Chapter-1

Environment and Associated Hazards – A Summary Note

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1. Introduction

Ever changing natural environment over the earth has significant influence on human activities requiring modern societies to adjust to the changes. However, technological advances partially marginalize the effects of environmental changes and enable humankind to extend the limits of the use of environmental resources. The human response to environmental change, reflected in the transformation of geomorphic features and damages caused in case of extreme episodic events like floods or earthquakes, is two fold, firstly to assess the impact of the changes and then to make appropriate adjustment to cope with the changes. The changes in environment are, however, not uniform and vary in space and over time. The importance of spatial scale of environment from global pattern of its elements to the environment of a river catchment or a city is always considered to understand the pattern of landforms (being related to topo-sequences/catena) and their micro-areal features that specify spatial ordering of hazards (Goudie 2001). Goudie's (2001) classification

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of major world zones on the basis of their environmental characteristics is, therefore, ideal and useful in understanding environment across the world and its associated hazards. The environment of one part of the world differs in its characteristic features from other parts and each faces the problems associated with a specific type of hazards. For example, cold environment of Arctic region has environmental problems and hazards in Tundra development. Likewise, Siberia and Alaska have avalanches near steep slopes, rockfalls, slope instability and infertile soils. Studies undertaken in Poland show that the snow has a direct impact on the vegetal cover in the high altitudes of Tatra Mountains in South Poland (Kozlowska and Raczkowska 2006).

The mid-latitude areas (the Temperate zones of the world) are considered to be affected by climate change through the occurrences of a variety of natural hazards associated with rapid changes in atmospheric circulation. These assume the shape of storms, hails, thunder storms, tornadoes causing floods, and other windstorms. Similarly, in the humid tropics and monsoon areas, droughts, intense and prolonged precipitation resulting in floods and such other hazards are largely dependent on the shifting of Inter Tropical Convergence Zone (ITCZ). In turn, temperature, humidity and high precipitation produce deep weathered mantle and initiate the process of lateritisation. The combined effect of a variety of climatic parameters causes the loss of nutrients in the soils (deforestation), rapid runoff, soil loss and erosion by rainstorms, flooding (land degradation), and hurricanes which cause an enormous loss of life and property. However, the extreme conditions of environmental elements develop entirely different scenarios of landscape. For instance, a kind of deforestation, land degradation, mass movements, landslides and hazardous weathered rocks are the parts of landscape in the areas of extreme humid environmental conditions. On the other hand, extreme aridity develops desert realm which is associated with a variety of hazards such as extreme heat (health hazard), extreme salinity built up (sand and salt-water), arrested plant growth and erosion by wind. The mountain and coastal areas also have extreme events of environmental phenomena and their associated hazards. So far as the concentration, severity, damage and vulnerability of natural hazards in the world are concerned, the distribution of such events shows that more than 42 per cent hazardous events occur in Asia.

Floods, storms and earthquake are dominating disastrous events in Asia. Such events accounted for more than three-fourth share of the total occurrences in the world during the 20th century (Alantara-Ayala 2002).

2. The Over View

Many of the hazards are associated with land surface dynamics. A sudden change in the long-term surface behaviour by application of force unknown in its magnitude and intensity causes a significant change in the initial conditions of land surface. In order to understand the consequences of applied natural force in land form system, Slaymaker (1996) distinguished geomorphic hazards into three categories, namely, the endogenous (which includes volcanoes, neo-tectonics, mountain buildings), the exogenous (floods, karst surfaces, mass movements, snow avalanche, coastal erosion) and the climate and land use changes (desertification, permafrost, degradation, salanitisation, water erosion). However, a general classification of natural hazards based on the risk/dangers associated with the natural phenomena was given by Goudie (2001). He classified hazards into three broad categories as: the climatic hazards (dangers or risks associated with atmospheric elements), the geomorphic (largely dependent on structural changes in rocks, mass-movements, subsidence/emergence or alteration in relief features of landscape) and the biological hazards (degradation in plant and biodiversity and animal kingdom because of change in habitat and alteration in ecosystem).

