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Mailing Address

Disaster & Development
National Institute of Disaster Management
Ministry of Home Affairs
Government of India
IIPA Campus, I.P. Estate, Mahatma Gandhi Marg, New Delhi -110002
Phone: 91- 11 -23702445, Fax: 91- 11- 23702446

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Contents

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Contributors

- Abhijat Abhyankar, Assistant Professor, National Institute of Construction Management and Research, Pune.
- Abinder. S.Chadda, Executive Engineer, Irrigation and Public Health Department, District Bilaspur, Himachal Pradesh.
- Ajay Singh, Research Scientist, Shailesh J. Mehta School of Management, IIT Bombay.School of Management, IIT Bombay.
- Anand Parwardhan, Professor, Shailesh J. Mehta School of Management, IIT Bombay. IIT Bombay.
- Hamendra Dangi, Assistant Professor, Faculty of Management Studies, University of Delhi, Delhi .
- J.S. Murli, Senior Specialist (Medical Preparedness), NDMA, Govt. of India.
- K.J. Anandha Kumar, Associate Professor, National Institute of Disaster Management, New Delhi.
- Kiranmay Sarma, Assistant Professor, University School of Environment Management, Guru Gobind Singh Indraprastha University, Sector 16C, Dwarka, New Delhi.
- Madhuri S. Rishi, Department of Environment & Vocational Studies, Punjab University, Chandigarh.
- Muzaffar Ahmad, Honourable Member, National Disaster Management Authority, Govt of India
- Nandlal L. Sarda, Professor, Department of Computer Science and Engineering, IIT Bombay.
- Prashant Kumar, Inspector General (Provisioning), I.T.B.P., Ministry of Home Affairs, India
- Rakesh Kumar Sarmah, Research Fellow, RS and GIS Division, North Eastern Space Applications Centre, GOI, DOS, Umium, Meghalaya.
- Reshma Praveen, Jharkhand Space Application Center (JSAC), Department of Information Technology, Government of Jharkhand.

- S.K. Barik, Professor, Department of Botany, North-Eastern Hill University (NEHU), Mawlai, Shillong , Meghalaya.
- Sreeja S. Nair, National Institute of Disaster Management, Ministry of Home Affairs, New Delhi.
- Sunanda Dey, Project Associate, National Institute of Disaster Management, New Delhi.
- Swati Singh, Project Associate, Indo German Environment Partnership, GIZ India
- Venu, Department of Environment & Vocational Studies, Punjab University, Chandigarh.
- Vidya Satija, Intern, National Institute of Disaster Management, Ministry of Home Affairs, New Delhi.
- Vivek Kumar Singh, Department of Mining and Geology, Corporate Ispat Alloys Limited, Abhijeet Group, Nagpur, India.

Editorial Note

During the last two decades we have seen an alarming escalation in disasters and their impacts across different parts of our nation and the world, both natural and human induced disasters. In the year 2012, India witnessed many natural and human induced disasters. Notable amongst are Assam Floods (June-August), Flash Floods and Landslides in Uttarakhand (August), Himachal Pradesh (August-September), Cyclone Neelam and Floods in Andhra Pradesh (October), Blast in Vishakhapatnam Steel Plant (13 June), Fire Accident in Tamil Nadu Express (30 July), Dubri Boat Capsize, Assam (30 April) and so on.

Wide range of disaster management related research is going on in our country at universities, research institutions, science and technology departments and response agencies. NIDM through "Disaster and Development" Journal promotes a comprehensive and dynamic perspective, providing readers with up-to-date information regarding the evolving nature of the research in the field of disaster risk reduction. Recognizing the inherent links between disaster and development, the journal aims to serve as a bridge between them, encouraging exploration of their underlying relationships, interactions, and synergies. The journal also serves as a bridge between the researcher and practitioner communities, facilitating the kind of collaboration and coordination that enables them to appreciate and benefit from the associated implications and inherent connections in their fields. It is only from the intersection of these two perspectives and the interchange of ideas that the most compelling knowledge, novel insights, and best practices can emerge. The NIDM journal has an interdisciplinary approach that reflects the expanding boundaries of these two disciplines of Disaster and Development by including such contents as Health and Psychosocial issues, Geoinformatics, Environment Management, Legal and Policy issues, Natural Resources Management, Disaster Risk Reduction and Traditional Knowledge Management and so on.

I would like to extend my thanks to all the authors who have contributed papers, and the members of the editorial advisory board and reviewers, editors of the journal for the outstanding work. We welcome your comments and also contributions for the future issues of the journal.

(Satendra)
Executive Director, NIDM

Disaster Management in Hospitals: Shifting Strategy Towards Systems Approach

Muzaffar Ahmad[1] and J.S. Murli[2]

Abstract

The risks and vulnerability of hospitals to different disasters require a modified strategy to plan for adequate preparedness towards mitigating the impacts and sustain functionality of services during emergency situations. The systems approach is a purposive viewpoint that addresses holistically and comprehensively the various concerns and gaps in the disaster management cycle. The approach necessarily focuses on the underlying causes of disasters, the pre-conditions of disaster risks and the vulnerability of the community. This article recommends integrating structure, process and outcome measures with disaster risk management strategy into a systems approach model for disaster management in hospitals.

Key Words: Disaster Management, Disaster Rsk Management , Systems approach, Structure, Process and Outcome

Introduction

A large number of natural and man-made disasters have been witnessed globally that resulted in enormous loss of precious lives and massive destruction of property. India due to its unique geo-climatic and topographic conditions remains vulnerable to a variety of hazards. About 59% of our landmass is prone to earthquakes, 40 million hectare of land is prone to floods, about 7500 km of coastline is prone to cyclones and almost 68% of total geographical area is vulnerable to droughts. The heavy toll, caused by such hazards, of precious lives and infrastructure including health care establishments has led to significant setbacks to the economy of the nation. For instance, the Gujarat earthquake in 2001, with Bhuj at its epicentre, killed more than 17,00 people and destroyed nearly 3812 health care institutions (WHO, 2009). These incidents exposed the poor state of preparedness of our hospitals. The frequent episodes of disaster events in the country have accentuated the need to adopt a multi-dimensional endeavour involving diverse scientific, engineering, financial and social processes.

1. Honourable Member, National Disaster Management Authority, Govt of India
2. Senior Specialist, National Disaster Management Authority, Govt of India

Some Historical Data...

- **Gujarat Earthquake (2001) : 3812 health care facilities destroyed**
- **Indonesia Tsunami (26 Dec 2004) : 30 health facilities destroyed and 77 damaged seriously**
- **Sri Lanka Tsunami : 92 facilities including 35 hospitals destroyed**
- **Muzaffarabad (2005) : 49% health facilities destroyed**
- **China (Sichuan) earthquake (2008): 11,000 medical institutions destroyed**

(Source: WHO, FAQ on WHO Day, 2009)

Shifting Strategy from Traditional to Modern Approach

Hospitals, like any other establishments are vulnerable to both natural (Earthquake, Floods, Tsunamis, Cyclones) and human-made disasters (Accidents, Fires, Terror attacks). Traditionally, the approach to disaster management has been focussed on anticipating and responding to natural or man-made hazards and responses have been mainly directed towards relief and rescue operations and rehabilitation. Government of India have brought about paradigm shift in the approach to disaster management that helped in gaining better understanding of the variables determining the intensity and extent of disaster impacts and thus aim at designing and implementing a mechanism to either eliminate the actual causes or at least mitigate the impact of disasters. Hospitals are vulnerable to damages, both structural and non-structural, when exposed to disasters of various kinds. In case of hospitals, implementing quality improvement programme along with an 'All-Hazard' approach to emergency preparedness is considered ideal.

Need for a Modified Approach

The enactment of Disaster Management Act in 2005 provided a great impetus to the institutionalisation of the mechanism of disaster management at the national, state as well as district levels in India. Further, the modern day disaster in form of terrorism related events have also necessitated authorities to frame steps for better action plans and strategies for hospital preparedness to such events. The new disaster management policy also emanates from the belief that investments in preparedness and mitigation are much more cost effective than expenditure on relief and rehabilitation.

Historically, the approach was directed towards providing post-disaster relief and rehabilitation. The changed policy/approach, however, mandates a priority to all aspects of disaster viz. mitigation, prevention and preparedness. Typically, the disaster management system should address three distinct phases viz. pre-disaster planning (early warning), activities during the disaster (response) and post-disaster (includes relief, rescue and rehabilitation). This new approach can easily be translated into a road map covering an institutional mechanism along with risk reduction and disaster prevention strategy, early warning system, disaster mitigation, preparedness and response, and human resource development (Guzman, 2003)

Systems Approach

Systems are dynamic architectures of interactions and synergies among various sub-systems and processes. Systems approach includes identifying, understanding and managing interrelated activities or processes within the system that contributes to effectiveness and efficiency in achieving desired objectives. While considering the hospital as a system, a thorough assessment of various interrelated and interdependent components with respect to all aspects of safety and security is crucial. The systems approach is a purposive viewpoint that addresses holistically and comprehensively the various concerns and gaps in the disaster management cycle encompassing all aspects related to hospital system. In this regard, it necessarily focuses on the underlying causes of disasters affecting the hospitals as well as the risks and vulnerability of the hospitals to various disaster situations. It further emphasises multilevel, multidimensional and multidisciplinary cooperation and collaboration for effective disaster reduction and response (Simonovic, 2012).

Systems thinking, in disaster management, aims at enhancing the ability to make better decisions in developing preparedness and response mechanism keeping in view the overall aspects of risks and vulnerability. It encompasses building a sound framework for risk reduction while using existing resources, selecting scientifically designed buildings, safe transportation systems, effective communication networks, adequate & competent educational and medical facilities, appropriate processes, suitable waste-disposal techniques, better crime prevention methods, etc.

Disasters cannot be seen as isolated random acts of nature. Rather, they are consequential evidence of poor risk management and inadequately handled interconnected social and physical processes; that can increase risk and vulnerability to even modest threats. Hence, a systems approach that integrates a multi-dimensional concept of disaster risk management and the structure, process and output directed interventions need to be adopted and further nurtured for a robust disaster management strategy.

Not Every Hazard is a Disaster !

Hazards have always been an integral part of our environment. Any phenomenon, event or occurrence which has varying degree of potential to cause loss or injury to life or damage to property or the environment can turn into a hazard whetherdue to naturally occurring causes e.g. flood, tornado, volcano eruption, earthquake, landslide or human-induced e.g. terror attacks, bomb blasts, CBRN (Chemical, Biological, Radiological and Nuclear) hazards. However, a mere exposure to a hazard does not necessarily mean disaster. Hospitals are very sensitive and important public places. It is vital to anticipate and assess the consequences of exposure to a hazard in terms of magnitude of the phenomenon, the probability of its occurrence, and the extent and severity of its impact.

Risk and Vulerability

Risk, in disaster management refers to the probability of loss or injury to life and property as a consequence to exposure to a potential disaster event. UNDHA (1992) refers risk as a product of social vulnerability and hazard. Let us illustrate by taking the example of two persons crossing the ocean-one in an ocean liner, the other in a rowing boat. It is clear that although in both cases, the main hazard i.e. exposure to deep ocean waters and waves remains the same, the risk is far greater in case of the person rowing the boat as the rowing boat is more vulnerable to the impact of the waves. Vulnerability refers to the susceptibility of a community to any hazard and the prevailing conditions, including physical, socio-economic and political factors that adversely affect its ability to respond to such events. Vulnerabilities can be manifested as physical, social, or attitudinal vulnerability.

Systems Approach Model for Disaster Risk Management

Risks occur if we cannot control the relations within this system and if we don't know the impacts of changes in the environment. Hence integrated risk analysis and risk reduction techniques should be in place for achieving the desired objectives. The starting point of an integral risk management concept is the relation between hazard, vulnerability, risk and risk management. World Institute for Disaster Risk Management (DRM) is a network for applied research, implementation and dissemination in the field of disaster risk management and provides the framework for major contributions towards an integrated risk management and a sustainable risk prevention culture. Systems approach requires

of tools for an overall risk mitigation by developing methods and measures to support prevention and intervention activities such as monitoring, forecasting, early warning and decision-supporting tools for frontline decisions (Bieri (n.d)).

Risk management is the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risk. As a process, it includes analysing the risk, estimating its potential effects, and determining its importance in the scheme of things. It includes an evaluation of all the elements that are relevant to an understanding of existing or probable hazards and their effects on a specific community or environment. When considered in socio-economic and political terms, such evaluation enables the determination of appropriate vulnerability reduction, prevention and mitigation, as well as preparedness and response strategies.

Risk and Vulnerability Analysis

Risk or vulnerability analysis is a technical evaluation process for identifying hazards and estimating the probability of their occurrence and consequences under certain given conditions. A facility audit, at the initiation of the process, to identify structural or non-structural damages would aid immensely in progressing further. The WHO has created Hospital Safety Index (HSI) that can be used to evaluate how safe a health facility is. These assessments then can be further compared with a standard or pre-defined criterion in order to decide whether or not some interventions are essential to protect people, property, or environment from a potential hazard.

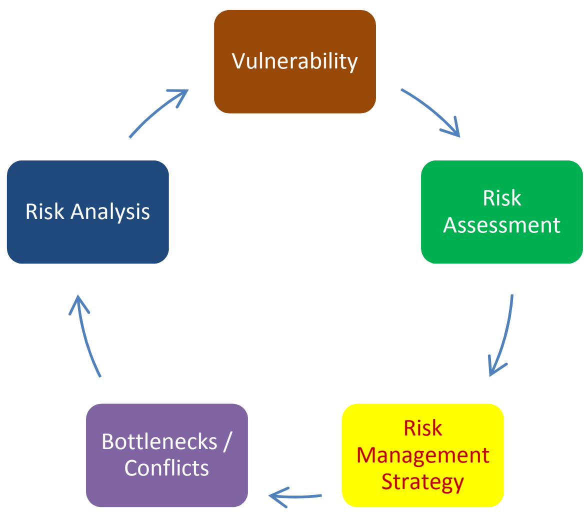

Figure 1: Risk and Vulnerability Analysis

Risk analysis and risk management as a process

Risk analysis is the systematic use of available information to determine the likelihood of occurrence of certain events and the magnitude of their impact. It includes the following activities:-

- identifying the nature, extent, and risk of threat;
- determining the existence and degree of vulnerabilities;
- identifying the capabilities and availability of resources;
- determining acceptable levels of risk, cost-benefit considerations;
- setting priorities relative to time, resource allocation, effectiveness of results;
- developing methods to protect people and key resources and reduce overall losses; and
- designing effective and appropriate management systems to implement and control.

An ideal model of systems approach as adopted by DRM links together the elements of risk analysis, vulnerability, and risk assessment.

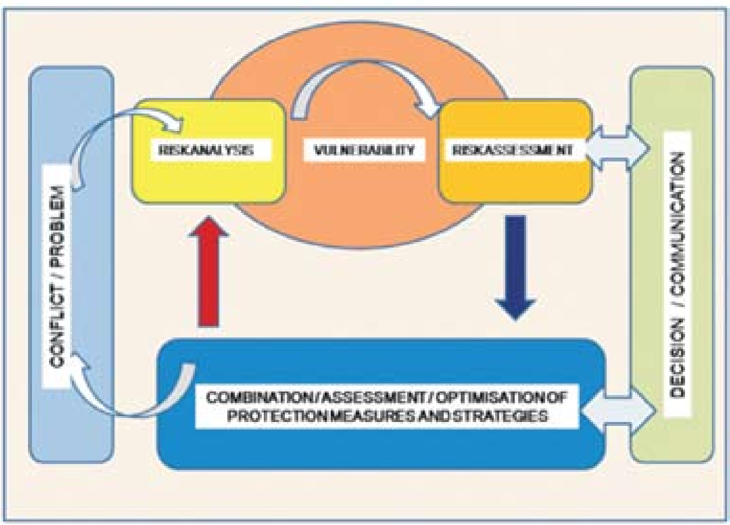

Figure 2: Systems Approach model for Disaster Risk Management

Quality Concept and Hospital Disaster Management

Hospitals bear a distinct threat and vulnerability to hazards. It is not only the precious lives of patients and others in the hospital that are at risk, but also the costly infrastructure including sophisticated latest medical devices and professionally competent human resource are equally vulnerable to loss / damage. The dependency of community on a hospital during the time of a disaster further adds to its uniqueness in the need for a more secure mechanism of maintaining safety from potential disasters.

The popular saying in Armed Forces "The more we stress in peace, the less we bleed in war", clearly applies here. It really matters how much care was taken in anticipating each aspect separately and how much of effort was put in for rectifying defects before re-implementing process. The more attention given for structural safety, process safety and implementation aspects, the lesser is the risk and vulnerability to hazards.

Structure, Process & Outcome Model

The recent developments in the field of quality in health care and accreditation standards for hospitals have established new scope for safety and security. The interrelatedness and interdependency between structure, process and outcome aspects of hospital system, as described by Donabedian, brings new horizons in systems thinking towards disaster management for hospitals.

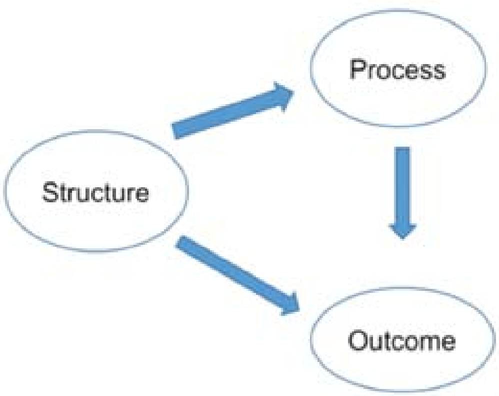

Figure 3: Structure, Process and Outcome Concept

If we closely analyse the adoption of systems approach emphasises on each element of the Donabedian model discretely, some important interventions would include appropriate measures and activities directed towards minimising the magnitude of vulnerability in each aspect i.e., structure or design activities, process driven and implementation activities and outcome or evaluation activities coupled with definite corrective steps wherever necessary.

Structural Measures

- Site plan & Design of the building as per local safety norms/safe building codes.
- Provision of safety mechanism e.g. seismic proofing, flood proofing, fire proofing, etc.
- Equipment and installations adhering to safety standards and secured safely (fall proof).
- Trained and competent staff.
- Effective communication network system with emergency backup facility.
- Mobile field hospitals
- Capacity building among civil defence and healthcare workers.
- Hospital Safety Index and facility audit

Process Measures

- Comprehensive operational & preventive maintenance plan.
- Fire fighting drills, Periodic checks for functionality of fire safety devices.
- Regular mock drills with and without involving patients.
- Mitigation measures such as Early Warning system, etc.
- Capacity development programmes e.g. regular training for Medical First responders.

Outcome Measures

- Performance indicators to assess implementation strategies and initiate appropriate & timely intervention.
- Rehabilitation activities to contain further loss of lives and restoration of working population.
- Media Management to encourage relief and rehab activities rather than ndulge in unnecessary political vandalism.
- Evaluation Mechanism including Feedback systems for continuous improvement in all activities. including feedback systems

A systems approach model involving various activities and interventions addressing each aspect i.e. structural safety, process safety and safety during their implementation which can be applicable to hospitals, is depicted in the figure below.

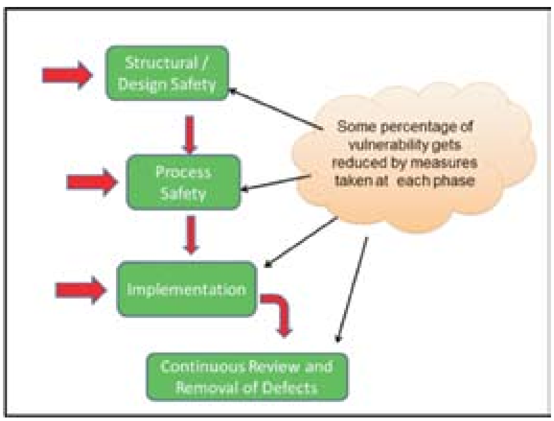

Figure 4: Systems thinking and reduced vulnerability to disasters

Govt Initiatives and Role of Multiple Agencies

In today's fast changing global environment, the detrimental consequences of disasters on society, economy, natural environment, and even politics, cannot be overemphasized. Moreover, socio-economic studies have revealed that the secondary effects and indirect costs of damages to hospitals due to disasters have long-term effects on societies, regardless of their level of development.

