Electrical Soundings (Schlumberger Configuration) were also carried out in the study area. The VES interpretations were found to be in good agreement with the earlier borehole surveys. The study shows that the saline water intrusion in the area is localized and occurs wherever the backwater channels extend inland.

APPLICATION OF RS & GIS IN GEOMORPHOLOGICAL MAPPING OF MATHERAN HILL STATION, WESTERN GHATS, INDIA

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Matheran, a famous tourist centre is located in the closed vicinity of the Western Ghats in Maharashtra. Administratively, the hill station of Matheran is located in the Raigad district of Konkan division in Maharashtra. The place experiences very heavy downpours during the monsoon. Every year the landslides take place during the heavy showers of monsoon which damage the roads and railway tracks. Also the soil erosion takes place which is responsible for deforestation. Hence, if the physical background of Matheran hill station is unchecked, there will be damage to the environment that may decrease the potential for tourism and affect the economy of the study area. Therefore, to study the physical background of Matheran hill station; the geomorphological mapping is a must.

The database form the Remote Sensing has been processed in GIS environment for the present study. SRTM data is used to prepare digital elevation model. The digital elevation model and its second derivatives are used to understand the various terrain characteristics. The aspect map, plan curvature, wetness index map, flow accumulation map are prepared. The various maps pertaining to relief characteristics such as absolute relief, relative relief, dissection index and slope are prepared by grid operation.

It was observed that, the remote sensing & GIS has proved to be an important tool in the geomorphological mapping which is useful to understand the terrain characteristics of the hill station and this geomorphological mapping plays an important role in the management of the geomorphological hazards at the Matheran hill station.

A SURVEY ON GRID COMPUTING AND ITS APPLICATION TO NATURAL DISASTER

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Grid computing an extension of distributed computing supports computation across multiple administrative domains which enable it to be distributed over a local, metropolitan or wide area network. As, the users can access the resources simply and transparently without knowing where they are physically located, there are many challenges involved for constructing the grid environment. Grid computing emerged mainly to solve very large applications that cannot be solved by traditional way of computing. This paper gives a detailed survey on the challenges and characteristics of the grid and how to manage the resources in the grid environment. This paper also deals with the Role of Grid computing in natural disaster recovery issues related to grid.

Keywords: survey, grid, characteristics, challenges, resource management.