Natural hazards are also greatly influenced by the environment created by humans. Human interference is an important factor; the human actions sometimes modify the environment in the form of resource-use. Intensification of human activities for maintaining human health and standard of living in response to land use changes and, consequently, the stress on landscapes especially in the countries carrying high population densities are appropriate examples of land-man interface (National Academy of Sciences 2001). The environmental change is thus a complex phenomenon and associated hazards are man-made also. Such complexity of changing landforms have been first viewed by Scheidegger (1996) in the form of non-linear geomorphic systems exemplifying the size-frequency relationship in landslides, distribution of erosion features and self-ordered criticality which follow power-law based systems of geomorphic events. Later on, the source of non-linearity in geomorphic systems was analysed by Phillips (2003) highlighting thresholds of the system that are interpreted in the parametric forms such as: (i) the ratio of force of a factor applied for and resistance of surface material (as the case of stream power and sediment transfers in the river systems), (ii) the storage effects (non-linear responses of geomorphic processes to produce energy in close system) and (iii) the self reinforcing positive feedback (flood plain development and flood frequency). Thus, assessing predictability of an event in non-linear system is complex and uncertain. In present-day processes, such assessments of event occurrences became more complex when humans have induced an additional factor, i.e., the technology. It leads to surface changes and land degradation and also produced obnoxious wastes for accelerating geomorphic hazards.

Severity of geomorphic events is related more to the disturbances in the geological structure caused by endogenous processes which are responsible for shaping and reshaping the land surfaces up to an extent (as Active Fault Zones). The occurrence of calamities/disastrous events or the extremes in weather conditions (exogenous) are responsible for sharpening the pre-existing shapes through altering the valley cross sections, drainage pattern, displaced terraces, emergence of fluvial fans, gully erosion and flash floods.

In order to study the long past history of development of earth surfaces and its changing environments, the models associated with general circulation of matters and catastrophism are widely accepted. Such models addressed the issues of the land surface features created by catastropgic events. The long past changes in environmental conditions were also studied by the use of scientific approasches, namely, Oxygien isotope strategraphy and dendroclonological evidences of climatic changes in tree rings (Mannion 1999). However, in recent past, there has been an explosion in the literature on environmental changes and its consequences on various aspects of land forms starting from the insights of the processes accelerating environmental changes to the interpretation of how ecosystems and human societies interact in these changing perspectives of environment. Major scientific issues of the emergence of new social pattern in responce to environmental changes have comprehensively been addressed by the

Committee of Global Change Resaerch to search an optimal path for future course of action on human interferences (National Research Council 1999). However, a more scientific and closer look of the effects of human activities and environmental changes on variations in phenotypic and genetic components of ecosystems prevalent in different environments was brought out by Hoffmann and Parsons (1997). In fact, organism changes when there are changes in different cycles (e.g., nitrogen, carbon and hydrological) of ecosystem that alter the biophysical properties of land. Intensified impact of anthropogenic forces also stemulates changes in the properties of ecosystem. Such scientific issues of changes in environment were addressed by conducting the study on possible changes in the fitness of organism in responce to extremely stressful conditions of ecosystem and evolution of organism in changing gradients of the environment of ecosystem (Hoffmann and Parsons 1997).

The occurrences of environmental events bring changes not only in the pattern of environmental elements but also in the intensity and extent of hazardous events in the form of redistribution of matter and energy over surface. The wide application of geomorphology in this connection is recognizable. The terrain evaluation with geo-mechanics viewed by Grant (1968), the parametric approaches applied by King (1970) and Moller (1972) towards landscape classification and landform sequences, the numerical classification of land systems used by Scott and Austin (1971) and the environmental specific classification forwarded by Goudie (2001) to understand the nature and characteristics of the pattern of natural hazards are realization of facts that geo-system follows ordering and hierarchy and the geomorphic sequences are result of such ordering. The parametric relationships of landform elements provide their possible sequences to analyse the geomorphic events and its severity. For instance, derivates of altitudes (that are altitude and slope as primary parameters of landform) are directly linked with the rock resistance, over land flow velocity, removal of transported material and gravitational stability. Such parametric relationships evolve (a) the denudation landforms of the hills and mountains following its elements like crest, steep slopes, earth flow, small stream network, and (b) the alluvial landforms evolved in the plains like flood plains (as locally called *khadar*), ox-bows, point-bars, upland plains (as *bangar*), *beels*, meanders and levees. Such surficial occurrences and changes therein are never ending because of disordering in geo-environmental system that tries to follow the 'steady state' condition (equilibrium) and the maximum reshaping of surface through the minimum expenditure of energy of the system. As a result, hazards are consequences of disordering and disequilabria over the surface that generate the energies and changes the action of environmental forces.