The pre-hospital care in the country is grossly deficient. The on-ground experience and constraints during various disaster situations have necessitated the requirement for ambulatory services by way of ambulances and standby containerised or modular field hospitals for an early deployment and immediate treatment in the eventuality of hospital themselves becoming victims of internal or external disasters.

The JPN Apex Trauma Centre, New Delhi has been identified as the nodal agency by National Disaster Management Authority to create a pool of skilled first responders by organising capacity development programmes and pre-hospital Trauma life support training. These trained personnel will contribute not only by applying their knowledge and skill during an emergency, but also disseminate their experience to others at their respective areas of working. Similar initiatives have also been taken at state level e.g. establishment of Shushruta Trauma Centre at LNJP Hospital in Delhi, schemes for establishing Trauma care centres at most of the National Highways such as Mumbai-Pune Highway, a centre with Sassoon Hospital Pune, etc. Such measures would minimise the consequences of hazards, although with limited effect on the risk and vulnerability.

Conclusion

The vulnerability to different types of disasters require an assessment of the potential risks and possible hazards that can affect the hospital system. The multi-dimensional role of hospitals and its long term economic and socio-political impact further necessitates a shift in the approach to preparedness. Systems approach is one of the several essential tools for restructuring the relationships within the health system. The approach intends to integrate, complement, and enhance the existing disaster reduction and response strategies along with adoption of quality concept for disaster management in hospitals. With leadership, conviction and commitment, systems thinking can open powerful pathways to identify and resolve health system challenges.

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Groundwater Management during disasters in India

K. J. Anandha Kumar[1]

Abstract

The disasters events that occurred in the last three decades in India have also affected the water resources of the respective areas in various ways, some times in a deteriorating way, initiating response from the stake holders of the area. So far, the action of these stake holders in general, have been, playing the role of a responder to the disaster. The learning from these experience can be utilized for coping with such future events. The Groundwater plays a vital role to restore water supply in an area affected by disaster, especially during the recovery and rehabilitation period. The scientific knowledge of occurrence and movement of this precious, invisible resource through various hydrogeological surveys, exploration and monitoring will help to protect and utilize this resource at the time of disaster. Further, in the changing scenario with paradigm shift in disaster management policy towards disaster preparedness from that of responsive role, the experience gained, knowledge, expertise and data base available, can help to achieve the reduction of the impact of the disaster by protecting the available fresh water sources and restoring the potable water supply with minimal loss of time. The experience of impact of disaster on groundwater regime and its management are discussed in this paper.

Key words : Groundwater, ground water management, disaster and groundwater

Introduction

The disaster events which occurred in the last two to three decades in the country, like the Severe drought of 1987, affecting several parts of the country, Super Cyclone of Odisha of 1999, the Bhuj earthquake, Gujarat of January, 2001 and the Tsunami of 26th December, 2004, which hit the coastal areas of southern India, remind us of the disaster it created and its impact on water resources. This also showed us, how these disasters have ruined the life of millions, as preparedness to face such events were not in place. Such events may recur as seen else where in the world like the recent cyclone of Myamnar (May, 2008), the earthquake of China (May, 2008) and the very recent earthquake followed by tsunami of Japan (March, 2011). The various

1. Associate Professor, National Institute of Disaster Management, New Delhi

Governmental agencies can prepare a management plan to act in such events to restore the normalcy to these areas as early as possible, using the scientific knowledge and expertise we have gathered over the years about the natural resources. The constitution of National Disaster Management Authority, State Disaster Management Authority and the District Disaster Management Authority after the enactment of Disaster Management Act 2005 are examples of some of the steps initiated by the Government in this direction.

World wide figure shows that floods represented 50% of the disasters between 1990-2001 and drought 11% and Asia faced 35% of all water related national disasters during the same period (UNESCO, 2006). In terms of life too, drought claimed the greatest number of victims during the same period, world wide.

Need for drinking water

When everything is shattered, the human and cattle population of the disaster affected areas, will require first and primarily, the potable water to drink for survival apart from food, fodder, clothing etc. The experience in the above mentioned disaster events of our country has also shown that the primary effort of different agencies were to restore water supply for drinking, though on emergency basis packaged drinking water is distributed. If the area is naturally endowed with fresh groundwater, it will be justifiable and economical to develop/redevelop groundwater, as it is available at the place of requirement.

National Disasters – Indian Experience

Super Cyclone of Coastal Odisha

The Super cyclone that hit the coastal Odisha, in the eastern part of India, in October, 1999, created unprecedented havoc for the human life, cattle and property. 9893 people died and life came to a stand still for several days (Gupta, M.C et al, 2001). It took several months to limp back to normalcy. During the super cyclone of October 1999, well hydrographs (Figure 1) showed sudden rise only to decline of the normal level within a short period. Except in the fringe areas of the coast where the dug wells were contaminated by seawater flooding, there was hardly any effect of cyclone on the tube wells and ground water regime (Das et al., 2005). The contaminated wells were also developed for several days to pump out the saline water accumulated in the well to try to improve the quality groundwater.

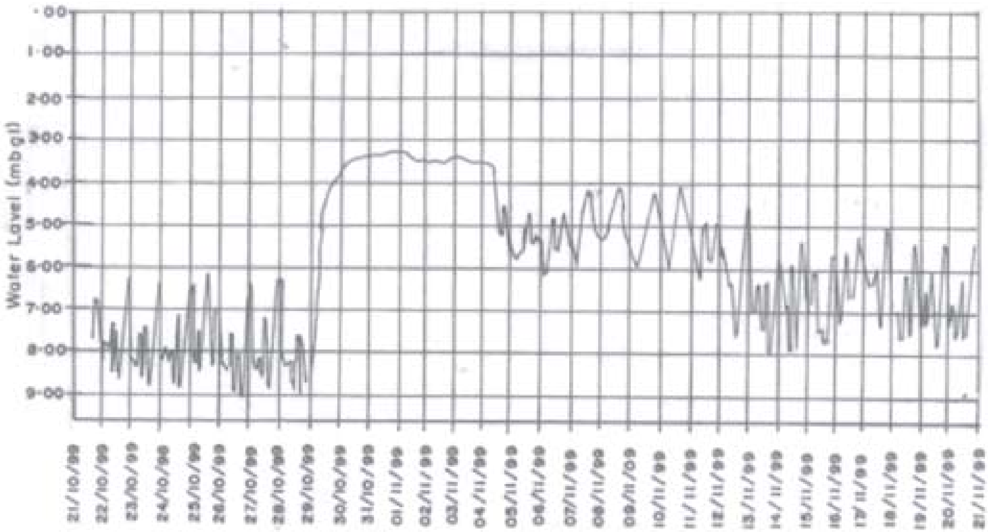

Figure 1: Hydrograph of network stations at Bhubaneshwar showing abrupt rise in water level which indicates effect of cyclone of 29th Oct 2009

This experience has shown that for drinking water supply during such events, it is important to identify the areas which are likely to be submerged by sea water flooding and also the time period for which it will remain submerged, so that alternative water supply can accordingly be planned. To overcome the effects of flood, mapping of vulnerable areas which may include, identification of aquifers which have substantial resources and that are not likely to be affected by floods have to be carried out to face such events in a planned way. Thus the experience during the Super cyclone of Odisha could establish a fact that the ground water remains a sustainable resource even in periods of cyclones.

Frequent droughts

Over all, considering deficiency in rainfall, India's two third of the arable area is at one time or other susceptible to drought (Subbiah, 1993). A study which analysed the rainfall data of the country from 1875 to 1998, for 124 years noted that there were three occasions i.e. during 1877, 1899 and 1918 when percentage of the country affected by moderate and severe drought was more than 60 percent, which indicated the severity of the situation. During the period from 1871 to 2009, India experienced 27 major droughts. According to the Emergency Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED) report, droughts affected nearly

1,061 million people and killed nearly 4.25 million people in India during 1900-2007. Droughts are very common in some parts of our country. The governmental agencies have even demarcated some areas as drought prone from the experience of recurrence of such droughts. These include parts of Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu, Bihar, Jharkhand, Uttar Pradesh, West Bengal, Odisha, Haryana and Jammu & Kashmir. Droughts are responsible for degradation and desertification of nearly a third of the world's arable land (UNESCO, 2006). The drought of 1987 was one such event which affected several parts of our country. Low rainfall adversely affected the ground water recharge. The effects of rainfall scarcity on ground water regime were systematically studied in the drought year of 1987 in selected observation wells of Odisha. The study generally showed a nominal decline of ground water level to the tune of 0-2 m in the coastal areas except in Baleswar district where the steep decline in water level of the order of 2-4 m was due to accentuated withdrawal of ground water during the drought period. The piezometric levels of aquifers deeper than 100 m had been less affected than the upper groups of aquifers. This may be due to excessive withdrawal of ground water during the drought period through shallow tube wells (Das, 2005).

This experience has also shown that the deeper aquifers identified can be utilized even during drought situation as they are less affected as seen in the discussion above. In Rajasthan identification of deep (100 to 500 m deep) aquifers like Lathi Sandstone with an aerial extent of 3,270 Sq km has proved useful during drought. The management solution of drought is usually preventive, as well as mitigating the drought. The long term preventive methods include integrated use of surface and ground water, water conservation (through contour bunding, gabbion structures, gully plugs etc), artificial recharge of ground water (through percolation ponds, check dams, rain water harvesting using roof top, paved areas etc.) and induced recharge.

Bhuj Earthquake

Drastic changes in the groundwater level were observed during several earthquakes. The extent of the change (fluctuation) of groundwater level depends on the earthquake's magnitude, distance from the epicentre and earthquake source mechanism. The earthquake of 26th January, 2001, destroyed the entire city of Bhuj (in the state of Gujarat, Western part of India) and 800 villages around, disrupting the entire water supply system. The digital water level recorders showed fall and rise in water level during and afer the earthquake. There was no significant change in the quality of water drawn from dug wells and tube wells located in different formations (Chadha et al., 2006).

Remote sensing data aided by detailed geophysical survey was carried out to identify drilling sites as an immediate step after this earthquake on war footing. To restore water supply nine deep drilling units were engaged to drill tubewells were mainly confined to Bhuj Cretaceous sandstone. About 55 tube wells were drilled in the depth range of 70 to 156 m to utilise 45 of them. The total water supply of 20,000 cubic metre could be restored initially and then slowly other tube wells were also rehabilitated and water supply restored (Chadha, et al., 2006).

Tsunami

Tsunami is a wave of high energy, which is generated by an earthquake or landslide in the sea. An earthquake of 9.3 magnitude on the Richter scale struck the active subduction corridor along the eastern margin of the Indian lithosphere off the coast of Sumatra in Indonesia. The waves reached Andaman and coasts of Tamil Nadu and Andhra Pradesh. These sea waves on reaching shallow water were transformed into forceful tidal waves of great heights (10-30 m) creating vast damages. Unlike Super cyclone of Odisha, the sea water intrusion due to tsunami adversely affected the groundwater, in terms of quality and quantity. The water level declined by 0.5 to 5.5 m after the Tsunami. The Tsunami waves also resulted in the intrusion of saline water up to 2 km inland at some places. It damaged several hand pumps that were being used as drinking water source in rural areas. Pumping was continued for several days in dug wells to pump out the brackish water which entered these dugwells due to tsunami. The groundwater that remained unaffected was utilized for drinking water needs, immediately. And further new tube wells were drilled to meet the water requirements in other areas especially in Andamans (Keshari, et al., 2006). How ever this event also showed that there should be management plan in place to face such situation.

Groundwater resource, monitoring and database

Groundwater resources comprises of two parts namely dynamic, in the zone of water table fluctuation and static resources, below this zone, which usually remains perennially saturated. As per the India's National Water Policy, 2002, the dynamic groundwater resource is essentially the exploitable quantity of groundwater, which is recharged annually, and is also termed as replenishable groundwater resource. The annual replenishable groundwater resource of the country is estimated to be 433 billion cubic metres (bcm) and the net groundwater availability is 399 bcm after allocating 34 bcm for natural discharges during non-monsoon season. The annual groundwater draft for the year 2004 was 231 bcm, out of which 213 bcm is utilised for irrigation and 18 bcm is used for domestic and industrial purposes (Chattejee, 2009).

Hydrogeological approach in disaster areas will vary depending upon the aquifers, its disposition and geomorphological conditions for example, the area affected by earthquake will have different impact from the one affected by tsunami in the coastal areas. The shallow aquifers in large alluvial river basins can be substituted by deeper confined aquifers of the underlying geological strata. Development of static ground water resource is one of the solution when the dynamic resource is contaminated or quality deteriorated due to the disaster. This will be more appropriate in case of drought in the arid regions also.

The hydrogeological survey of the entire country has already been carried out by different agencies and some areas were even covered for detailed survey. The groundwater levels of the shallow and deeper aquifers are being monitored by the national (Central Ground Water Board, Ministry of Water Resources) as well as State level agencies dealing with groundwater since 1969. Quality of groundwater is also monitored generally once a year by these agencies. Groundwater renewability in general is considered in terms of recharge, discharge and renewable time. However, during disaster situation where human lives are at stake and drinking water supply has to be restored, the groundwater from deeper aquifer or even non-renewable entrapped fossil water bodies can be utilized if they provide adequate yields. This cannot, however, substitute for regular water supply.

Thus, the available hydrogeological knowledge can be utilized for proposing suitable alternative to reliable groundwater resource in case of such natural disasters, using the experience gained from these disasters. This will form some measures for the exploitation of groundwater when the country is facing such situation in the future. Renewable supplies of groundwater tend to be more reliable than surface water supplies and groundwater storage affords the possibilities of enhancing the quantity and often the quality of available supplies. Groundwater and groundwater formations are especially valuable in time of intensifying scarcity. Groundwater will become increasingly important as a buffering resource in the time of drought and as a resource that can be managed more intensively to enhance water availability and quality in the time of chronic and acute scarcity (Henry, 2011).

A conceptual groundwater model can also be developed for various basins/sub-basins initially, with the available data base and the confidence level of this model can be enhanced when it is updated by more data which is made available and when it is tested by the events. Mathematical model is the model which is used to simulate the field situation by means of governing equations thought to represent the physical processes that take place. In case of ground water simulation studies the mathematical model simulates ground water flow indirectly by means of governing equations to represent the physical processes that occur in the system, together with equations that describe heads or flows along the boundaries of the area for which the model has been developed (Anderson et al., 1992). Generally deeper aquifer is used in case of drought as discussed above and in such cases the data of deeper aquifers are not generally available like phreatic aquifer in space to have good control, for the development of model. This can often be a complicated task to achieve. However the process has to be initiated and then the required data can be acquired in due course of time to have more confidence over the model. This can be a tool for good planning and management of water resources in case of disasters.

Conclusion

The review of the major disaster events in the recent past clearly shows that groundwater resources are affected in a varying intensity. In most of the disasters discussed, the impact on groundwater was not severe. The normal or alternative water supply also could be restored in a nominal period, except when new wells were to be drilled like in the case of earthquake affected areas of Bhuj and tsunami affected areas of southern part of India and Andaman. However, keeping in view the recent experience of Japan in March, 2011 earthquake and tsunami it is suggested that there is a need for the development of data base and assessment of the vulnerability of the disaster prone areas of the country from multi-hazard point of view including groundwater to protect the groundwater resources as well to plan for the utilization of this precious resource in the event of any disaster. Using the knowledge, experience and the data available on quantity and quality of the groundwater occurrence and its movement, necessary steps shall be taken in this direction to protect, conserve and utilize this resource at the time of need.

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Soil Erosion Vulnerability Mapping of Nokrek Biosphere Reserve, Meghalaya Using Geographic Information System

Kiranmay Sarma[1], Rakesh Kumar Sarma[2] and S.K. Barik[3]

Abstract

The present study is undertaken to find out the soil erosion vulnerability of Nokrek biosphere reserve of Meghalaya using Geographic Information System. The aspects of slope, drainage density, soil characteristics, geology and land use/ cover are taken into consideration for the study. Landsat ETM Remote Sensing data are used for preparing the land use/ cover map. For slope and drainage density mapping source of data was SOI topographical maps. Geology and soil maps are prepared based on the available literatures. Classification of satellite imagery shows that about 86 percent area of the biosphere reserve is covered by forest. But about 9 percent area is utilized by shifting cultivation irrespective to the vulnerable geological, edaphic and geomorphological factors. The biosphere reserve attains more than 60% area with slope more than 22 degrees. It is again found that only about 11 % of the biosphere reserve area falls under low drainage density and could be considered as stable zones with good vegetation cover. Remaining areas are recognised as vulnerable if they do not have proper vegetative cover. Weighted overlay multicriteria analysis of GIS is applied to find out the spatial distribution of vulnerable areas in terms of soil erosion. By integrating all the thematic layers with proper weightages and influences an area of about 30 sq km from the biosphere reserve is designated as most vulnerable for soil erosion. Moderately high vulnerable area found in the study is about 77.5 sq km. The findings of this study regarding the identification of spatial distribution of areas under risk due to soil erosion could be useful for the management authority to check it from further deterioration.

Key words: *Nokrek biosphere reserve, GIS, weighted overlay, slope, drainage density, shifting cultivation*

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1. Assistant Professor, University School of Environment Management, Guru Gobind Singh Indraprastha University, Sector 16C, Dwarka, New Delhi.
2. Research Fellow, RS and GIS Division, North Eastern Space Applications Centre, GOI, DOS, Umium, Meghalaya.
3. Professor, Department of Botany, North-Eastern Hill University (NEHU), Mawlai, Shillong , Meghalaya.

Introduction

Soil erosion and sediment transport are recognised as one of the major environmental hazards globally (Pimentel et al., 1995; Shiferaw and Holden, 1999 & Bewket and Sterk, 2002).The steps involved in soil erosion could be splash erosion, which occurs when soil particles are detached and transported as a result of the impact of falling raindrops; sheet erosion, which removes soil in thin layers and is caused by the combined effects of splash erosion and surface runoff; rill erosion, which is the transport or detachment of soil particles caused by concentrations of flowing water; and gully erosion, which occurs when flow concentration increases and the incision becomes deeper and wider than rills (Mwendera and Saleem 1997; Mwendera et al. 1997; Morgan 2005). The process of soil erosion is governed by the topography, climate (weathering), soil, vegetation cover, and land use and management factors through mechanisms including particle detachment by raindrop impact, hydrology, flow hydraulics and other processes (Kosmas et al.1997; Harvey 2001; Lu et al. 2003;Bodoque et al. 2011). Soil erosion has a range of environmental impacts, including loss of organic matter and nutrients, reduction in productivity and downstream water quality degradation (Newcombe & MacDonald, 1991). Effective control of soilerosion is a critical component of natural resource management (Pimentel et al.,1995).For management and control of soil erosion,cause identification and proper delineation of vulnerable sites is pivotal. Geoinformatics tools and space based information could be utilized for identifying the potential areas of soil erosion considering various physical and anthropological aspects of an area. Geographic Information System (GIS) is well suited for the systematic estimations leading to slope stability evaluation and hazard zonation mapping by handling and analyzing various associated spatial data sets (Boroughs and McDonald, 1998 & Baban and Sant, 2004).

Soil erosion study has become a global issue as a consequence of its applied implications (Valentín et al., 2005). The study related to sheet erosion has been conducted globally depending on its contribution towards the conservation of ecologically fragile areas (Poesen et al. 2003; Smith, 2008; Godfrey et al., 2008 and Reid et al., 2010). The selection of any appropriate hazard modelling technique is dependent upon the management scale, site-specific conditions and data availability (Carrara et al., 1999). The present context could be related with numerous works carried out globally using GIS (Carraraet al., 1991; Van Westen, 1993; Van Westen et al., 2003; Armesto et al., 1978; Prakash and Gupta, 1998; Joshi et al., 2003 & Balaguruet al., 2003).The recent development in spatial data analysis using GIS tools (Issaks and Srivastava, 1989; Rossi et al, 1992; Jackson and

Caldwell, 1993) and its consequent advances allow more extensive examinations of spatial analysis (Palmer and Dixon, 1990; Reed et al., 1993; Wiegand et al., 1997; Pastor et al., 1999; Nicotra et al., 1999; Woods, 2000; Wallace et al., 2000; Palmer et al. 2000; Friedman et al., 2001; Sarma and Barik, 2010).