3. Investigations Carried Out

Geologists, geomorphologists and hydrologists have tried resolving the issues of transfer of material and energy with their own perspectives. In addition to spatial scale of understanding geomorphic hazards as described in the preceding paragraphs, the time scale is also one of the important dimensions to understand the past processes of environmental changes and differentiation of the clustering of inherent environmental elements which would provide a sound base of knowing the present-day processes and forecast of environmental changes and landscape development (Starkel 2003, 2004a, Soja and Starkel 2007). Paleo-geomorphic researches are contributing to the assessment of sediments' movements and climatic changes of the past. In some investigations, the paleo-magnetic data of different floral taxa were generated to know the effects of paleo-climate on vegetation in Quaternary sediments in the North-East Belgium by Evlogiev et al. (1997), and the plant fossils in the littoral/flych sequence of Tatra mountain in South Poland by Glazek and Zastawniak (1999). The paleo-karst sediments were investigated by considering the weathering processes operating in different karst areas of the world. Reviewing the development of paleo-karstic systems in the world, Glazek (1989) and Bardossy et al. (1989) mentioned that the paleo-karst areas have varieties of minerals and scenic beauty in different environmental conditions. For instance, the South African gold mine areas of the far West Rand have Upper Cainozoic weathering residuum upto 300 m thick; the coal mining subrosion subsidence zone of Belchato between Warta and Pilica rivers of Central Poland were developed because of available karstified Upper Jurassic limestones in paleo-karstic system; the Zonguldak coal mining areas of Turkey and Peruca area of Yugoslavia have paleo-karst fields with karst channels and dolines. Likewise, a paleo-karst structure developing in Bledzelfane areas of Tunisia has 15 to 25 per cent ferrous and 2 to 10 per cent zinc contents. The Northern parts of Ural Mountains have even significant iron ore deposits in its paleo-karst areas. The karst phenomena in humid tropical climate of a strong monsoon have a variety of features in different areas. Irregular limestone messes of the Mogote type in North Vietnam (Glazek 1966) and the horizontal water corrosion within the polje on the base of the magote and limestone caves in Cherrapunji area of high rainfall (located in North-Eastern part of India) are major geomorphic features developed by the environmental conditions.

Another most significant area of environmental impact and geomorphic hazards is to identify the Active Fault Zones (AFZ) where land surfaces are under the stress of endogenous forces. Identification of AFZ, severity of associated hazards in such zones and its predictions are major issues for geomorphologists and geologists. The investigations in the areas of environmental extreme conditions in closed geomorphic systems are of a great importance to analyse the impact of exogenous forces. Fluvial geomorphologic processes, suspended sediment sources in river catchments, underground water movement and so on are parameters to understand the magnitude and intensity of power applied for and material transported (Kale 2002, Collins and Walling 2004). However, the work done substantially on changing land surface by one element of environment rather than work produce collectively by many called 'catastrophic' condition of landscape, has different scenario of land degradation and natural hazards. Catastrophic rainfall leads to a specific type of land problem associated with laterisation with strong hydrological cycle resulting into soil degradation, erosion and dominance of heavy metal in the surface soils. On the other hand, the extreme aridity has desertification, salanisation, calcification in the soil processes and sand-dunes topographic features of land surfaces. Likewise, extreme cold regions of the Arctic world have different geomorphic processes and ice actions on land surface.

On account of fast increasing population of the world, the humans could transform the geomorphic environment and change the land surfaces in a variety of ways. For the purpose of understanding man-nature relationships, 'anthropo-geomorphology' term is given to analyse the human impact on environmental changes (Goudie 1997). In fact, the present-day processes are loaded by the human interventions in acceleration of matter and energy transfer over land surface at the temporal scale of environmental changes. It was also advocated that the parallel investigation of environmental elements would support decision-making and forecasts of geomorphic hazards (Starkel 2004b). The methods of investigation for the study of such processes at temporal scale are to conduct investigations in disturbed and undisturbed sequences of sediments of similar past phases and to compare the features for getting differentiations of frequencies and clustering of events (Starkel 2003). These investigations may provide important clues to priorieties the factors of geomorphic changes and applied forces acted upon land forms at different past phases.

Geo-hydrological environment is another important area of investigation and water resource management. Hydrological investigations are based on the closed system of land surfaces (called river basin/catchment/ watershed at its geographic size and geo-hydrologic domain) in which soil erosion and runoff are the agents of transfer of material and energy. Many working groups were constituted, a number of International Symposia were organized and several technical reports were prepared under world-wide programme of the International Hydrological Decade (1965-1975) and subsequent long term International Hydrological Programme (IHP) of UNESCO, Paris in 2001 as an essential part of International frameworks for scientific research, education and training in the field of hydrology. A few UNESCO publications on this theme are noticeable as listed here for ready reference (Table-1.1).

A world-wide education and training programmes have been conducted by UNESCO to transmit knowledge of IHP upto grass-root level. Further, it is obvious from the literature produced by the hydrologists that theoretical researches on basin hydrology have also been simultaneously undertaken to develop new tools and techniques in the field. For example, the sediment budgeting was analyzed by application of a variety of soil erosion and sediment delivery models such as physically based erosion model (Santos et al. 2003), distributed soil erosion model (He and Walling 2003) and dimensionless flood hydrographs (Singh 2005). Such closed system models were also used to predict the landslides occurring by rainfall (Dhakal and Sidle 2004) and to predict the flood hazards (Prokop 1999, Dutta et al. 2000, Tripathi et al. 2005).

Table-1.1

International Hydrological Programme (IHP- V) of UNESCO and its Technical Documents in Hydrology as published in 2001

Sl.No	Document No.	Volume No.	Name of the Report	Remarks
1	39	-	Environmental Isotops in the Hydrological Cycle- Principles and Applications, edited by W. G. Mook	Total 6 volumes produced
2	39	II	Atmospheric Water by J. R. Gat, W. G. Mook and H. A. J. Meijer	In collaboration with International Atomic Energy Agency
3	40	-	Urban Drainage in Specific Climates, edited by C. Maksimovic	Total 3 volumes produced
4	40	III	Urban drainage in Arid and Semi-arid Climates, edited by M. Nouh	In collaboration with International Research and Trainaing Centre on Urban Drainage
5	47	-	Ecohydrology- Hydrological and Geochemical Processes in Large River Basins, edited by M. E. McClain and M. Zalewski	A summary of the International Symposium, Manaus, Brazil, 15-19 November 1999
6	48	-	Public Participation in the Design of Local Strategies for Flood Mitigation and Control, by B. Affeltranger	The follow-up activities of the UN International Decade for Natural Disaster Reduction (1990-2000)

Contd...

Sl.No	Document No.	Volume No.	Name of the Report	Remarks
7	49	II	Present State and Future Trends of Karst Studies, edited by G. Guney, K. S. Johnson, D. Ford and A. T. Johnson	Proceedings of the 6th International Symposium and Field Seminar, Marmaris, Turkey, 17-26 September 2000
8	50	-	Guidelines on Non-structural Measures in Urban Flood Management, by I. Andjelkovic	In collaboration with International Research and Trainaing Centre on Urban Drainage
9	53	-	Negotiation over Water, edited by U. Shamir (Under Working Group 4.1 on International Water System: Conflict Analysis and Resolution)	Proceedings of Haifa Workshop on Negotiation over water: Conflicts, Results and Techniques, held in Haifa, Israel, 25-27 May 1997

Following close river system, an integrated land development approach to mitigate flood effects in the flood plains was adopted to preserve the natural course of water actions and to optimize the social benefits in regulating the flood plain river ecosystems of the Upper Mississippi River catchments in the United States (Sparks et al. 2000). Such ecosystem approach was proved to be the best for land management and water resource use in the context of establishing strong land-man relationship in specific geo-environment. But it does not provide a sound base for mitigation of flood hazards of flood plains.