The Nokrekbiosphere reserve (NBR) of Meghalaya in north-east India is one of the 18 biosphere reserves notified on 1st September 1988 and has many distinct and unique bio-physical features that need to be conserved. It is a unique area with a number of rare and endangered species of plants and animals. NBR is severely affected by sheet erosion mainly because of the age old tradition of shifting cultivation in the fragile hills slopes aided by other anthropogenic activities. Shifting cultivation is regarded as one of the main drivers for this degradation (Sarma and Barik 2010; Yadav et al., 2012) (Figure 1). The heavy rainfall during summer accelerates the erosion rate in the areas which are free from vegetation cover. This indiscriminate activity within the biosphere reserve has been detrimental to the fragile ecosystem and has resulted in large-scale degradation of the landscape, soil, water and forest causing serious threat for its existence (Sarma and Barik, 2012). Vegetation is one of the major factors controlling soil erosion, while most soil erosion occurrences are due to removal of vegetation and topsoil (Bochet and Fayos, 2004).

This paper aims to identify and map the spatial distributions of different categories of risk zones of soil erosion for the management authorities to check it from further degradation. The main objectives of the study include collection and collation of data related to soil erosion vulnerability, preparation of spatial database for Nokrek biosphere reserve pertaining to soil erosion, preparation of risk map indicating various zones, and proposing remedial measures based on the outputs of the study.

Figure 1: Photograph shows the base for sheet erosion in different slopes after removing the vegetation for shifting cultivation in the buffer of Nokrek biosphere reserve

Study area

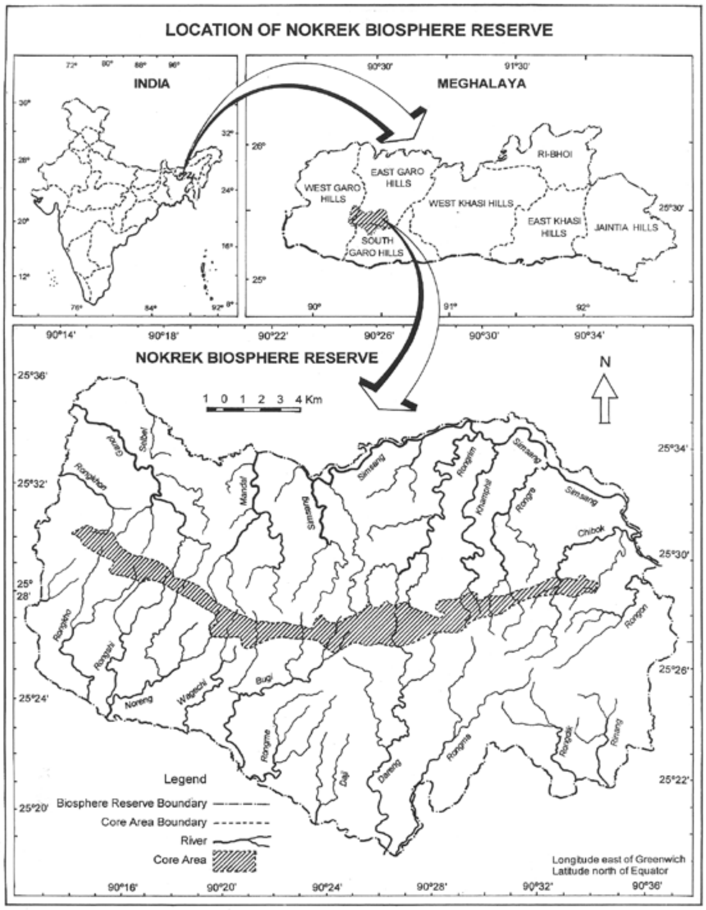

Figure 2: Location of Nokrek biosphere reserve of Meghalaya

The present study was carried out in the western part of Meghalaya, having an area of 820 sq km covering all the three districts of Garo Hills viz., East Garo Hills, West Garo Hills and South Garo Hills that has been designated as Nokrek biosphere reserve. The biosphere reserve lies between 25° 18’ 39” N and 25° 36’ 07” N latitudes and 90° 13’ 30” E and 91°37’17” E longitudes (Figure 2). NBR is located in the Tura range, which is a part of Meghalaya plateau, having an average altitude of 600 m. The highest point in this region is the Nokrek peak (1,412m) lying within the biosphere reserve. The core area of the biosphere has been designated as Nokrek national park, which is spread over an area of 47.48 sq km.

The soil of most part of the biosphere reserve is red loam and is poor in silica but rich in clay forming materials. The soil is generally loamy but often found clay to sandy loam. The surface horizon which is about 30 cm thick has colours ranging from reddish brown to dark reddish brown. The soils are rich in organic matter and nitrogen but deficient in phosphorous and potassium and they areacidic in reaction (Sarma and Barik, 2012). The climate of the area no word as monsoomic is found in english dictionary directly influenced by the south-west monsoon. The vegetation of Nokrek biosphere reserve can be broadly classified into tropical and subtropical types depending on the altitude. The tropical vegetation is found up to an elevation of about 1000m (Sarma et al., 2005).

Materials and Methods

Landsat ETM satellite data of 06.02.2010 and 30.01.2010 with path and row 138 & 42 and 137 & 42 are used for the present study. The satellite image with bands (7) were stacked to prepare an FCC of bands 3(Red), 2(Green) and 1(Blue). The relevant topographic maps and image were geometrically rectified in 1:50,000 scale using geographic projection system UTM; speroid and datum used were WGS 84 with UTM zone 45N. The thematic features of drainage and contours were delineated from the topographical maps. Soil and geology maps are prepared based on available maps (Sarma, 2002; Sing and Singh, 2000). Sufficient field survey was carried out for validation after image interpretation. The GIS and image processing software used are ArcGIS 2010, Erdas IMAGINE 2011 and Quantum GIS.

Land use/cover mapping

The image features on the satellite data were interpreted to prepare land use/ cover map using the various image elements like tone, texture, pattern, shape, size, shadow, location and association (Garg et al., 1988 & Lillesand and Kiefer, 1987).

Slope analysis

The slope analysis was estimated following Zakrzewska (1967), the modified version of Wentworth (1930).

Slope in degree = $\tan \theta = V * N / 0.6366 K$

Where, V = Vertical contour interval in meter or in feet

N = Number of contour crossing per square kilometer or per square mile

K = Constant, 1000 for metric units and 5280 for British units

Thus, to find out the nature of average slope and its characteristics, the area had been divided into one by one kilometer grids and the number of contours crossing per square kilometer were counted and average slope per grid was computed. Based on the results, a slope map had been prepared and classified into five categories of slope i.e., high (above 29°), moderately high (23° to 29°), moderate (16° to 22°), moderately low (9° to 15°) and low (2° to 8°).

Drainage density analysis

Drainage density was analysed by following a simple device developed by Horton

(1945) as expressed in the formula below:

Du = (EL) u / Au

Where, Du= Drainage density in km per square kilometer

(EL) = Sum of the total length of streams of all orders in km

Au = Total area of drainage basin in square kilometer

To know the variation, drainage density has been computed per square kilometer for the entire biosphere reserve. The area had been divided into one by one kilometer grids and drainage density per grid was computed. Four categories of drainage density were delineated i.e., high (above 9 km/sq km), moderately high (7 to 9 km/sq km), moderately low (5 to 7 km/sq km) and low (below 5 km/sq.km).

Weighted Overlay Analysis

Integration of thematic layers was performed using weighted overlay analysis. Based on the contribution and understanding the behaviour of different thematic layers a weightage which is a qualitative assessment, has been given range on a scale of 1 to 9 depending on their hazard potential level for soil erosion. The influence percentage of each thematic layer has also been assigned according to the contribution (Table 1). All the thematic layers which include land use/cover, slope, drainage density, geology and soil types were converted into grid with related item weight and integrated with one another through GIS (ArcInfo spatial analyst environment). The cell size assigned is 30m x 30m. As per this analysis, the total weightage of the final integrated grids were derived as sum of the weightage assigned to the different layers based on suitability. In the present study, soil erosion hazard mapping of NBR has been generated by integration of all above grid layers. The delineation has made by grouping the grids of final integrated layer into four vulnerable zones.

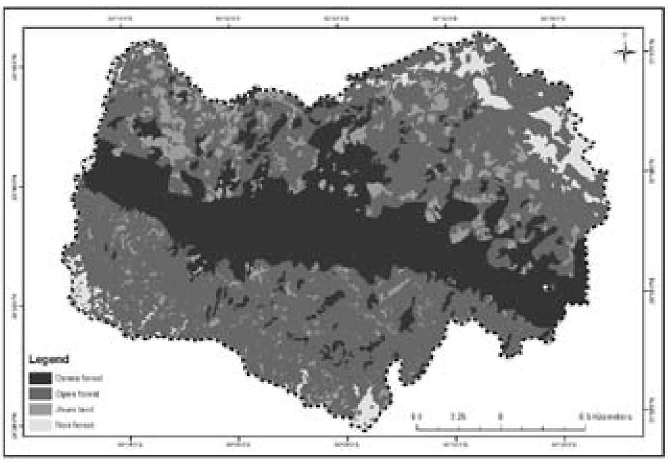

Figure 3: Land use/cover of Nokrek biosphere reserve

Results and Discussions

Land use/cover analysis

The land use/ cover of Nokrek biosphere reserve has been broadly classified into dense forest, open forest, shifting cultivation and non-forest area (Figure 3). A considerable portion of the biosphere reserve is under forest cover (86%) either dense or open. Out of the non-forest about 8.8 percent falls under current or abundant shifting cultivation area.

Slope characteristics

More than 60 percent of the total area of NBR attains more than 22 degree slope. Area with slope degree less than 8 occupies about 7.5 percent. The slope map reveals that the most of the central and the central northern part of the biosphere reserve have the higher average slope (more than 16°). The high slope zone is confined along the Tura range in the western part and three small pockets in the northern fringe. The area under moderately high slope falls mainly along the central ridge and northwestern

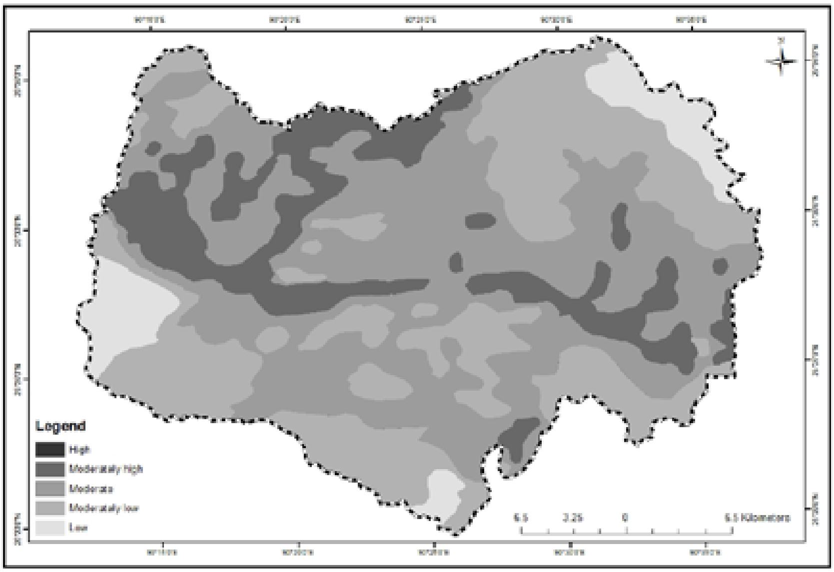

Figure 4: Slope categories of Nokrek biosphere reserve (Sarma and Bari, 2010)

part. The moderate slope occupies the central part of the biosphere reserve. The moderately low slope is confined to the northeastern, southern and southwestern corner. The area under low slope falls in the southwestern and northeastern corner and a small area in the southern part (Figure 4).

Drainage density analysis

The zones with dissected hilly terrain of high altitude, high negative relief and high

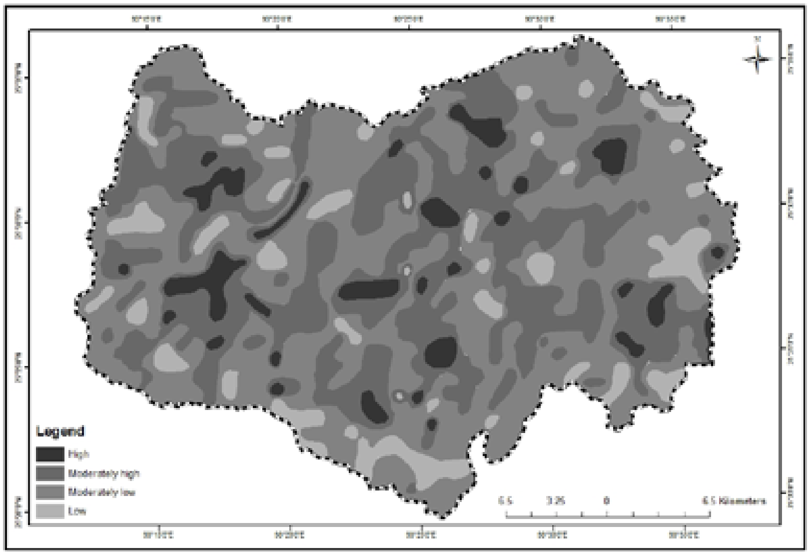

Figure 5: Area under different drainage density categories of Nokrek biosphere reserve (Sarma and Barik, 2010)

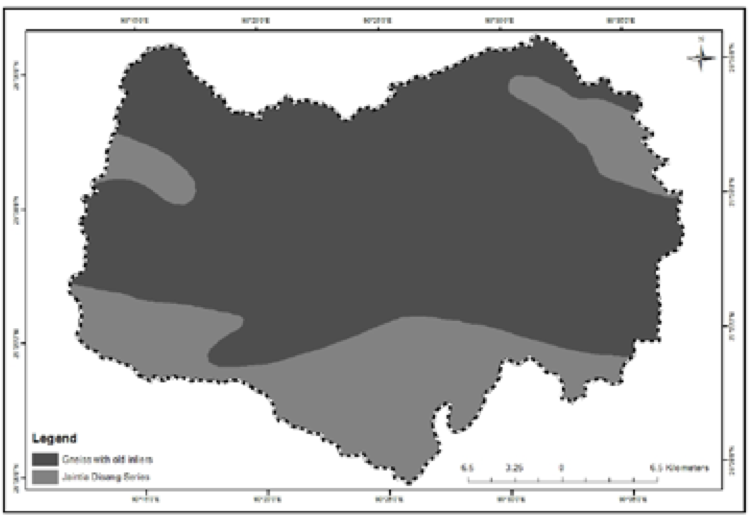

Figure 6: Geology of Nokrek biosphere reserve (Singh and Singh, 2000)

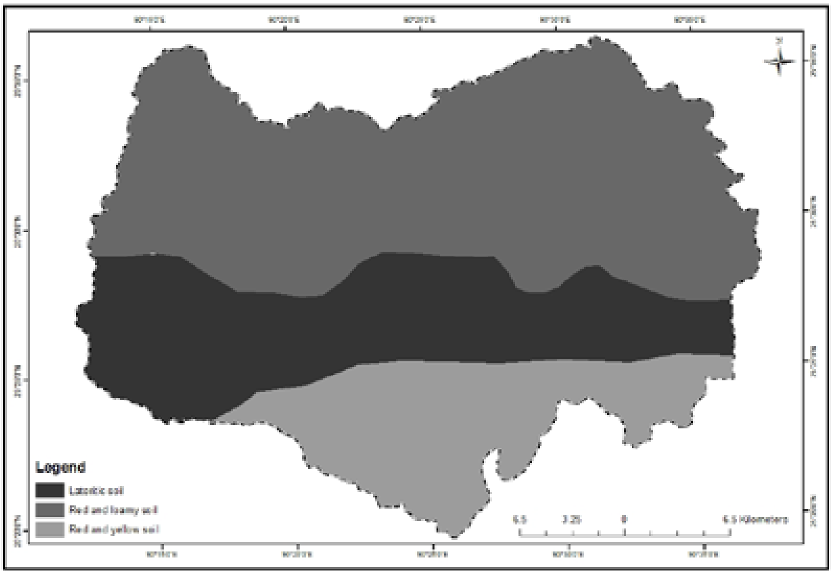

Figure 7: Spatial distribution of soils of Nokrek biosphere reserve (Sarma, 2002)

average slope usually show high drainage density (Sarma 2002). As Nokrek biosphere reserve itself is a dissected hilly terrain with high average slope, the drainage density shown in the area is quite high (Figure 5). Only 87 sq km

(10.6%) of the total areas fall under low drainage density zone which could be considered as stable zones with good forest cover.

Geology and soil mapping

The geology of NBR is mostly composed of two types i.e., Gneiss with old inliers (72.3%) and Jaintia Disang Series (27.7%) (Figure 6). In case of soil major portion of the biosphere reserve comprises of red and loamy soil (52%) followed by lateritic and red and yellow soils (Figure 7).

Weighted Overlay Analysis

By utilising the weighted overlay analysis model (Table 1) a map showing different soil erosion vulnerable potential zones of most vulnerable, moderately high vulnerable,

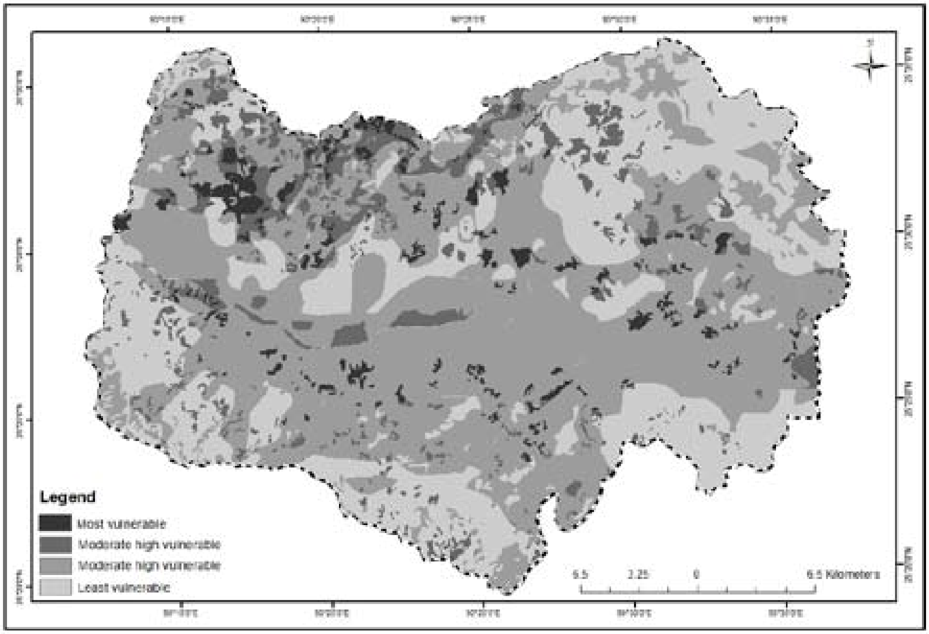

Figure 8: Soil erosion potential zones of Nokrek biosphere reserve

moderately low vulnerable and least vulnerable has been prepared (Figure 8). The findings of the study reveals that a considerable portion of the biosphere reserve (about 4 percent) is found to be most vulnerable probably due to maximum anthropogenic influences in terms of shifting cultivation which are free from vegetation cover with steeper slopes comprising of loose soil conditions. These all criteria attribute for delineating the areas under risk due to soil erosion in NBR.