In spite of development of a variety of models and approaches and simultaneous use of modern techniques of getting the optimal solutions for minimizing the risk factors and managing the land resources (like high resolution geo-spatial images, accurate Global Positioning System, and improved degital techniques), the issues of 'near exact' predictions of hazardous events and optimal resource use are still unresolved. Frequent and intensive parallel investigations and modern monitoring system of environmental events may provide more clues and exactness in predicting the severity of events and minimizing their risks through quick decisions, precursors and foremost relief.

4. The Output

Denudation (the removal of surface material by natural forces), that is an indication of disequilibria over the surface, is largely associated with three natural processes and energy equations.

(i) The gravitational energy through which the processes of removal of surface material keep on working over surface material continuously until a critical threshold level of the response to these processes reached. The responses of such processes are in the form of the 'mass-movement'.

(ii) Molecular stress through the chemical and physical processes over the surface is responsible for a static activity that is the 'weathering'. Soils and upper lays of rocks are always exposed to weather conditions and change its properties in situ.

(iii) Application of kinetic energy by moving material to the surface along with its motion (as the response to energy in its dynamic form) is associated with the intensity and extent of 'erosion'. Energy is generated by the external agents such as water, wind, glacier and surface material moves as the direction and intensity of force applied for;

$$KE = \frac{1}{2} mv^2 , \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where KE = kinetic energy, m = mass and v = velocity of a particular natural agent.

The theme of Seminar was sub-classified as per above given discussion on natural processes of land surface changes and geomorphic hazards and also followed to arrange the Seminar material coherently in the present Volume.

A number of papers discussed at the time of Seminar were drawn in its modified version from the experts of different fields such as geomorphology, geology, hydrology and agricultural sciences. The papers discussed in the Seminar and a few invited papers have been arranged in five Parts, namely, Environment and its Extremes including a summary note on the Volume, Mass-movements and Landslides, Environmental changes and Seismicity, Surface water and Flood Hazards, and Desertification. This arrangement of collected material follows fundamentally the sequences of denudation categories of geomorphic events and case studies of different events in different environments.

Three main papers on the general theme of the Seminar are included in the first Part of the Volume. Zwolinski's contribution on Arctic environment and Latocha's view on the variable extreme events brought out significant evidences on the extreme conditions of the Temperate environment have been incorporated in Part –I. Latocha emphasized on the extreme events that have great impact on redistribution of matter and energy in the geo-system prevalent on specific landscape and the interfering human activities intensify the impact of these events. The steady state condition of landforms is achieved by readjustment of material and energy in the geo-system on land surface. Exemplifying from different environmental conditions prevalent in Temperate Europe, she argued that interactions between human and occurrences of extreme events are complex and cannot easily be generalized.

The Mass-movement and landslides have been the core subject matter of the studies of geomorphic hazards and are arranged by following holistic approach in the Part-II of the Volume. In this Part, the causes of mass-movement and landslide occurrences were explained by establishing relationship of such events with weather conditions. Reviewing literature on the theme, it was obvious that the geomorphologists of Polish Academy of Sciences tried to find out the threshold levels of landslide occurrences by correlating the intensity and occurrences of landslides with precipitation and water circulation in different environmental conditions (Gil and Kotarba 1977, Gil and Starkel 1979, Thiel and Zabuski 1979, Froehlich and Starkel 1987, Gil 1997). Surface morphology and slope-failures are consequences of such events. Migon in his presented paper argues that heavy rainfall, that has direct bearings on slope-hydrology and slope-geometry, was the main cause of slope failure. The evidences of slope-failure collected from granite terrains of different parts of the world were forwarded to confirm such given relationships.