Soil erosion is the result of interrelationships among vegetation, topography, drainage, bedrock and soil (Lucía et al., 2010). The present study shows that primary forests of NBR have been destroyed to a great extent by age old tradition of shifting agriculture which is extensively practiced in the studied area as well as in hilly regions of the north-east India (Ramakrishnan, 1992 & Yadav et al., 2012). This activity has led to the development of a variety of successional plant communities ranging from open forest to recently abandoned shifting cultivation fields (Prabhu 2004). Sarma and Barik (2010) concluded that steep slopes of Nokrek biosphere reserve are also exploited for the purpose of shifting cultivation. The buffer zones of the biosphere reserve represent a mosaic of degraded landscape owing to the gentle slope of the area. This finding is similar to that of Susana and Mario (2000) who reported that deforestation may be widespread in areas where slopes are relatively gentle. Steep slopes of Nokrek biosphere reserve have remarkable influence on the forest cover. Similar results have been observed by Balaguru et al. (2003) from Shervaryan hills, Eastern Ghats of India. Strahler (1960) postulated that a region underlined by massive, hard sandstone beds under heavy forest

Table 1: Influences and weightages of different thematic layers for contributing potential soil erosion hazard along with the areas under each category of Nokrek biosphere reserve

Raster data	% Influence	Field	Scale value	Area (sq.km)	% Area
Drainage Density	15	Moderately low	3	368	44.88
		Moderately high	5	274	33.41
		Low	2	87	10.61
		High	6	91	11.1
			1 to 9	**820**	**100**
Geology	5	Gneiss with old inliers	5	593	72.26
		Jaintia Disang Series	3	227	27.74
			1 to 9	**820**	**100**
Land use/cover	30	Non forest	6	41	4.97
		Shifting cultivation	8	72	8.78
		Open forest	3	453	55.27
		Dense forest	1	254	30.99
			1 to 9	**820**	**100**
Slope	35	High	8	13	1.58
		Low	2	61	7.44
		Moderate	5	367	44.76
		Moderately high	7	116	14.15
		Moderately low	3	263	32.07
			1 to 9	**820**	**100**
Soil	15	Red and yellow soil	3	157	19.17
		Lateritic soil	5	237	28.91
		Red and loamy soil	3	426	51.92
	100		**1 to 9**	**820**	**100**

Table 2: Areas under different soil erosion vulnerable classes of Nokrek biosphere reserve

Vulnerable class	Area	%
Most vulnerable	30	3.7
Moderately high vulnerable	77.5	9.5
Moderately low vulnerable	451.8	55.1
Least vulnerable	260.7	31.8
Total	**820**	**100.0**

cover shows the drainage density averaging 1.8 to 2.5 km/sq.km. The region with medium drainage density averaging 7.5 to 10 km/sq.km is underlined by thin bedded sandstones and thick shales, relatively easily eroded and is characterized by the development of thick deciduous forest. The finding of thisresearch absolutely supports this observation. The present area under investigation is again similar to the findings of Kirkby (1980, 1993) who predicted that under a humid climate, drainage density should decrease with increasing slope.

Baban and Sant (2005) while studying the susceptibility mapping for the Caribbean island of Tobago using GIS, multi-criteria evaluation techniques with a varied weighted approach found that about 6.4% of the total area is under severe risk of soil erosion. This finding is in support of the present research. Anbalagan et al. (2008) analysed the relationships of slope morphometry with different aspects like lithology, structure, land use/ cover, and relief. They assigned the maximum influences where higher slope is free from vegetation cover and with the influence of other anthropogenic activities. Their approach is an agreement to the present study.The findings of this research show that soil erosion rates are influenced by slope, drainage, geology, soil and human induced activities. Besides other factors vulnerability is maximum in the areas where human interferences are more. This study is a point to the findings of Neil and Fogarty,1991; Prove et al., 1995 & Edwards and Zierholz, 2001. In another study Neil and Galloway (1989) compared the soil erosion rates in the cultivable lands with native forests in the plateau of New South Wales. Their results show that there is significant increase of erosion rate in the cultivable land though the nature of slope is same. Similar observations are found by Erskine et al., (2003) and Mahmoudzadeh et al.(2002). The probable vulnerable areas of soil erosion as depicted after the present research is an agreement to these observations.

Conclusion

Nokrek biosphere reserve supports a dense forest cover that is mainly concentrated in the core zone and should therefore be conserved for biodiversity. However, this zone is also slowly encroached by the local people for shifting cultivation and other anthropogenic activities which are threatening the biodiversity of the biosphere reserve. Slush and burnt practice even in the steep slopes creates havoc towards the sustainability of the ecosystem. The drainage showed high density in open forest and non-forest areas indicating vulnerability in terms of soil erosion. The shifting cultivation cycle should be at least 15-20 years against existing 3-5 years as short cycle not only effects soil fertility but also exposes the top soil for erosion. Further, the conversion of forest areas of buffer zones into other land use should be properly planned. The most important step that needs to be undertaken to prevent the area from further deterioration is to educate the people and make them aware of the consequences of deforestation and shifting cultivation. The spatial distributions of different categories of risk found in this study could be useful for the management authority to check it from further degradation.

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Burnout amongst Paramilitary personnel in India: A Study

Prashant Kumar[1] and Hamendra Dangi[2]

Abstract

Paramilitary personnel typically suffer a variety of physiological, psychological and behavioural stress effects. The working conditions of paramilitary personnel require intervention from social and human aspects. Certain jobs by their nature are more prone to stress than others. Evidences suggest that paramilitary personnel also lose life due to job related stress/burnout. The manifestation of stress and burnout in the form of suicide, fratricide and killings highlight the urgent need that these must be looked into. In India, the government has taken lots of measures for the welfare of Paramilitary personnel in general but a lot requires to be done for the personnel deployed in disaster prone areas and their well-being vis-a-vis job burnouts. The focus has always been on the job to be done. In the present study an attempt has been made to analyse condition and level of burnout amongst paramilitary personnel using two stage research designs. Results indicate that there is a need to pay immediate attention to increase job satisfaction and productivity of personnel.

Key words: Burnout, Paramilitary personnel, Job satisfaction.

Introduction

A very few occupations require employees to face the kind of adverse situation and challenges that paramilitary personnel do encounter as part of their daily routines. Mass media, both print and television have familiarised viewers with obvious dangers that paramilitary personnel encounter in protecting society and nature while deployed in various disaster prone areas and attending disaster response duties This constant exposure of Paramilitary personnel to physical danger puts them in a state of continual conflict between human instinctual tendency to avoid hazard and their obligation to face up the risk. Their continuous observation of incidents of injury, death and suffering only serves to reinforce this conflict. The working conditions of paramilitary personnel need intervention from social and human aspects. It needs more inputs in the form of training and capacity building perspective so that

1. Inspector General (Provisioning), I.T.B.P., Ministry of Home Affairs, Govt. of India
2. Assistant Professor, Faculty of Management Studies, University of Delhi, Delhi

they are well prepared to meet the challenges of task pressures topped with public condemnation.

Paramilitary personnel typically suffer a variety of physiological, psychological and behavioural stress effects. It has been observed that special attention should be given to occupational stress, as its potential negative consequences affect society in more direct and critical ways than those stressed in many other occupations. Officers and men operating under severe and chronic stress may well be at greater risk of error, accidents and overreaction that can compromise their performance, jeopardize public safety and pose significant liability costs to the organisasion (Colwell, 1988; Violan, 1992; Mathur,1999 and Marshall, 1986).

In India too, the work environment of Paramilitary personnel resemble this reality. The presence of stress amongst paramilitary personnel Jawans/officers/all ranks is seething from within but not yet has not been addressed properly. The focus is on delivery of services in shortest possible time and rarely on the personnel's state of mental health, fatigue & stress. Stress is considered to be the part of the job. It is taken for granted that a job in police is bound to be stressful. The media reports on police cruelty, indiscipline and mismanagement are but smaller glimpses of the force. The focus has always on the job to be done. Strenuous task such as policing, securing, guarding, eventually becomes too arduous and exacting. While emphasizing on performance, organisations must keep in view the physical and mental health of the personnel also. This study attempts to provide some insight into the burnout levels in the Indian context through a survey of a sample of Paramilitary personnel who have participated in disaster response.

Review of literature

Pines and Maslach (1978) depict burnout as a syndrome of somatic and psychological exhaustion with multiple classifications. Burnout manifests as a subjective feeling of dysphoria, impacting on physical and emotional aspects of one's well-being, and leading to a reduction of behavioural activity and motivation, and the debilitation of one's efforts to perform (Maslach & Jackson, 1981). Further, burnout results from the inability to stabilize internal and/or external needs, and as a result inhibits the allocation of energy resources effectively (Leiter & Maslach, 2005). It may also result from a situation where negligible rewards are bestowed for a goal in which a large investment was made (Rupert & Morgan, 2005; Schaufeli et al, 2004).

Maslach and Pines (1978) identified the symptom of somatic and psychological exhaustion, accompanied by a lack of sleep and headaches, amongst a sample of nurses. Research on burnout began through clinical studies, allowing the construct to become recognised, at least in the health sector (Anagnostopoulos & Papadatou, 1992; Ahola & Hakanen, 2007; Montgomery et al., 2006 and Vahey et al., 2004).

The amount of research on the phenomenon of burnout renders the need for its measurement and diagnosis as imperative, especially if one considers the adverse effect that it produces. Consequently, burnout has been operationalized internationally based on Maslach's theoretical framework (Maslach & Jackson, 1981; 1986). The framework highlights a single syndrome defined by three components namely Emotional Exhaustion, depersonalization and the feeling of Reduced Personal Accomplishment.

Maslach and Jackson (1981) developed the Maslach Burnout Inventory (MBI), which consists of 22 items that load onto the three factor structure mentioned above: Emotional Exhaustion (EE; nine items), depersonalization (DP; five items), and personal accomplishment (PA; eight items). The results of this inventory consist of three separate scores, one for each factor. A combination of high scores on EE and DP, and a low score on PA, correspond to a high level of burnout. In an effort to categorize and prioritize the dimensions of burnout as outlined by the Maslach Burnout Inventory (MBI), the progressive Phase Model of Burnout was created by Golembiewski, Munzrider, and Stevenson (1986). According to the authors, through the use of this model, precise, convenient, burnout information could be made available to policy makers and organisasions, to assist them in reducing the effects of job burnout.

The Boudreau Burnout Questionnaire (BBQ)

The research model for this study engages the components of Emotional Exhaustion/ Energy (EEE), Depersonalization/Personalization (DPP) and lack of/personal accomplishment (LPA) through the Boudreau Burnout Questionnaire (BBQ). This instrument was developed as a practical response to some of the discrepancies and measurement ambiguities currently existing in the field of burnout research and in particular, with the Maslach Burnout Inventory, MBI (Boudreau, 2000). As indicated by Boudreau, there is a need for more questions and more general questions; a need for an adequate measure of continual character of burnout; a need for terms that are easily translated, not colloquial expressions, and a need for positive and negative questions (Boudreau, 2000). Burnout results acquired through the use of the BBQ can be used in Phase Model applications and can be compared with other burnout studies which have employed the MBI in its various forms.

Another such instrument popular is Boudreau burnout questionnaire which can be used in conjunction with the Phase model Approach developed by Golembiewski, Munzrider, and Stevenson (1986). The three components of burnout viz Depersonalization(DPP), Lack of Personal Accomplishment(LPA) & Emotional

Exhaustion (EEE) can be organised by importance and divided into high (HI) and low (LO) categories. Paramilitary personnel have a unique situation in that they may experience the stressors of the helping professions at the same time as they may face the stressors accompanying management and entrepreneurial roles (Gautam, 2000). Their actions and experiences are also deeply bound to the norms and are changing with the demand level and scrutiny of an informed public. The severity of outcomes is also unique to the profession. Although accidents and impairments occur in other helping professions, the responsibility, public accountability, and potential magnitude of their errors, raise the performance yardstick very high for Paramilitary personnel. For paramilitary personnel, inability to effectively manage stress has its most dangerous consequences in the line of duty. Their work often places officers in situations where reaction, speed, co-ordination and the capacity to make rapid decisions and accurate, judgments under pressure is critical and inefficient mental and emotional responses to stress can significantly impair these abilities. In the extreme, stress can cause officers to lose balance and composure to the degree that employ unsuitable or excessive force in dealing with subjects (Moore & Donohue, 1976). At the psychological level, the stress of police work may result in persistent negative emotions such as anger, anxiety or depression which can ultimately lead to psychological burnout or Emotional Exhaustion (Gaines et al.,1983; Vena et al, 1986).

The unusually stringent demands for self control, compounded by the unavailability of effective strategies for inner self-management becomes an added stressor in its own right for police (Abernathy, 1995; Ganster et al.,1996).

On the basis of existing literature, following objectives were formulated.

- To study and identify level of burnout amongst paramilitary personnel who participated in disaster response.
- To find out relation between level of burnout and demographic variables such as age, position in organisasional hierarchy etc.

Methodology

In the present research two stage research designs was used. In the first phase an exploratory study was conducted through review of literature and in-depth interviews with experts. Exploratory study helped in defining research problem and formulating research hypotheses. In the second stage conclusive research in the form of multiple cross sectional descriptive research design was used. Findings of descriptive research design helped for generalization and validation. Survey methods of data collection were used for second stage of research design. In the present research non probability sampling technique in the form of quota sampling was used. A total of 160 respondents through personal survey were contacted involving 40 respondents each from Indo-Tibetan Border Police (ITBP), Central Industrial Security Force (CISF), Central Reserve Police Force (CRPF) and Border Security Force (BSF) through a structured questionnaire. Data obtained through questionnaire were analyzed using IBM-SPPS 17.0 version.

Findings and Discussion

Profile of respondent is summarized in table below

Table 1: Profile of respondents

Variable	Characteristics	Percentage
Age Groups	Less than 35 years	51.25
	36 to 44 years	32.50
	45-55 years	16.25
Marital status	Married	67.50
	Single	31.87
	Separated	0.63
Family structure	Joint	66.25
	Nuclear	33.75
Position in hierarchy	Top	7.50
	Middle	32.50
	Field level	60.00
Time spent on hobbies (weekly)	Less than 5 hours	26.88
	5-9 hours	40.62
	10 to 15 hours	22.50
	More than 15 hours	10.00

Majority of the respondents (51.25%) were in the age group of less than 35 years which is being followed by the middle age groups 36-44 years (32.50 %). The respondents of 45-54 years were least 16.25% in number of the sample. 67.50% of the respondents were married while 31.87% were single. One respondent represented the widowed/ separated group. 33.75% respondents live as nuclear families while the rest 66.25% belonged to joint families.60% respondents were field workers whereas 32.50% were from middle supervisory level and 7.50% respondents were from top level. Almost 26.88% of the Paramilitary personnel spend merely less than 5 hours on hobbies or areas of special interest in the course of an average week while approximately 40.62% spend up to 5-9 hours per week. Almost 10% spend more than15hours per week and 22.50% spend between 10-15 hours.

Descriptive statistics pertaining to the three burnout components viz. depersonalization (DPP), lack of personal accomplishment (LPA) and Emotional Exhaustion (EEE) are presented (- /+) in Table 2. These results reflect the reverse coding of the positive statements in the questionnaire.

Table 2: Descriptive statistics

	Depersonalisation	Lack of Personal Accomplishment	Emotional Exhaustion
N	160	160	160
Mean	23.16	24.18	24.65
Std. Deviation	6.72	5.75	6.00
Minimum	10.00	11.00	11.00
Maximum	42.00	46.00	38.00

Further phase wise burnout is presented in the Table 3

Table 3: Frequency of respondents categorized in three phases of burnout

Phase	Frequency	Percent	Cumulative Percent
Advanced	86	53.8	53.8
Initial	28	17.5	71.3
Moderate	46	28.8	100.0
Total	160	100.0	

To generalize findings of survey, following hypothesis were formulated and tested.

Hypothesis 1: Burnout amongst Paramilitary personnel depends upon the age group

Chi square test was performed to test the hypothesis, while running the chi square test, the categories 45-54 years and >55 years were merged. Result of test is presented in the table 4 below:

Table 4: Chi square test: Age and Burnout

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.287	4	0.015
Likelihood Ratio	3.182	4	0.528
N of Valid Cases	160		

This indicates that there is a significant relationship between age and burnout.

Recalling that 53.42% of the Paramilitary personnel in the sample, in advanced burnout state are in the age group < 35 years and 32.56% in the age group 36-44 years, the hypothesis that "burnout amongst paramilitary personnel depends upon the age groups was supported. In India, Jawan of paramilitary personnel after a most rigorous training, typically completes his probation at the age of about 20 years. The subsequent years are filled with wear and tear. They are continuously on duty and these punishing hours almost as a badge of honor, going without proper & timely sleep and meals. No wonder, burnout rates are the highest in this age group.

Hypothesis 2: Paramilitary personnel who are single tend to have higher rates of burnout.

Again Chi square test was performed after merging widowed/separated category with "single" category due to inadequate representation in the former.

Table 5: Chi-Square Tests – Marital Status and Burnout

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.874[a]	4	0.423
Likelihood Ratio	3.904	4	0.419
N of Valid Cases	160		

As indicated in the table 5 the difference was not found to be significant at 0.05 level hence hypothesis that "Paramilitary personnel who are single tend to have higher rates of burnout" was not supported. It was felt that since single Paramilitary personnel may not have avenues for ventilating their pent up feelings, they experience higher rates of burnout. On reviewing the literature, not much information regarding this variable vis-a- vis burnout could be found. However, the study did not support this view.

Hypothesis 3: Paramilitary personnel living in nuclear families tend to have higher rates of burnout.

To test whether there is association between type of family structure and level of burnout chi square test was performed. Results of test are presented in table below.

Table 6: Chi square test: family structure and burnout.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.109[a]	2	0.947
Likelihood Ratio	0.109	2	0.947
N of Valid Cases	0.160		

As indicated in the table 6, value were not statistically significant at 0.05 level and the hypothesis that "Paramilitary personnel living in nuclear families tend to have higher rates of burnout" is not supported in the present study. Contrary to the hypothesis that paramilitary personnel living in nuclear families tend to have higher burnout rates, no relationship was found between the family structure and burnout levels. The hypothesis was based on the premise that respondents in nuclear families lack the social support that joint families provide.

Hypothesis 4: Burnout depends upon the type of organisasion.

Again Chi square test was performed to determine association between type of organisasion and level of burnout. Results are shown in table below

Table 7: Chi square test: type of organisasion and burnout Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.802a	6	0.001
Likelihood Ratio	20.897	6	0.002
N of Valid Cases	160		

In this case values were statistically significant at 0.05 level supporting the hypothesis that burnout depends upon the type of Paramilitary organisasion. Based on the main hypothesis that burnout depends upon the type of Paramilitary organisasions, an attempt has been made to analyze as to how the three components of burnout [depersonalization (DPP), lack of personal accomplishment (LPA), Emotional Exhaustion (EEE)] using analysis of variance (ANOVA). Results are shown below

Table 8: ANOVA: Burnout components: Organisasion.

a)

		Sum of Squares	**df**	**Mean Square**
Depersonalization	Between Groups	2042.419	3	680.806
	Within Groups	5138.675	156	32.940
	Total	7181.094	159	
Lack of Personal Accomplishment	Between Groups	1117.350	3	372.450
	Within Groups	4137.750	156	26.524
	Total	5255.100	159	
Emotional Exhaustion	Between Groups	978.650	3	326.217
	Within Groups	4747.750	156	30.434
	Total	5726.400	159	

b)

ANOVA			
		F	**Sig.**
Depersonalisation	Between Groups	20.668	0.000
Lack of Personal Accomplishment	Between Groups	14.042	0.000
Emotional Exhaustion	Between Groups	10.719	0.000

Further to check which component varied significantly between organisasions, Post hoc test was performed.

Hypothesis 5.1: DPP component of burnout differs in various Paramilitary organisasion in which the study was done.