In a different mountain environment of Tertiary rocks with humid climate, the study of surface-morphology was conducted by Joshi and Rawat to understand the nature and characteristics of depositional features. Young river terraces, alluvial plains and channel bars are main features of surface morphology along the Main Boundary Fault in the Outer Himalayan foot-hill areas. They argue that the lineaments and rock structure are main causes for the development of such features which have direct bearings on the mass-movement and landslides. Another analysis of emerging geomorphic features on laterite ridges and flat valley bottoms in the humid areas of laterites was conducted by Jha. The eastern extention part of Rajmahal Trap shows evidences of changing geomorphic features.

Delineation of landslide hazard zones in hazard prone areas and their mappings are importatnt dimensions for the analysis of landslides. Such zonation was studied by using different tools and techniques. For example, Heuristic cum statistical technique for the landslide hazard zonation was used some where else by Singh et al. (2007). Landslide susceptability mapping was done by using GIS technique by Rajkumar et al. (2007). However, Surya Kant and Sapra argue on the mapping techniques of landslide hazards giving emphasis in their paper on 'fuzzy logic in GIS environment' as suitable technique for delineation of landslide hazards along road sides of Kalka-Shimla Highway. Further, Husain emphasizes on the characteristic features of landslides in Sikkem Himalaya and argues that the weathered material of sandy rocks is major cause of the frequent occurings of landslides in this part of Himalaya.

Apart from these five papers aligning the theme of this Part, one paper, which is associated with the affects of anthropogenic forces on geomorphic hazardous features, was also included in this Part. Rai emphasized more towards the effects of human activities on increasing landslides in the extreme humid tropics giving example from Meghalayan horst, which is built up of and surrounded by many thrusts and faults. Stress by new-tectonic movements on the surface of plate movement is a fundamental cause of landslides but the areas of road side cuttings are more prone to landslides.

Seismic zones have its own environment which is largely dependent on tectonic movement. It alters the environment over the earth and brings out a variety of seismic events, activities in fault zones, earthquakes and jolts on the product of such events. Papers included under Part-III are four in numbers and most of them belong to the North-Eastern Region of India that comes under Active Fault Zones and calamites by earthquakes. Gadkari et al. deal with the seismo-tectonic characteristics of the area and earthquake predictions through analyzing associated precursors. Walia et al. emphasize towards methodological issues of geophysical data, identification of Active Fault Zones giving example of Meghalaya Plateau. They tried to delineate the zone of more sensitive seismic activities by considering geo-physical data of four stations to identify the most sensitive areas/sites of seismic activities. Zuchiewicz and Cuong describe the geomorphic hazards in Red River Active Fault Zones in Vietnam. They argue that NW – SE segments of the Quaternary valley of Red River have evidences for considerable amount of normal slip of about .50 to 1.10 mm per year. Arun Kumar et al. comment on early Holocene deformation taking place along the Imphal River which flows from the Patkai Hills.

Papers related to the issues of the runoff and flood hazards were arranged in Part-IV in which the matters concerned with flood occurrences and their effects on different parts of the landscapes are dealt with.

Impact assessment, runoff modelling and surface and sub-surface flow actions in different environmental conditions (Temperate, Tropical and Monsoonal and Urban environments) have been coherently argued. Starkel and Soja argue that the effects of rainfall in modelling the landscape differ in the areas of different geological structure. They supported the facts on the basis of collected evidences that the foot hills of Darjeeling and Bhutanese Himalayan belt which is built up of sedimentary rocks, have achieved 2-3 times the threshold of rainfall in one century to develop clustering of environmental events and then to achieve steady state condition, while the landscape of extreme rainfall events (the southern slopes of Meghalaya Plateau) is under conditions of human interference. In the similar conditions of the Himalaya, Sarkar conducted investigation foothills of Darjeeling to find out the causes of present day flood hazards in this area. He argues that concentrated heavy rainfall is the major cause of catastrophic soil erosion and innumerable landslides which produce huge sediments to transport it to be the conditions of devastating floods at lower reaches of main rivers in the foot-hill areas.

Methodological issues on the measurement of runoff and flood for prediction of associated hazards were also argued by three experts that have been put forward here. Bora's discussion on probability of flood occurrences is more fruitful towards testing the validity of the measurement of flood occurrences for monsoon hydrological regime. He argues that Gumbel's Extreme Value Distribution is most suitable for predicting flood frequencies in the extreme rainfall areas of North - East India. Kale argues that the measurement of energy by flood for geomorphic work is a prime aspect to understand the flood hazards. Having prepared flood hydrographs at daily discharge data for the Garudeshwar gauging site in the lower Narmada basin (located in the central part of India), he measured the stream power and compared with the flood hydrographs. Singh suggests in his paper a simple method of Unit Hydrograph for modelling runoff events in the river catchment.

Similarly, empirical model was suggested by Prokop to understand the intensity and extent of soil erosion in the extreme rainfall conditions of Cherrapunji area where it annually receives an amount of about 12,000 mm rainfall. The effects of floods on displacement of settlements in the catchments of third order tributaries of Brahmaputra basin are analysed by Syiemlieh and Barman with the arguements that the acceleration of depositional processes through flood occurences have severe impact on settlement in the humid conditions of Brahmaputra plains. Similarly, the nature and characteristics of flood hazards in temperate environment was described by Gebica by analysing the structures of splays in the areas of Carpethain foreland and argues that the such structures have high energy depositional environment in the flood areas.

Flow of sub-surface water and its quality are important dimensions to understand the risk of human and plant health hazard which is linked with the ground water quality. The analysis put forward by Shiv Kumar et al. shows the periodic variations of chemical quality of ground water in the shallow aquifers in the plain of western Uttar Pradesh. They traced out its effects on agriculture in biological crop hazards. Padmaja et al. contributed over a significant theme as urban flood scenario and argues that urban environment of Hyderabad city is largely influenced by the floods frequently occurred in Musi River passing through the city which creates havoc and disturbs urban system.

There is only one paper under theme of Desertification and Hazards which is arranged in Part-V. The paper was presented at the time of Seminar by Sharma et al. on land degradation in the semi- arid environment of the Thar Desert (Rajesthan). The effects of salinity of soils (high pH values) on the changes in land surface and land use were shown. The study brought out with the conclusions that the alkaline soils are major causes of deforestation and gully formation in the landscape of this area.

5. Concluding Remarks

The theme of the Seminar had a wide coverage with discussions that extended to paleo-geo-environment, present-day processes and geomorphic forms, geological and historical events and their impact, risks in different environment over the earth, environmental monitoring and risk analysis, stress on landforms due to anthropogenic factors, and the development of tools and techniques for prevention of geomorphic hazards. Yet, more emphasis was laid on the 'process-form' reasoning with comprehensive discussion on geological processes and geomorphological forms during the Seminar. However, technological interference and ever increasing demand on environmental resources disturb the ecosystem functioning of the landscape and enhance the risk of geomorphic hazards. Therefore, there is a need to review and re-assess the effects of environmental changes on landscape and the possible hazardous consequences that might follow.

There are many papers on hydrological events and associated hazards, a moderate coverage on mass movement and seismic activities, and a few papers on paleo-geo-environmental study. There remained still some important areas of environmental concern which could not be discussed.

1. The environment of arid zones across the world and hazards associated with the action of winds like Tropical disturbances (wind speed less than 63 km/hr), Tropical storm (63 to 119 km/hr) and Hurricane (more than 119 km/hr) (Dikshit 2006) which shape the land features in the arid lands. These remain to be investigated intensively.
2. More emphasis is to be given on modelling the effectiveness of floods and erosion processes in the close system of movement of matter and energy over the landscape (Hire and Kale 2006). Return period of an event, persistence of extreme event, interaction between extreme event and human activities and human influence on occurrences of events are major issues that could lead to a better understanding of the changing environment and occurrences of events.
3. Modelling on hydro-geological parameters (sub-surface and ground water movement) in understanding the nature of geomorphic events and prediction of geomorphic hazards (Elango and Jaykumar 2001) is to be strengthened. It is an important dimension of the integrative analysis of geo-environmental changes and associated hazards.
4. Human impact assessment and geomorphic hazards in micro areal frame are important dimensions to protect the environment.

However, collections of modified papers and research material have been arranged in different Parts of the present Volume which will be a step in this direction to give wider coverage on the main theme of the Seminar.

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