Table :9 Post Hoc Test for Depersonalization

Multiple Comparisons					
Dependent Variable	**(I) CPMF**	**(J) CPMF**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Depersonalization	ITBP	CISF	9.37500*	1.28336	0.000
		CRPF	7.82500*	1.28336	0.000
		BSF	4.87500*	1.28336	0.000
	CISF	ITBP	-9.37500*	1.28336	0.000
		CRPF	-1.55000	1.28336	0.229
		BSF	-4.50000*	1.28336	0.001
	CRPF	ITBP	-7.82500*	1.28336	0.000
		CISF	1.55000	1.28336	0.229
		BSF	-2.95000*	1.28336	0.023
	BSF	ITBP	-4.87500*	1.28336	0.000
		CISF	4.50000*	1.28336	0.001
		CRPF	2.95000*	1.28336	0.023

The p value (0.00) in table 9 indicates that null hypothesis 7.1 is rejected and it can be concluded that there are difference in various type of organisasions on the basis of DPP component. Further to check which organisasion suffers most, a post-hoc test was performed. It was found that ITBP is significantly different than CISF, CRPF and BSF in terms of DPP (p-value =0.00), while CISF differs from BSF. CRPF differs from ITBP & BSF while BSF differs from all three.

Hypothesis 5.2: - Lack of Personal Accomplishment (LPA) component of burnout differs in various Paramilitary organisasions in which the study was done.

Table 10: Post Hoc test for Lack of Personal Accomplishment

Dependent Variable	(I) CPMF	(J) CPMF	Mean Difference (I-J)	Std. Error	Sig.
Lack of Personal Accomplishment	ITBP	CISF	6.60000*	1.15161	0.000
		CRPF	6.02500*	1.15161	0.000
		BSF	5.47500*	1.15161	0.000
	CISF	ITBP	-6.60000*	1.15161	0.000
		CRPF	-0.57500	1.15161	0.618
		BSF	-1.12500	1.15161	0.330
	CRPF	ITBP	-6.02500*	1.15161	0.000
		CISF	0.57500	1.15161	0.618
		BSF	-0.55000	1.15161	0.634
	BSF	ITBP	-5.47500*	1.15161	0.000
		CISF	1.12500	1.15161	0.330
		CRPF	0.55000	1.15161	0.634

The p-value (0.00) in table 10 indicates that null hypothesis 7.2 is rejected and it can be concluded that there are difference in various type of organisasions on the basis of LPA component. In the post-hoc test, it was found that ITBP has significantly different than CISF, CRPF and BSF in terms of LPA (p-value =0.00) while CISF differs from ITBP. CRPF and BSF differ from ITBP.

Hypothesis 5.3:- Emotional Exhaustion (EEE) component of burnout differs in various Paramilitary organisasions in which the study was done.

Table 11 Post-Hoc Test for Emotional Exhaustion

Dependent Variable	(I) CPMF	(J) CPMF	Mean Difference (I-J)	Std. Error	Sig.
Emotional Exhaustion	ITBP	CISF	5.57500*	1.23358	0.000
		CRPF	4.92500*	1.23358	0.000
		BSF	6.30000*	1.23358	0.000
	CISF	ITBP	-5.57500*	1.23358	0.000
		CRPF	-0.65000	1.23358	0.599
		BSF	0.72500	1.23358	0.558
	CRPF	ITBP	-4.92500*	1.23358	0.000
		CISF	0.65000	1.23358	0.599
		BSF	1.37500	1.23358	0.267
	BSF	ITBP	-6.30000*	1.23358	0.000
		CISF	-0.72500	1.23358	0.558
		CRPF	-1.37500	1.23358	0.267

The p-value (0.00) in table 11 indicates that null hypothesis D 3 is rejected and it can be concluded that there are difference in various type of organisasions on the basis of EEE component. In the post-hoc test, it was found that ITBP has significantly different from CISF, CRPF and BSF in terms of EEE (p-value 0.00) while CISF, CRPF and BSF differs from ITBP. (p-value is 0.00 in all cases).

Personnel working in different paramilitary organisasions face mammoth work loads, with never ending challenges of their profession. They come face to face with people in agony on daily basis. Further, there are problems of challenging working conditions, occupational hazards and salaries, generally perceived to be not commensurate with the workloads. No wonder, burnout level depends upon the type of paramilitary organisasion. It has been found that ITBP personnel suffer severe burnout in all three component (i.e. DPP, LPA and EEE) than CISF, CRPF & BSF. It can be concluded on general that ITBP personnel suffer severe burnout in all these components (i.e. EPP, LPA and EEE) than CISF, CRPF and BSF.

Hypothesis 6: Burnout is associated with position of Paramilitary personnel in hierarchy.

Chi square test was used to check whether burnout depends upon position of respondents in hierarchy.

Table 12: Chi square test: Position in hierarchy.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.874a	4	0.000
Likelihood Ratio	2.041	4	0.728
N of Valid Cases	160		

As indicated in the table value was found to be statistically significant, hence the hypothesis that “burnout is associated with position in hierarchy” was supported in the present study (table 12).The issues and stressors facing Paramilitary personnel differed at different level of organisasion structure and hence, one can expect that resulting burnout level may also be different. It has come to light that the burnout is associated with position of hierarchy. Personnel working at field level have no or very little say in policy level decision making. Hence field workers have highest level of burnout vis-à-vis other levels.

Hypothesis 7: Paramilitary personnel spending less time on hobbies/ areas of special interest tend to experience higher burnout rates.

To check amount of time spent on hobbies influences level of burnout, Chi square test was performed and results are shown in table below

Table 13: Chi-Square Tests – Time spent on hobbies and burnout			
	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	7.860a	6	0.024
Likelihood Ratio	5.867	6	0.438
N of Valid Cases	160		

As indicated in Table 13, value was found to be statistically significant, hence hypothesis that "Paramilitary personnel spending less time on hobbies/areas of special interest tend to have high burnout rates" is supported in the present study. The study found relation between time spent on hobbies and burnout and the literature does also point lack of personal time as one of the stessors (Edwards, Kornacki, & Silversin, 2002; Huby et al., 2002; Vickman, 2000).

Conclusion

The results of this study throw light on the phenomenon of burnout levels on paramilitary personnel who have participated in disaster response. The percentage of paramilitary personnel in advanced burnout state is alarmingly high. Younger personnel and those working in ITBP are the most likely candidates to suffer burnout. Living with spouse or in a joint family setting seems to have no bearing on burnout. The severity of outcomes is also unique to the profession. Although accidents and impairments occur in other helping professions, the responsibility, public accountability, and potential magnitude of their errors, raises the performance bar very high for paramilitary personnel.

Paramilitary personnel operating under severe and chronic stress may well be at greater risk or error and over-reaction that can compromise their performance and public safety. The unrealistic expectations imposed by this occupational culture discourage officers from admitting to feeling stress and from openly expressing negative emotions. Thus, while they receive ample training in the theoretical knowledge and technical skills required to perform their jobs and take effective action in an emergency situation, most receive little if any training in the self-management skills to help them quickly regain psychological and physiological equilibrium after the intense challenges of their work. It is clear that practical stress management techniques are needed not only to help personnel remain more balanced during and after the acute stresses of their jobs, but also to take action to better manage and seek real solutions to the chronic stress related to organisasional and family issues. Having put burnout in a nutshell, the next and the most pertinent question is how to treat burnout. The answers are not easy. There are no quick fix remedies. First, the paramilitary personnel need to recognise and accept that they are suffering and need help rather than living in denial. This ought to be followed by counseling and practising stress management techniques. The paramilitary personnel need to have healthy work and lifestyle habits. This requires attention at multiple levels : the person, the work itself and the organisasion. It also requires changing the way burnout is viewed. It requires changing the medical perception of burnout as a "stigma of vulnerability". As Gagnon (2001) states: "The culture has to change from one of being tough to yourself to, where it's okay to take care of yourself."

It is hoped that this study will, in some way, draw attention to the issues of burnout faced by paramilitary personnel, and promote positive changes in their system to reduce burnout levels. Changes in the system, however, will require active commitment on the part of individuals, organisasions, and governments' alike. This study was primarily concerned with disaster operation and did not look at routine/day-to-day working conditions of Paramilitary personnel. Further only major Paramilitary personnel were taken for study. Moreover similar studies on defence forces, civil police and other actors, who participate in disaster response operation, can give a magnified view. Burnout also depends upon the time frame. During the study period, no major disaster has taken place. Results need to be carefully interpreted in the immediate after-math of disaster. These limitations, although restricting for the study, do provide suggestions and opportunities for future research in the field of burnout.

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Extreme Weather Events in India- A Preliminary Analysis of Impacts

Ajay Singh[1], Anand Patwardhan[2], Abhijat Abhyankar[3], Nandlal L.Sarda[4]

Abstract

Extreme weather events have enormous impacts to human society and environment. India is highly vulnerable to climatic extremes due to high population density, poor infrastructure, low human development and minimal coping capacity. In this context, it is important to look at damage caused by climate extremes over India spatially and temporally. Impact data constitute information about mortality, persons affected, villages affected, crops affected and total economic loss. All events combined show a significant increasing trend in impact. Impacts from dust storms, floods, hail storms and lightening show increasing trend. Floods share highest impacts caused by climate extremes. Total mortality due to the extreme events is greatest in Odisha. Normalised mortality is mortality per unit population. Odisha state has highest normalised mortality. Cold waves have a significant increasing trend in impact on Haryana, Rajasthan and West Bengal, whereas significant decreasing trend in Madhya Pradesh. In all states it is observed that there is increasing trend in heat wave occurrences. Finally policy implications of impacts of these events and future work have been discussed.

Key words : Extreme weather events, climatic extremes, heat wave, cold wave.

Introduction

Climate change may be perceived mostly through the impacts of extreme weather events, although these are to a large degree dependent on the system under consideration, including its vulnerability, resiliency and capacity for adaptation and mitigation. Growing human vulnerability due to increasing numbers of people living in exposed and marginal areas or due to the development of more high-value property in high-risk zones, is increasing the risk, while human endeavours, such as, by local governments, try to mitigate possible effects. As climate continues to warm during the course of the 21st century, it is expected that many forms of extreme events may also increase, because the thermal energy that drives many of these processes

1.Research Scientist, Shailesh J. Mehta School of Management, IIT Bombay
2. Professor, Shailesh J. Mehta School of Management, IIT Bombay.
3.Assistant Professor, National Institute of Construction Management and Research, Pune
4. Professor, Department of Computer Science and Engineering, IIT Bombay

will be enhanced. Public awareness to extreme weather hazards has risen sharply in recent years, in part because of the instant media attention that serves to emphasize the catastrophic nature of floods, droughts, storms and heat waves. Additionally, the economic costs of extreme events have increased in the past few decades, essentially because there has been a substantial rise in the number of inhabitants and penetration of infrastructure in risk-prone areas (e.g., Munich Re, 2005; Swiss Re, 2005). Insurance statistics highlight the fact that, with the exception of earthquakes, extreme climate events are those that take the heaviest toll on human life and exert some of the highest damage costs related to natural hazards. In the second half of the 20th century, there were 71 "billion-dollar events" resulting from earthquakes, but more than 170 events related to climatic extremes, in particular storms (tropical cyclones and mid-latitude winter storms), floods, droughts and heat-waves (Swiss Re, 2003). 2005 alone experienced one of the busiest hurricane seasons on record, with hurricane Katrina devastating the city of New Orleans with damages costs approaching an estimated USD 200 billion. The damage due to Odisha super cyclone of 1999 was estimated around Rs 100 billion (http://ncrmp.gov.in/ncrmp/Cyclone_Impact.html)

There is thus an obvious interest and incentive for the research community as well as the public and private sectors to focus on impact of extreme climatic events and the possible shifts in their frequency and magnitude. The shifts in extremes in a changing climate requires an understanding of the physical mechanisms that underlie these events. This in turn allows improvements in our ability to quantify the costs associated with climate-related hazards. Strategies for adapting to changes in mean and extreme climates can then be developed if there is a greater confidence in the understanding of these mechanisms. To develop future adaptation strategy it is important to understand historical impacts and their adaptation strategy to climate extremes. In Indian scenarios information on extreme climate events are scattered and very few attempts have been carried out (De et al., 2005a). A significant mortality caused by heat and cold waves in few northern states and Odisha is reported in a few studies (Chaudhury et al. 2000; De et al. 2005b). Significant rising trends in the frequency and the magnitude of extreme rain events in central India have been reported in a study (Goswami et al., 2006) using recent gridded dataset. The lack of information leads to present study of the spatio-temporal pattern of impact of climate extremes in India.

Data and Methodology

Data on the occurrence of extreme climate events and their impacts have been extracted from the reports on 'Disastrous Weather Events', an annual publication of India Meteorological Department (IMD). These reports are available from 1967 to 2006 (missing year 1977). They provide the information about characteristics and damage estimates of ten categories of events: flood, tropical cyclone, heat wave, cold wave also gale, squall, lightning, dust-storm, hailstorm and thunderstorm. They also provide information about the extreme event's characteristics including intensity, magnitude, location and date of occurrence and data on damage caused by these events. Damage data include information about mortality, persons affected, village affected, crops affected and total economic loss. There is considerable variation with regard to the reporting of damage information. Therefore we have only included information pertaining to mortality, persons affected, villages affected, crop area affected and total economic loss which are reported consistently for a large number of the events. Data source for the characteristics of the events are the meteorological stations installed by IMD. While there are in general many possible sources of information on extreme events, the IMD reports are perhaps the most extensive and consistent source. The impact data have been grouped into spatial resolution at state level. These data having state level information have been analyzed for trend and other descriptive statistics.

Results and Discussion

The years from 1967 to 1976 seems to have a reporting bias as the presentation of the report is organised in textual form. The data from 1967 to 1976 are ignored. The data from 1978 onward is in tabular form and more consistent in reporting hence considered in the present study. There is a highly significant increasing in the total number of events. A significant increasing linear trend in occurrence of extreme weather events has been observed. Figure 1 shows this trend with an increment of about 9 events per year on a linear scale.

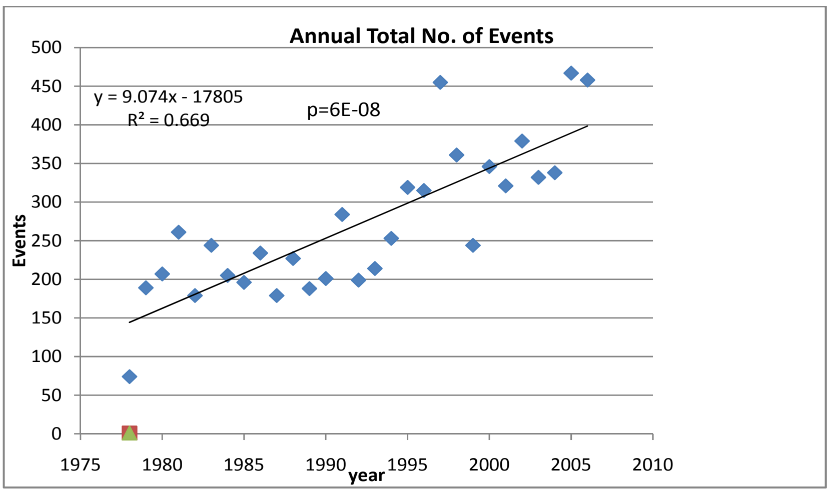

Figure 1: Annual total number of extreme climate events in India

Annual total mortality per year has increased from 1699 in 1978 to 3178 in 2006 (Figure 2). The mortality shows a considerable fluctuation across the years. It has more when the extremely disastrous cyclonic events have occurred, thus causing a large variance. The total mortality has significant increasing trend (even if ignoring the high value of 1999). Overall an increase of mortality due to extreme weather events (70 persons per annum) is revealed statistically significant.

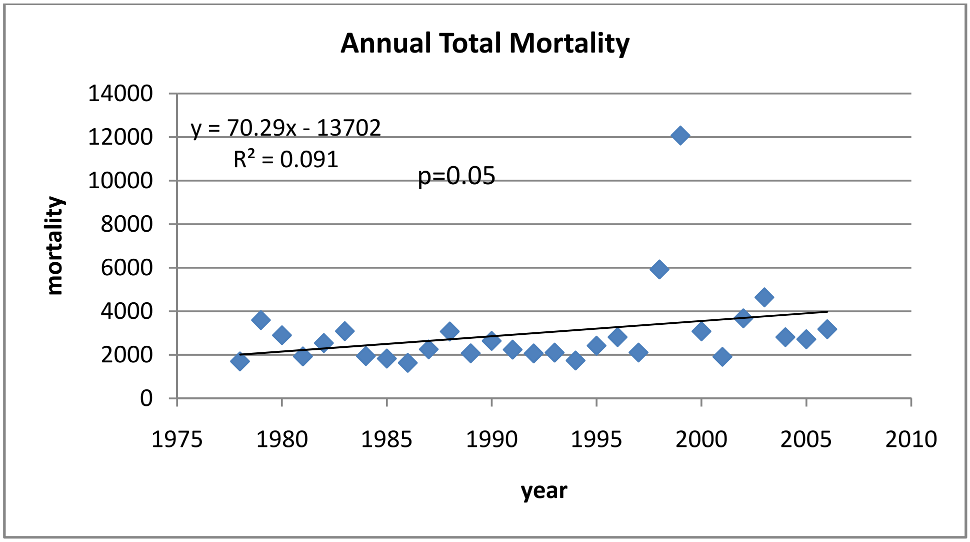

Figure 2: Annual total mortality in India due to climate extremes

Table 1: Trend in Extreme Climate Events by Impact

	Impact	
Event	**Trend (person/y)**	**p-value**
Cold wave	5.55	0.06
Cyclone	-7.58	0.81
Dust storm	0.92	0.03
flood	40.25	0.00
Gale	0.09	0.72
Hail storm	1.27	0.00
Heat wave	7.77	0.16
Lightening	7.36	0.00
Squall	0.23	0.12
Thunder Storm	5.07	0.00

Mortality due to various extreme events, as an indicator of impact has mixed trend (Table 1). Impacts due to cyclone has insignificant decreasing trend while that of other extremes have increasing trends. Flood, duststorm, hailstorm, lightning and thunderstorm have significant increasing trend in their impacts. On impact sharing, major chunk is due to flood (44%) (Figure 3). Impacts due to cyclones stand on second number, having share of 30% of all. Thus almost 75% of mortality due to extreme events is because of flood and cyclone. Impacts due to heat and cold waves share 18% of total. Rest of the impact is due to lightning, thunderstorm, duststorm, hailstorm, gale and squall.

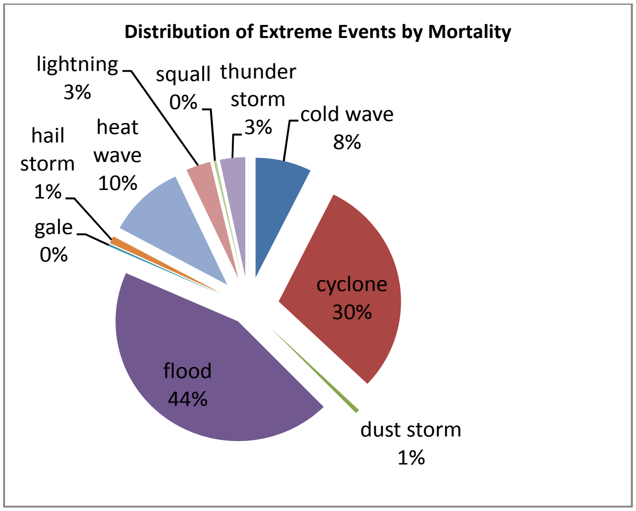

Figure 3: Distribution of the extreme events by mortality

Table 2: Leading states in the extreme events by number and mortality

Extreme Event	Leading States	
	No. of Event	**Mortality**
cold wave	Bihar	Bihar
cyclone	Andhra Pradesh	Odisha
dust storm	Uttar Pradesh	Uttar Pradesh
flood	Maharashtra	Uttar Pradesh
gale	Kerala	Odisha
hail storm	Maharashtra	Bihar
heat wave	Rajasthan	Andhra Pradesh
lightning	Maharashtra	Maharashtra
squall	Assam	West Bengal
thunder storm	West Bengal	West Bengal
Total events	Maharashtra	Odisha

The spatial distribution of events by associating each event with one (or more) states have been examined. 0. Most affected states in the extreme events by their impacts are calculated and presented in table 2. Although Odisha does not lead in the occurrence of any extreme weather events, but the total mortality due to the extreme events is highest in Odisha (Figure 4). Also mortality due to cyclone and gale is highest in Odisha (Table 2). Odisha stand first in normalised mortality also (Figure 5). Mortality due to coldwave is in its peak in Bihar. Bihar also leads in mortality due to hailstorm. Mortality due to flood and dustsorm is maximum in UP. Heatwave mortality is highest in Andhra Pradesh. This reveals the importance of considering exposure and coping capacity due to weather extreme events while assessing vulnerability.

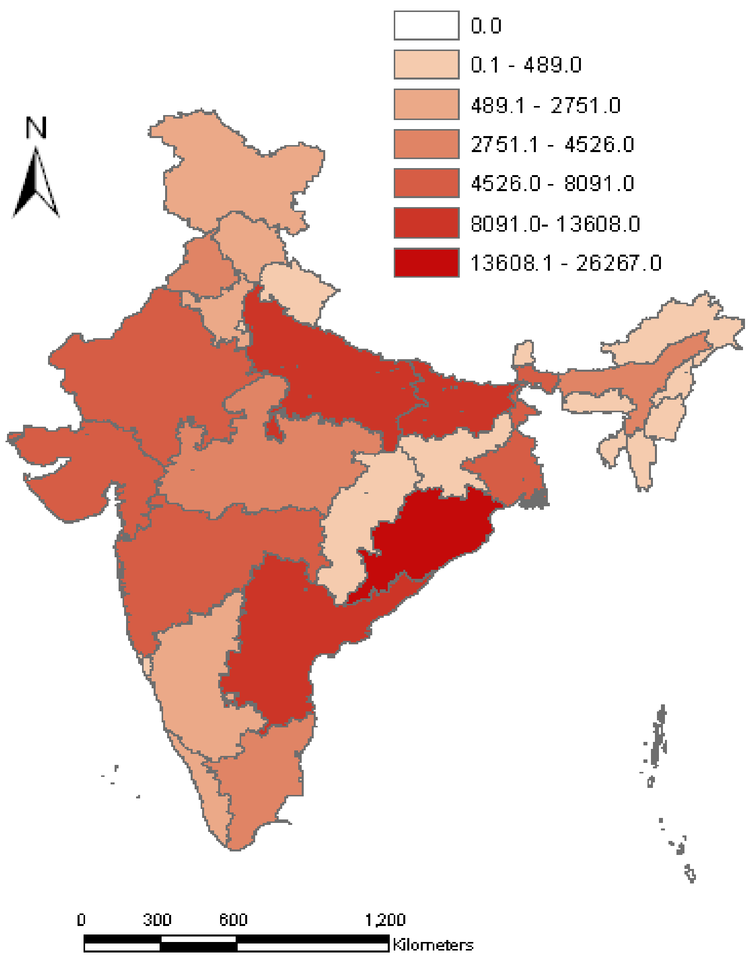

Figure 4: State wise total mortality due to climate extremes

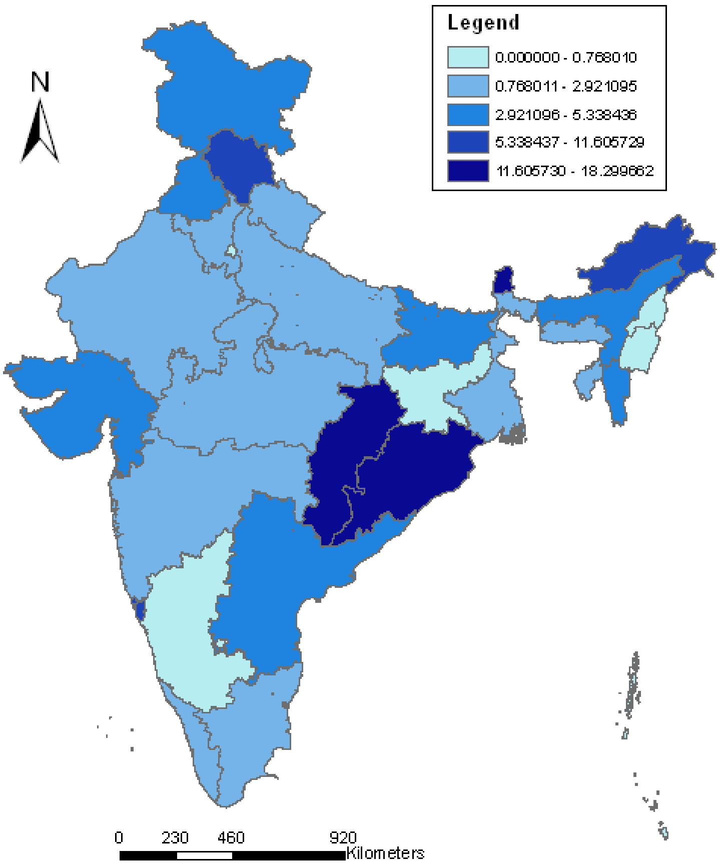

Figure 5: State wise normalised mortality per millio due to climate extremes

Conclusion

India is a large developing country with a population of over one billion, whose growth is projected to continue in the coming decades. In India, nearly two thirds of the population is rural, whose dependence on climate-sensitive natural resources is very high. Its rural population depends largely on the agriculture sector, followed by forests and fisheries for their livelihood. Indian agriculture is monsoon dependent, with over 60 per cent of the crop area under rainfed agriculture that is highly vulnerable to climate variability and change. Developing countries such as India have low adaptive capacity to withstand the adverse impacts of climate change. India has to be seriously concerned with the possible impacts of climate change. The assessment of climate change impacts and adaptation to climate change require a wide range of physical, biological and socioeconomic models, methods, tools and data. The methods for assessing the vulnerability, impact and adaptation are gradually improving, but are still inadequate to help policy-makers formulate appropriate adaptation measures. This is due to uncertainties in regional climate projections, unpredictable response of natural and socio-economic systems and the inability to foresee future technological developments coupled with inadequate data, poor infrastructure and weak implementation strategy.

Policy-makers must formulate plans to turn disasters into opportunities. There are lessons to be learned from how wealthier nations respond to crises following man-made disasters, such as the financial slump and technological adversities. In many such cases, policies are enacted to address the underlying problems that brought on catastrophe (such as poor regulation of the financial system), rather than simply focusing on the proximal cause (such as sub-prime mortgages) and attempting to bring conditions back to 'normal'. The fundamental problems exposed by these disasters are often known and highly predictable. However, the focus must be for changing underlying conditions for the better, rather than on a superficial rebuilding of what existed before. The underlying problems of poverty, poor construction, ineffective administration, inefficient enforcements of rules and regulations, and lack of economic security need to be addressed more comprehensively.

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Land use Land cover Changes in Context to Floods: a Case Study of September 2010 - Flood Affected Villages of Delhi

Vidya Satija[1] and Sreeja S. Nair[2]

Abstract

Due to the increased population and the scarcity of lands, people are increasingly choosing the unsafe areas for settlements and authorities are choosing the areas for unsafe development of infrastructure and public utilities. Whenever the physical land use planning have underestimated the disaster risk in a hazard prone area, the overall risk has been increased. Delhi has experienced six major floods during the year 1924, 1947, 1976, 1978, 1988 and 1995, 2008 and recently in September 2010. The present study was carried out to understand the land use land cover changes and its implications on floods. Eight villages severely affected during the 2010 flood from the north and north-east districts of Delhi were selected for the study. Detailed analysis of all the eight villages was performed to understand the changes land use land cover. Satellite imageries for the year 1992, 1998, 2001, 2005, 2008 and 2010 were used for the study. Land use classification followed by deriving of spatial statistics to understand the changes for 5 land use classes viz, settlement, water body, open area, agriculture and natural was performed for all the villages. It was observed that all the selected villages have experienced substantial changes in the Land Use and Land Cover pattern. Increasing trend was observed in the built-up area in all the selected villages. On contrary a decrease in open area and water body was also observed till 2008. Post 2010 flood there was an increase in the water body and natural vegetation observed in many villages. Comparative analysis was also made between the Land use Land cover patterns derived from classified image of October 2010 of the study area with the proposed land use map of National Capital Region Master Plan 2021. In the NCR Master Plan 2021 consideration of the prevailing flood risk has been taken and the proposed land use for the flood plain ares is predominantly open areas, play grounds, natural vegetation etc. In the flood prone areas/river beds/banks, no construction activities proposed. On the contrary the comparison has shown that significant deviation has already been observed in the present landuse with the proposed land use of NCR 2021.

Key Words: Land use, land cover change, Floods, Image Classification, Settlement, Spatial Statistics

Introduction

The term flood is a general or temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters or from the unusual and rapid accumulation or runoff of surface waters from any source (Bhaskar & Moorthy,

1. Intern, National Institute of Disaster Management
2. Assistant Professor, National Institute of Disaster Management

2003). Flood is one of the most frequent and most devastating disasters. Land use is a very meaningful indicator for the characterisation of urban structures and to know the ecological situation of the city. Changes in land use take place in two ways i.e. when natural areas such as water bodies, forest land are converted into habitation and for other purposes like industrial activities. On the other hand, agricultural areas are also converted for the township development and habitation. Urbanization in developing countries has been doubled from less than 25% in 1970 to more than 50% in 2006 (Gupta et al., 2011). Rapid and uncontrolled growth, bloom in number of vehicles, and financial constraints leading to diminishing investment on infrastructure, have worked together to make our city highly vulnerable to natural hazards. Overtime, continued urbanisation of natural floodplains has caused great annual losses of both wealth and human life. The most clinching evidence of floods having increased as a physical phenomenon comes from the increase in flood affected areas. The flood-affected area increased from an annual average of 6.48 mha in the 1950s to over 9 mha in 1980s and 1990s. This increase is definitely an indication of the country's growing flood proneness.

Table 1: Factors contributing to flooding

Metrological factors	Hydrological factors	Human factor aggravating natural flood hazards.
Rainfall	Soil moisture level	Land-use changes (e.g. surface sealing due to urbanization, deforestation) increase run-off and may be sedimentation.
Cyclonic storms	Groundwater level prior to storm	Occupation of the flood plain obstructing flows.
Small scale storms	Natural surface infiltration	Inefficiency or non-maintenance of infrastructure
temperature	Presence of impervious cover	Efficient drainage of upstream areas increases flood peaks.
Snowfall and snowmelt	Channel cross-sectional shape and roughness.	Climate change affects magnitude and frequency of precipitation and floods.
	Presence or absence of over bank flow, channel network	Urban microclimate may enforce precipitation events.
	Synchronization of runoffs from various parts of watershed.	
	High tide impeding drainage.	

Source: World Meteorological Organisation (2008), Urban Flood Risk Management – A Tool for Integrated Flood Management Version 1.0

Floods in Delhi

The Capital of India has suffered floods as back as in 1924, 1947, 1967, 1971, 1975, 1976, 1978, 1988, 1993, 1995, 1998 and 2010. The 1978 was the worst ever flood in Delhi when water level reached at 207.49 m (danger level is 204.83 m) with discharge 2.53 lakh cusec at old railway bridge (7.0 lakk cusec water released from Tajewala) resulted in submergence of 130 villages and 25 urban colonies in Delhi. As per the map of flood prone areas prepared by central water commission, Delhi has been classified into thirteen zones based on the flooding risk in relation to incremental rise in the water level of the Yamuna. Besides, the Delhi flood control order (2011) also divides the NCTD into four flood sectors, namely Shahdra, Wazirabad-Babrapur, Alipur and Nangloi-Najafgarg sectors. Eight severely flood affected villages from North Delhi viz. Burari, Badarpur, Baqia pad, Jagatpur, Pur, Sadatpur, Seelampur and Subhay pur village witnessed tremendous land use land cover changes over past two decades and the major cause of urban flood in these areas is due to uncontrolled development and land use changes.

Previous work

Flooding is a vigorous dynamic phenomenon where discharge is more than water carrying capacity of river resulting in over toppling of banks and inundation of areas which are otherwise dry (Apte, 2009). Heavy intensity rainfall is a principal cause of urban flooding and is further aggregated by human intervention. Urban areas i.e. cities and towns are growing uncontrollably resulting in drastic change in the land use pattern. This results in change of urban hydrology from gradual rising discharge to quicker and higher peak flows. Cities experiencing heavy precipitation due to their very nature of having large impervious areas, the rain flood water and wastewater do not infiltrate into the ground produce large run-off which the drainage network cannot accommodate, and are potentially exposed to floods (WMO, 2008). Under these circumstances the sustainable management of urban flood risk is becoming an increasingly challenging task for urban communities and the responsible authorities to address. Urban Flooding has become challenging problems in major cities like Delhi, Hyderabad and Calcutta. The un-even distribution of rain fall coupled with Mindless urbanization, encroaching upon and filling up natural drainage channels and urban lakes to use the high-value urban land for buildings are the cause of urban flooding (Pareva, ND). National Water Policy has been implemented over the years on regulating land use in the flood plains by scientifically demarcating areas under different degrees of risk from floods and limit. A case study has been performed on Flood plain zoning and management for Delhi (Rangachari, 2008). A detailed study on urban floods, its impacts and mitigation was carried out by NIDM with the support of IITs for 8 cities. A case study of Delhi with special emphasis on the demographic and settlement pattern to know the land use changes and the vulnerability of floods in the city also carried out under this project (Gosain et.al, 2009). A detailed study of the land use land cover changes and its impact on urban ecology carried out by Gupta et al. (2011).

Aim

The study is aimed at understanding land use land cover changes and it's implication on flood scenario in selected villages of Delhi.

Objectives

1. To identify the villages affected by flood during Delhi floods, September 2010
2. To generate time series land use maps for the selected flood affected villages
3. To identify the land use changes for the flood affected villages for various land use categories (built-up area, water bodies, vegetation, agriculture and open area).
4. To compare the present land use scenario with the land use proposed in 2021 NCR Region Plan
5. Analyse the implications of land use land cover changes

Materials and Methodology

Flood inundated areas of 2010 floods were identified using the inundation maps developed using RADARSAT data (NRSC, 2010). Inundation map was overlaid on the village boundary map of the area and 8 most affected villages were identified for detailed analysis of land use land cover changes. The villages identified were Burari, Badarpur, Seelampur, Baqiapad, Subhaypur, Sadatpur, Jagatpur and Pur village.

Time series land-use land cover maps were prepared using Landsat ETM Orthorectified data and IRS LISS. Data preparation was initiated with layer stacking followed by Georeferencing & Sub-setting of image. Haze reduction and image enhancement was performed for the LISS III data of 2008 for better image interpretation. Visual interpretation of the time series satellite imageries (Landsat ETM and IRS data) of 1992, 1999, 2001, 2005, 2008 and 2010 was performed. Besides Google images were also used for verifying the analysis for the period 2000-2010. Subset images were prepared for all the 8 villages.

Unsupervised classification with five major classes were prepared and compared with Google images. Unsupervised scheme of classification was performed because it is not feasible to do field check for the historic data. The images used for the study were from multiple sources; hence it was not feasible to perform direct change detection using image processing techniques. Alternatively spatial statistics was computed for all the classes from the classified imagery.

The following figure 1 shows the flow chart which explains the basic methodology followed in this study:-

Analysis and Results

Identification of Flood affected villages

Flood affected areas were identified using the RADARSAT data of September 2010 and also from the inundated area map obtained from National Remote Sensing Centre. Based on the visual interpretation and overlay analysis 8 affected villages were identified for detailed analysis. RADARSAT Image of 11 September 2010 and map showing flood affected villages of North and North East districts of Delhi are shown in Figure 2.

Interpretation of Land use changes

Visual interpretation of the time series satellite imageries (Landsat ETM and IRS data) of 1992, 1999, 2001, 2005, 2008 and 2010 depicts substantial changes in the Land use. In5all the selected villages, built area has increased and natural vegetation, agriculture and open area are reduced. (Figure 3 to 10). The outcome of the analytical study on different villages is presented in the following sections:-

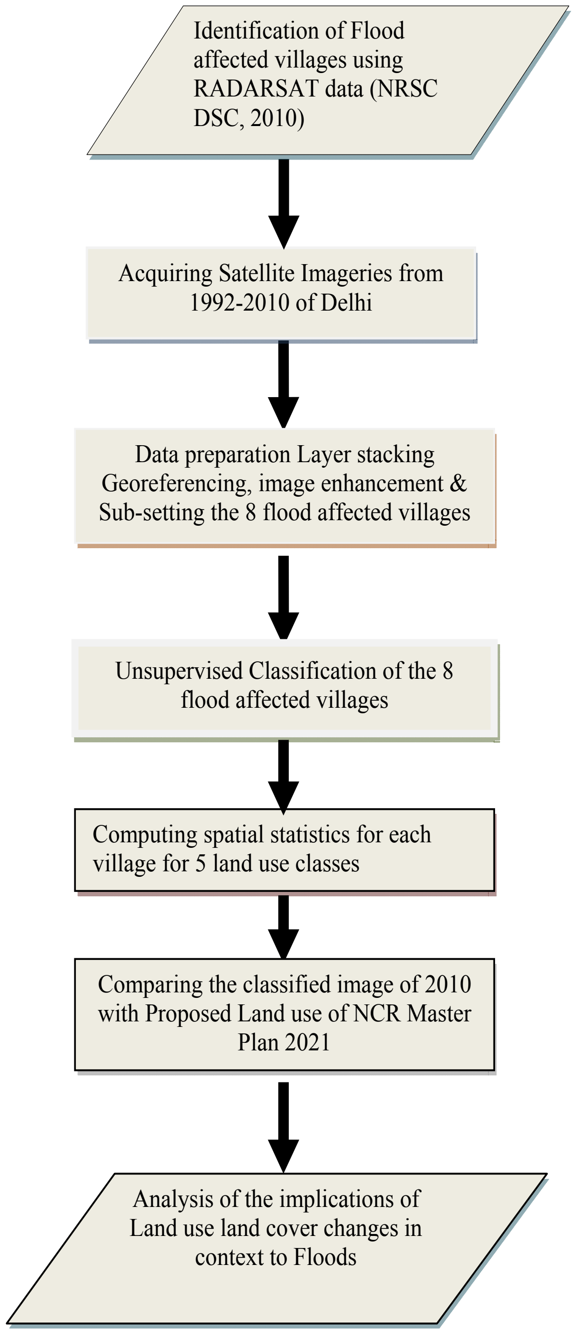

Figure 1: Methodology

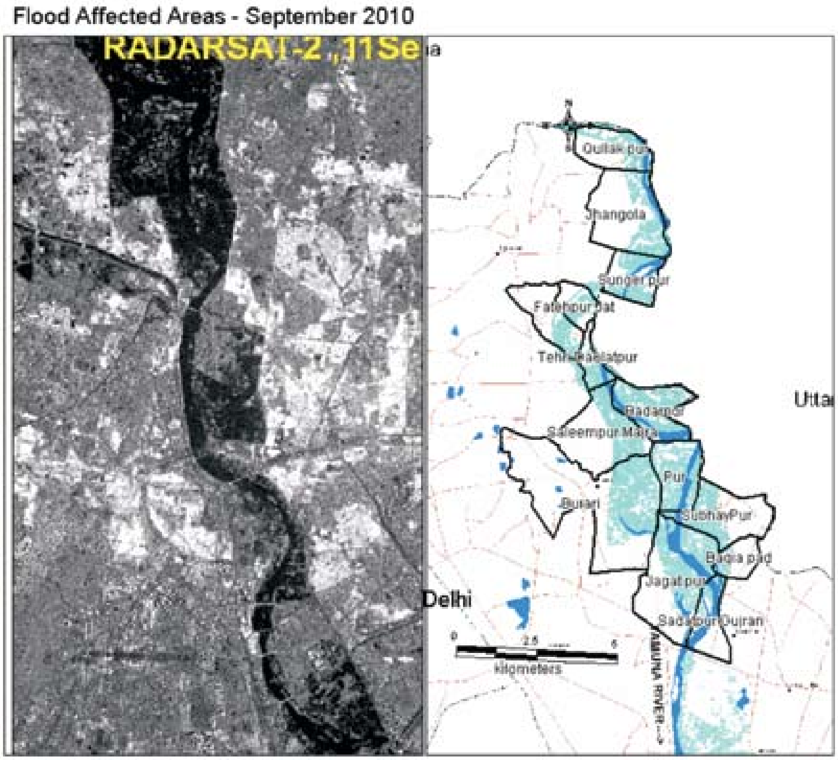

Figure 2: Map showing flood affected villages of North and North East districts of Delhi (*Source*: Decision Support Centre, National Remote Sensing centre, Hyderabad)

1. Burari village

Land use land cover mapping of Burari village depicts increase (more than 5 times) of built up area from 6.97 % in year 1992 to 35.43 % in year 2010. In 1992 satellite imagery Burari village shows an oxbow lake originated from Yamuna River but in 2001 the lake was disconnected from the river channel. The area of the lake was reduced later and in 2008 satellite imagery only a small water body left in south east area only about 2.26%. In the 2010 imagery, the lake area has shown increase due to 2010 floods. Also imagery shows very rich vegetation cover and agricultural land patches in 1992 and 1999 which were replaced by settlements in 2010 imagery. The landuse changes over the period 1992-2010 for the Burari village is shown in figure 3 and table 2.

Table 2: Land use changes in Burari village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1992	170.82	14.49	82.12	6.97	281.77	23.90	509.61	43.20	133.78	11.35
1998	161.55	13.71	237.04	20.12	228.78	18.16	450.28	38.22	117.54	9.33
2001	62.33	5.28	368.29	31.26	261.86	22.22	375.44	31.85	110.66	9.38
2005	61.87	6.94	365.19	30.99	182.64	15.50	480.65	42.83	84.78	7.53
2008	16.04	2.26	140.57	19..90	42.81	6.06	451.43	63.93	55.22	7.82
2010	154.89	13.14	417.42	35.43	133.74	11.35	346.23	30.30	128.32	10.89

For 2008 image was not available for the village

2. Badarpur village

Built up area increased from 4.06 % in the year 1992 to 21.36 % in the year 2010. On the other hand open area has been decreased to a greater extent The agriculture land percentage has remained the same during the analysis period. Change in the course of river channel is observed during period with in the Badarpur village area. Maximum change in the river morphology was observed in during 1992-1998 period. It was observed that the area under vegetation has decreased substantially i.e from 9.92 % in the year 1992 to 5.63 in the year 2005 and increased to 7.07 % after the 2010 flood event. The Land Use changes over the period 1992-2010 for the Badarpur village is shown in Figure 4 and table 3

Table 3: Land use changes in Badarpur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1992	46.38	19.77	13.32	4.06	77.24	23.59	172.03	42.63	18.35	9.92
1998	86.58	30.67	11.07	3.37	42.12	12.80	174.87	40.57	14.31	3.36
2001	45.05	13.71	38.94	11.87	71.59	21.82	147.404	44.81	18.30	5.46
2005	64.81	19.90	42.88	13.06	63.76	19.20	141.81	42.57	18.36	5.63
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	50.13	15.39	69.57	21.36	43.74	13.45	142.29	43.29	23.22	7.07

** For 2008 image was not available for the village.

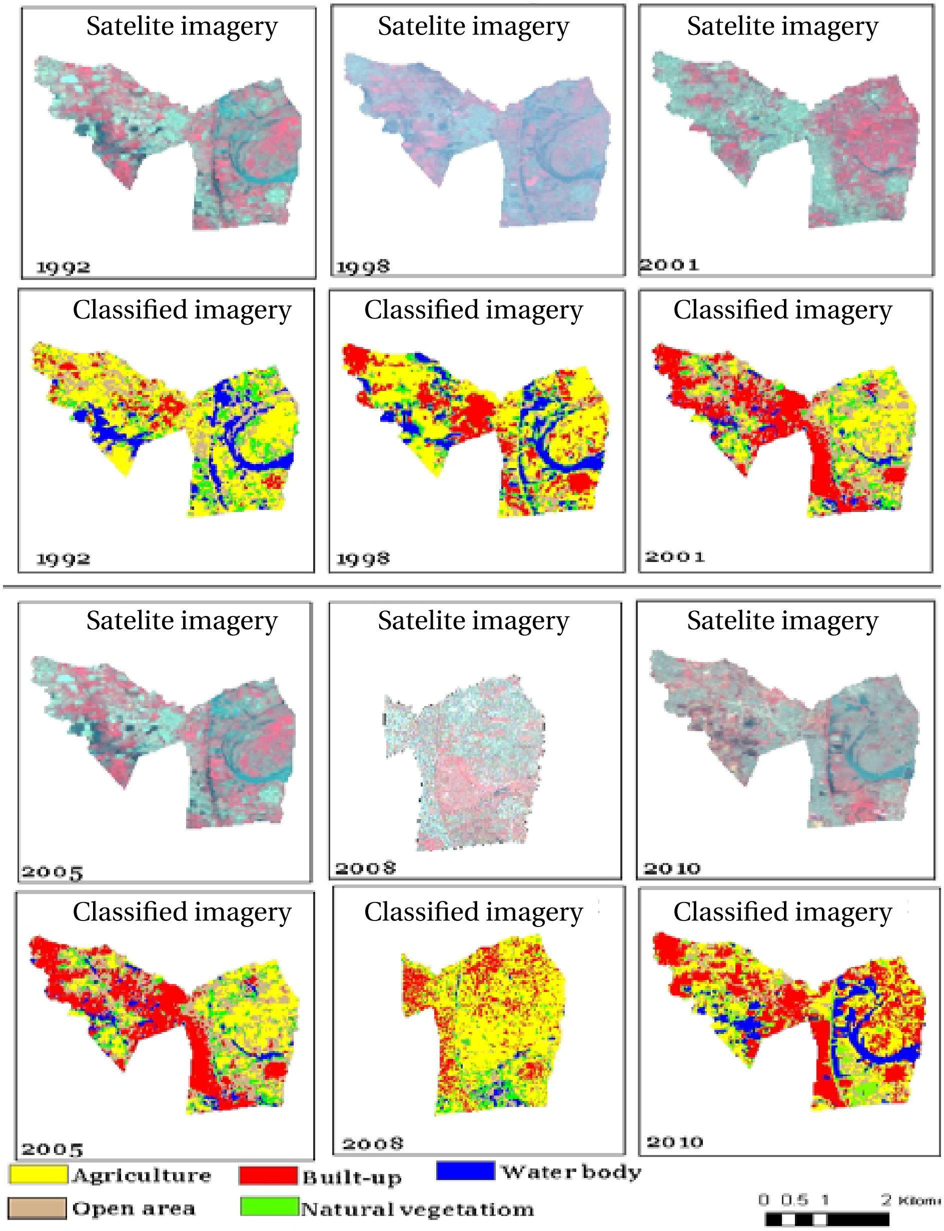

Figure 3: Time Series Satellite imagery and classified images of Burari Village

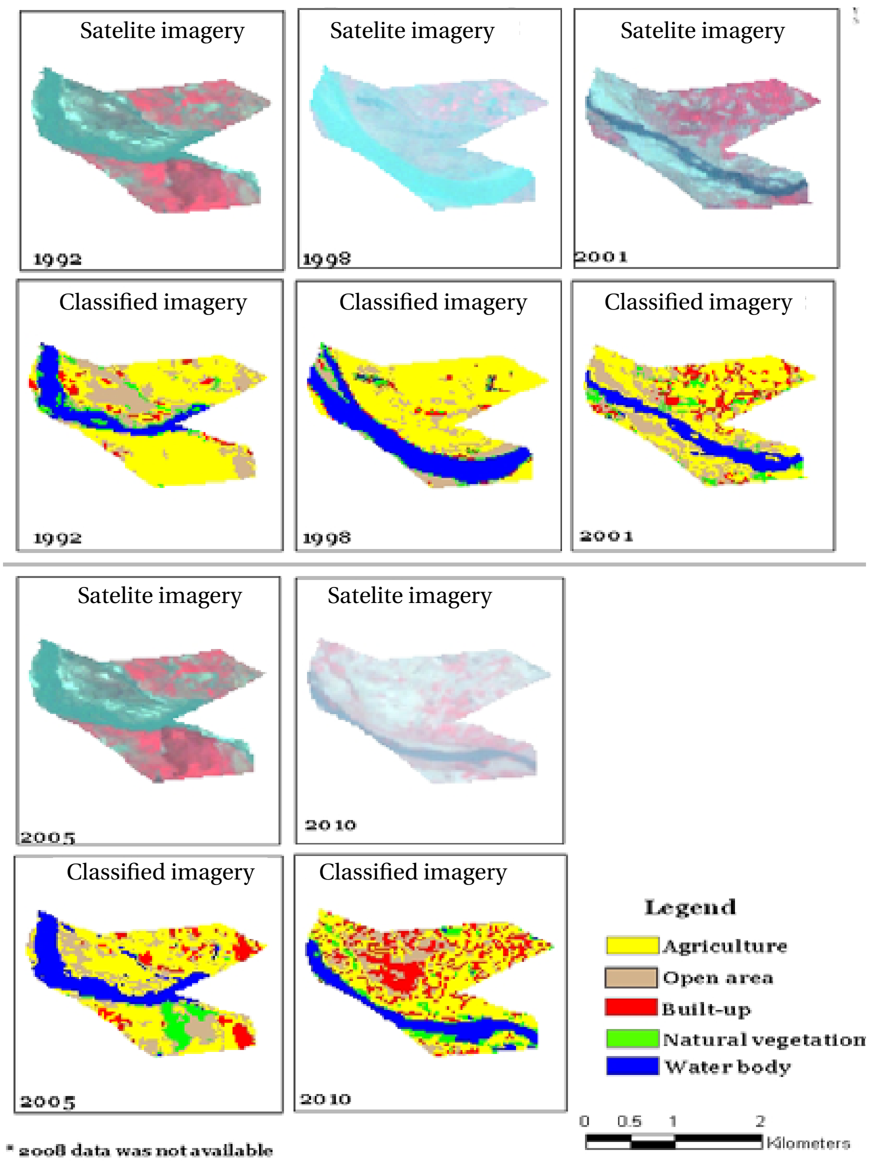

Figure 4: Time Series Satellite imagery and classified images of Badarpur Village

3. Seelampur village

An increasing trend of the built-up area has been observed for the Seelampur village. The increase is nearly two fold during the period 1992-2010 i.e. from 50.34 ha in year

1992 to 99 ha in year 2010. On the other hand decreasing trend was observed for the open area which has reduced by 50% from 115.451 ha in 1192 to 50.76 ha in year 2010. Agriculture area show marginal increase from 281.2 ha to 296.2 ha. The land use changes over the period 1992-2010 for the Seelampur village are shown in Figure 5 and Table 4.

Table 4: Land use changes in Seelampur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	%	ha	%	ha	%	ha	%	Ha	%
1992	23.39	4.63	50.35	10.08	115.45	23.18	281.20	56.69	25.42	5.12
1998	30.42	6.10	50.83	10.15	99.09	19.95	296.64	59.49	37.62	7.54
2001	4.95	1.813	51.18	9.28	69.84	23.99	281.54	56.99	39.80	8.05
2005	23.79	4.83	55.31	11.24	75.05	15.25	283.48	57.61	54.34	11.04
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	14.31	2.87	99	20.12	50.76	10.31	296.19	60.20	38.34	7.79

*** For 2008 image was not available.

4. Baqiapad village

Built-up area increased from 6.73 to 47.07 per cent (i.e. about 8 times). In Baqiapad village, small stretch of Yamuna River has shown eastward shift of about 200 meter during the period 1992-2001 and again westward shift during 2001-2010 period. Area of water body remained almost unchanged over the period although the water body was shrinked to 1.53 ha in the year 2008. The area of the water body increased to 3.15 ha after the 2010 floods. For the year 2008 the complete imagery of the Baqiapad village was not available. Natural vegetation is also showing a decreasing trend from 6.52 per cent in 1992 to 4.45 per cent in 2010.The land use changes over the period 1992-2010 for the Baqiapad village in figure 6 and table no 5

Table 5: Land use changes in Baqiapad village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	%	ha	%	ha	%	ha	%	ha	%
1992	2.92	1.95	10.07	6.73	71.23	47.66	55.48	37.11	9.747	6.52
1998	4.30	3.16	31.23	23.00	55.04	40.53	29.31	21.58	15.89	11.70
2001	4.30	2.92	42.57	28.93	55.04	37.41	29.31	19.92	15.89	10.80
2005	2.92	1.96	45.23	31.03	60.35	40.46	29.97	20.09	9.47	6.35
2008	1.53	1.16	46.46	34.55	18.86	14.40	60.83	46.47	4.44	3.39
2010	3.15	2.10	70.38	47.07	30.7	20.53	38.7	25.88	6.66	4.45

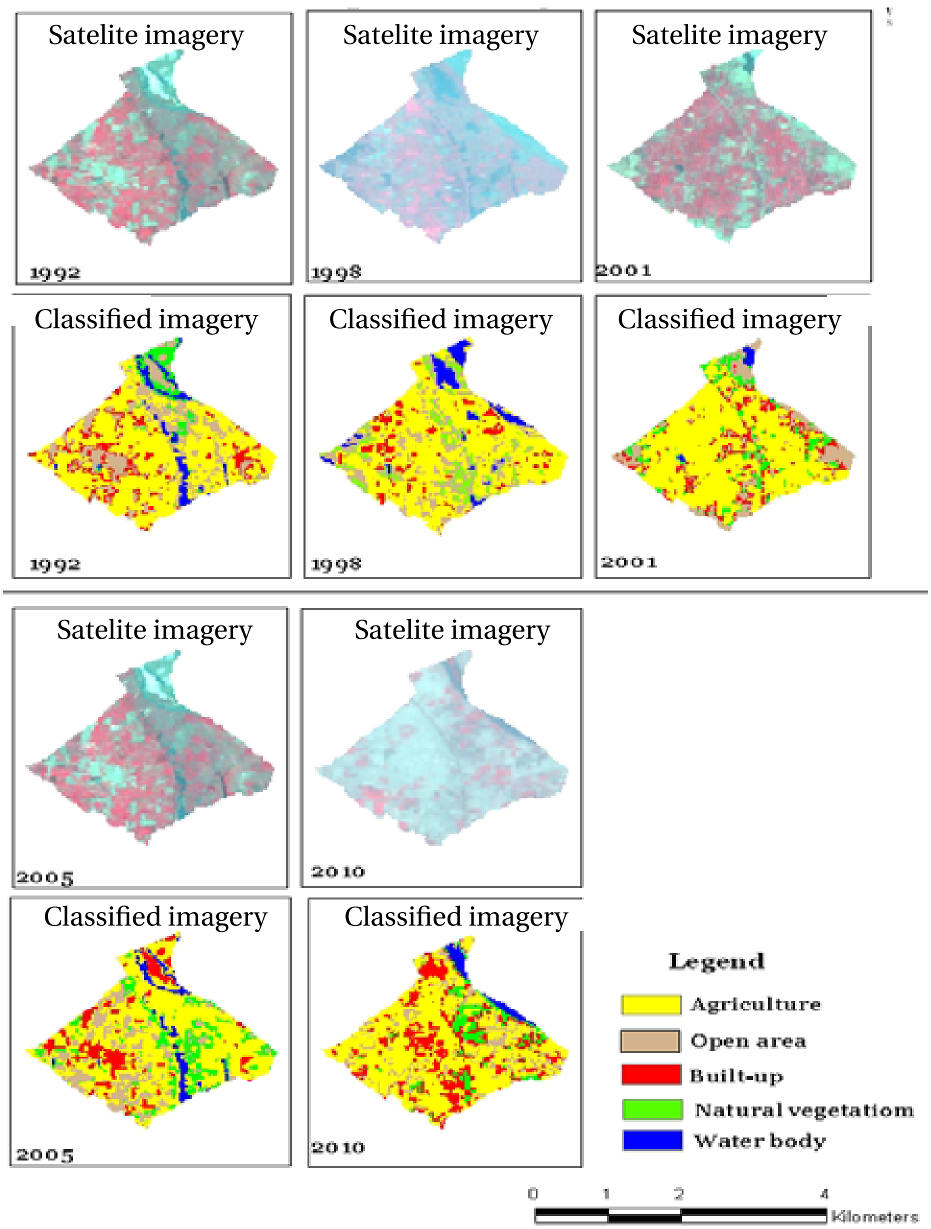

Figure 5: Time Series Satellite imagery and classified images of Seelampur Village

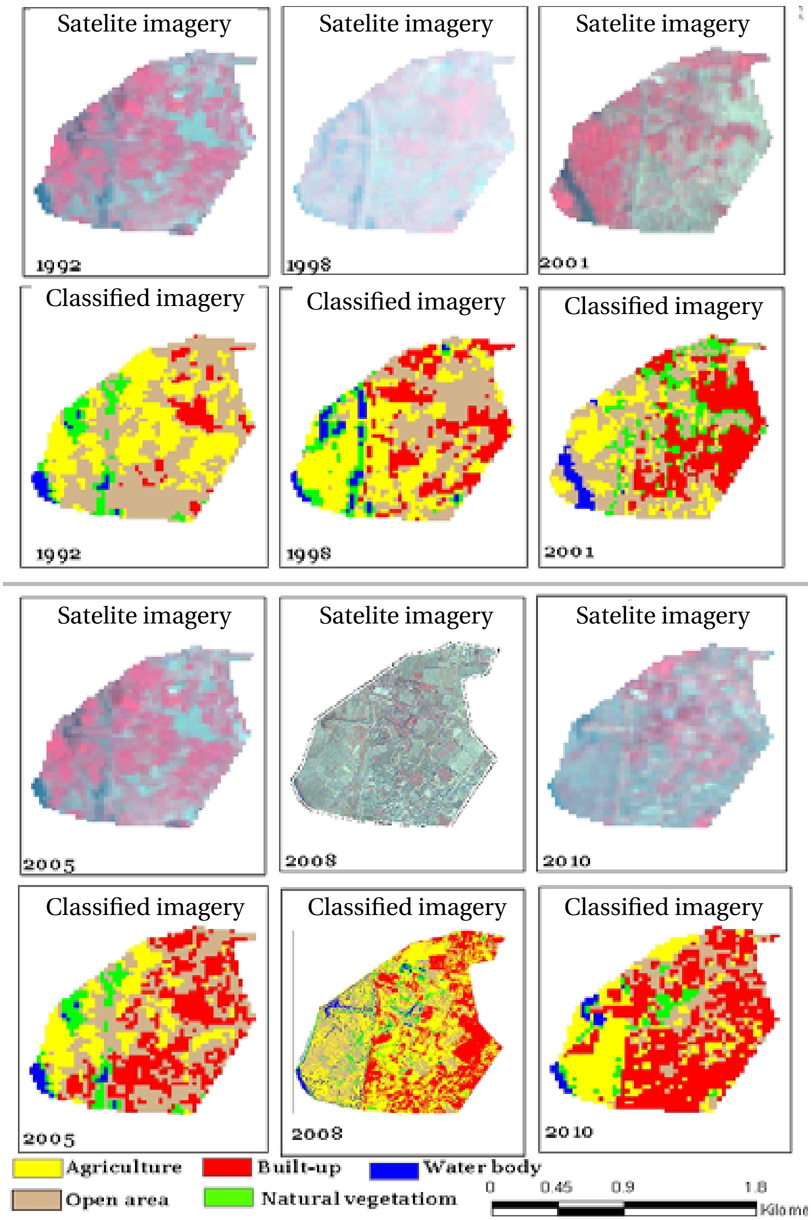

Figure 6: Time series satellite imagery and classified images of Baqiapad Village

5. Subhaypur village

The Land Use changes over the period 1992-2010 for the Subhaypur village is shown in figure 7 and table 6. Total area of Subhaypur village is 394.2 hectares out of which only 17.48 per cent of the total area was built-up (settlement) in 1992. The area has shown gradual increase from the 40.04 ha in 1992 to 100.53 ha in the year 2010. The percentage of land covered by open area has decreased from 26.98 per centrin the year 1992 to 15.33 per cent in the year 2010. For the agriculture land minor variations were observed from 46.57 per cent to 48.97 per cent during the analysis period. Area under the natural vegetation has also remained unchanged over the period.

Table 6: Land use changes in Subhaypur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	%	ha	%	ha	%	ha	%	ha	%
1992	23.39	4.63	50.36	10.08	115.45	23.18	281.20	56.69	25.42	5.12
1998	30.42	6.10	50.83	10.15	99.09	19.95	296.64	59.49	37.62	7.54
2001	4.95	1.81	51.18	9.28	69.84	23.99	281.54	56.99	39.80	8.05
2005	23.80	4.83	55.31	11.24	75.05	15.25	283.48	57.61	54.34	11.04
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	14.31	2.87	99.00	20.12	50.76	10.31	296.19	60.20	38.34	7.79

6. Sadatpur village

About 1/4th geographical area of Sadatpur village is covered by Yamuna river (year 2010). From year 1992 to 2010 there has been substantial increase in built up area from 8.11 per cent to 29.51 per cent. There has been increase in open area by 12.5 per cent to 29.9 per cent and there is decrease in agriculture land by 20.67 per cent. Natural vegetation also increased from 5.05 per cent in 1992 to 9.27 per cent in 2010. Water bodies including floodplains and smaller lakes are being converted into open areas. Agriculture area also decreased by 50 per cent. This strongly indicates that wetland and agricultural lands are converted into open areas for future non agricultural and non eco friendly purposes.

The Land Use changes over the period 1992-2010 for the Sadatpur village is shown in figure 8 and table7.

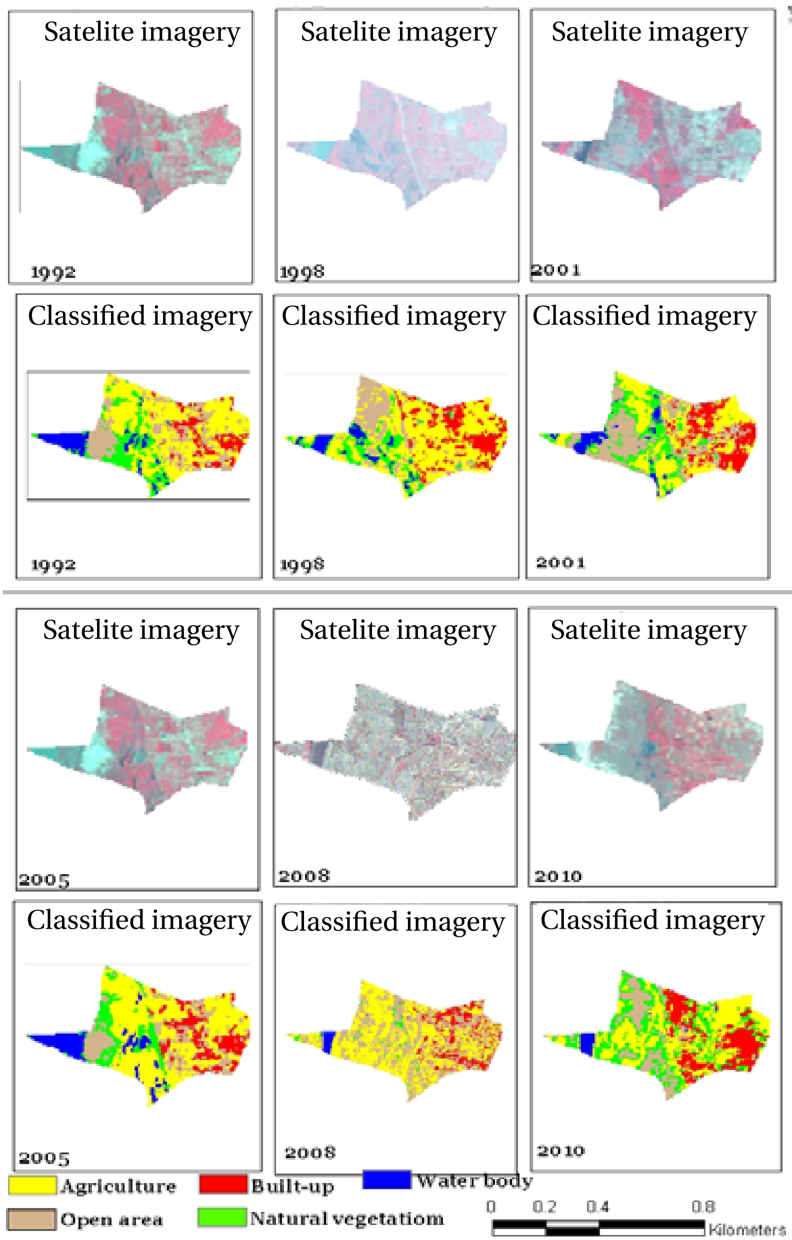

Figure 7: Time series satellite imagery and classified images of Subhaypur Village

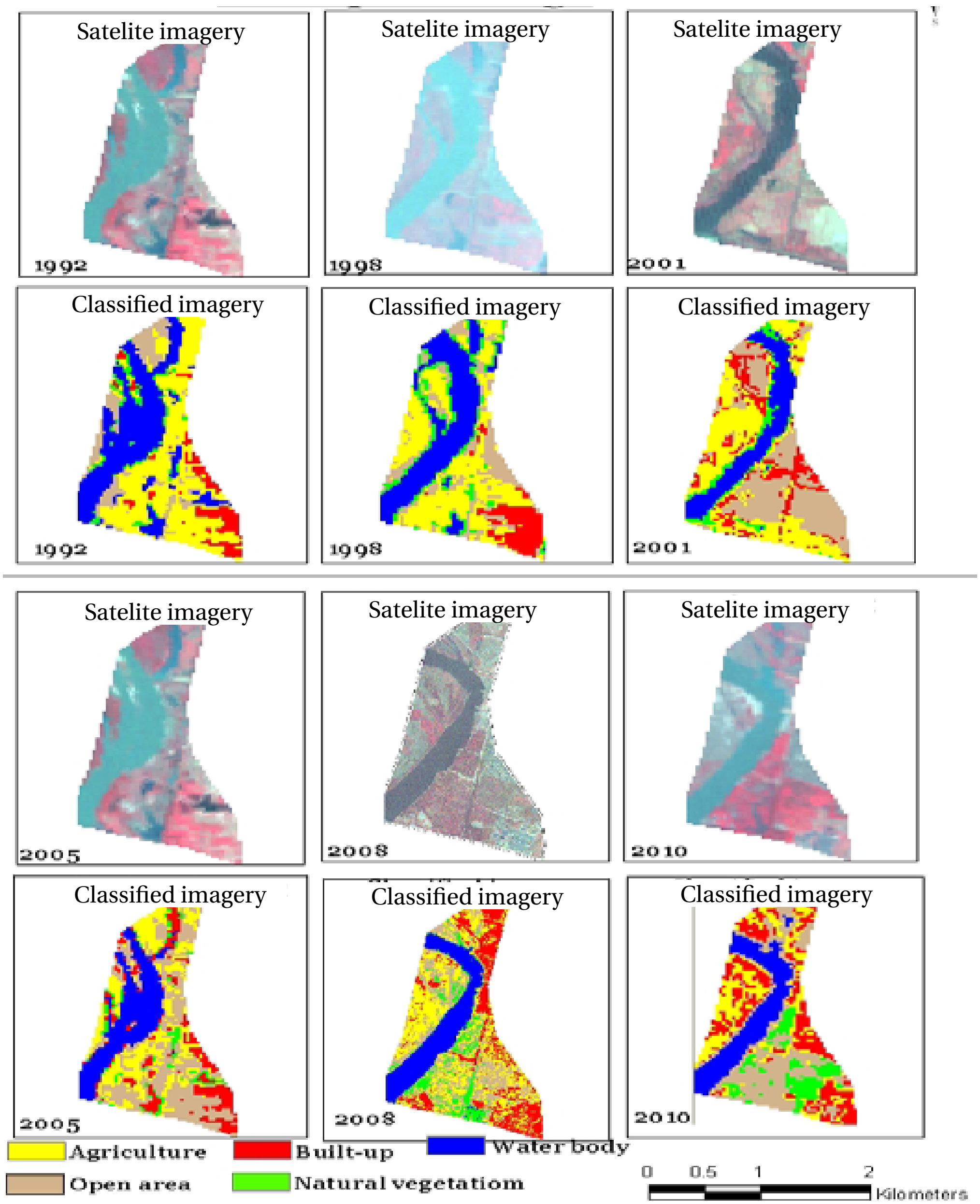

Figure 8: Time series satellite imagery and classified images of Sadatpur Village

Table 7: Land use changes in Sadatpur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1992	76.60	33.54	18.52	8.11	28.59	12.52	93.08	40.76	11.53	5.05
1998	64.53	28.10	21.24	18.06	40.32	8.74	78.84	34.33	24.48	10.66
2001	39.07	18.45	30.07	19.37	69.98	11.31	71.59	44.79	13.92	6.10
2005	51.09	28.60	32.81	18.74	78.22	23.62	54.99	24.08	11.21	4.90
2008	42.64	18.70	44.27	19.41	57.90	25.39	63.33	27.77	18.90	8.29
2010	44.82	19.65	67.30	29.51	66.33	29.09	45.81	20.09	21.15	9.27

7. Jagatpur village

Built-up area has shown an increase of 7.41 per cent in the year 1992 to 34.84 per cent in year 2010. From the table listed it can be observed clearly that open area was under agriculture as seen in 1998 and 2001 imagery.

Table 8 : Land use changes in Jagatpur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural Vegetation	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1992	112.17	16.35	50.85	7.41	143.69	20.94	320.76	46.76	58.40	8.51
1998	115.56	16.72	74.97	10.84	105.39	15.24	356.67	51.60	38.52	5.57
2001	121.09	17.61	148.57	21.61	78.88	11.47	268.49	39.06	70.30	10.22
2005	119.73	17.45	142.55	20.78	75.13	10.95	286.48	41.78	61.97	9.03
2008	59.72	8.71	199.90	29.18	50.43	7.36	312.34	45.59	59.09	8.62
2010	58.32	8.44	240.57	34.84	107.10	15.51	240.75	34.87	43.74	6.33

This may be due to the growing of seasonal crops like vegetables etc in the open area during winter season. This is also evident from land use map of 2001, 2005, and 2008. Water body in the Jagatpur village has shown a gradual decrease from 16.35 per cent in year 1992 to 8.44 per cent in year 2010. The Land Use changes over the period 1992-2010 for the Jagatpur village is shown in figure 9 and table8.

8. Pur village

In Pur village there is an increase in built-up area from 2.19 per cent to 25.34 per cent over the period 1992-2010. For the year 2008 satellite imagery for a part of the village is available and hence the spatial statistics is showing lower values for settlement. A decrease in the percentage of agriculture area has been observed from 50.62 per cent in 1992 to 31.38 in the year 2010. Due to the growing population and urbanization most of the agriculture land has been converted to settlement. Area covered by natural vegetation is also showing a gradually decreasing trend till 2008. Further there is a minor increase in area under natural vegetation due to 2010 flood event similar to other villages.

The Land Use changes over the period 1992-2010 for the Pur village is shown in figure 10 and table9

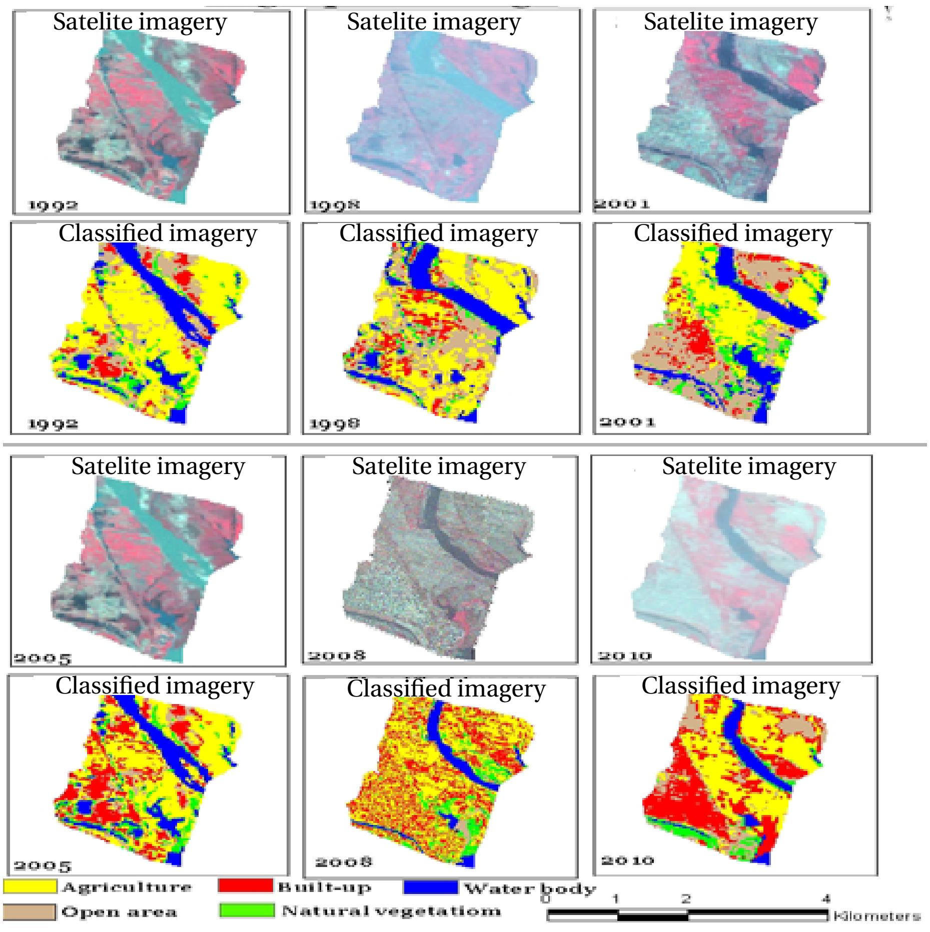

Figure 9: Time series satellite imagery and classified images of Jagatpur Village

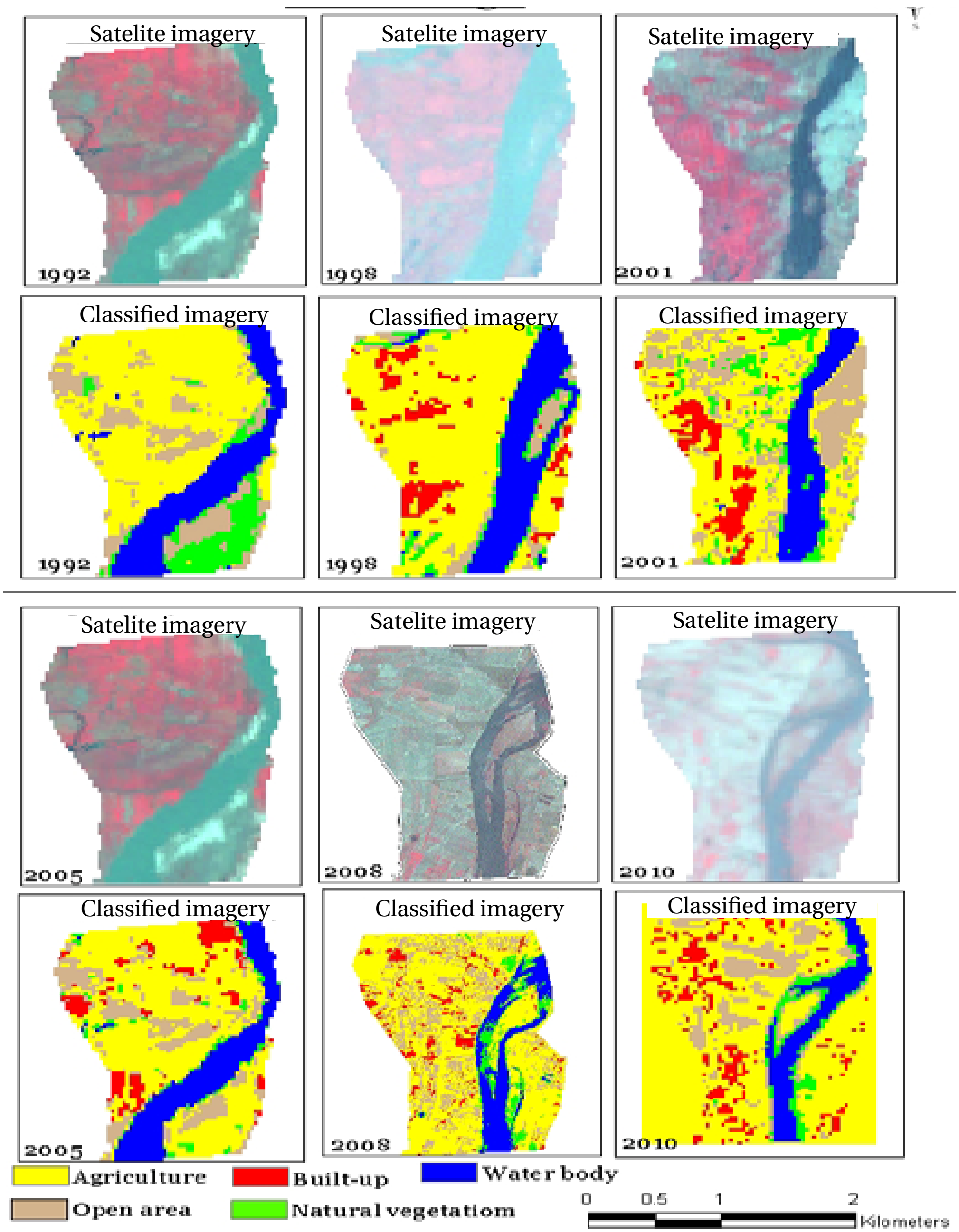

Figure 10: Time series satellite imagery and classified images of Pur Village

Table 9: The Land Use changes over the period 1992-2010 for the Pur village

Land use / year	Water body		Settlement		Open area		Agriculture land		Natural vegetation	
	ha	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1992	59.29	19.55	0.00	0.00	51.17	16.87	153.52	50.62	32.57	10.74
1998	65.16	21.39	6.66	2.19	66.51	21.63	156.96	51.53	15.93	5.23
2001	43.54	14.27	23.69	7.76	64.11	21.01	140.55	45.90	26.97	8.84
2005	55.63	18.29	24.61	12.12	50.44	12.89	162.45	53.47	9.67	3.83
2008	30.76	11.43	15.22	5.65	42.16	15.67	164.70	61.22	16.16	6.01
2010	38.79	12.75	33.57	25.34	44.64	24.33	168.12	31.38	20.25	6.66

Discussion and Conclusion

Urban areas are increasingly being reported to suffer with menace of urban flooding. The increasing trend of land-use shift towards built-up area also indicate permanent use of natural vegetation area or open area or conversion of agriculture land to non-agriculture purpose which is a irreversible change. **Study of land use land cover changes in the 8 flood affected villages of Delhi during 2010 September clearly depicts** significant changes in the land-use over the last two decades (1992 – 2010). The trends observed were not linear for all the land-use types. Prominent change of land-use was noted towards 'settlement' indicating increase of the built-up area in the villages – a common sign of urbanization impact and developmental aspiration.

Maximum increases in the settlements have been observed in Sadatpur village where the 48.79 per cent of land use under built-up area. Supporting to the observation on settlements, the open areas were reduced significantly in three of the villages, viz. Seelampur, Badarpur, Jagatpur. In the present study as well, certain villages, viz. Subhaypur, Sadatpur and Pur village has shown a marked reduction in area under active agriculture. These villages have also shown a decrease in the water-body. Gradual siltation of river course and thus making river-bed dry and hence susceptible for other land-use, i.e. for temporary settlements, agriculture or open areas.The images used for the present study are mainly post-monsoon data. Due to the floods in 2010, area under water bodies showed increase in 2010 image. In certain locations like that in village Burari, high floods have caused clearing of silt-loaded riverbed and thus allowing water to recede fast after a flood event.

A significant reduction in area under agriculture has been observed as a result of flood incidence in year 2010.Thus, there has been observed substantial loss of agriculture as result of flooding. On the other hand, flood risk and perception of likelihoods

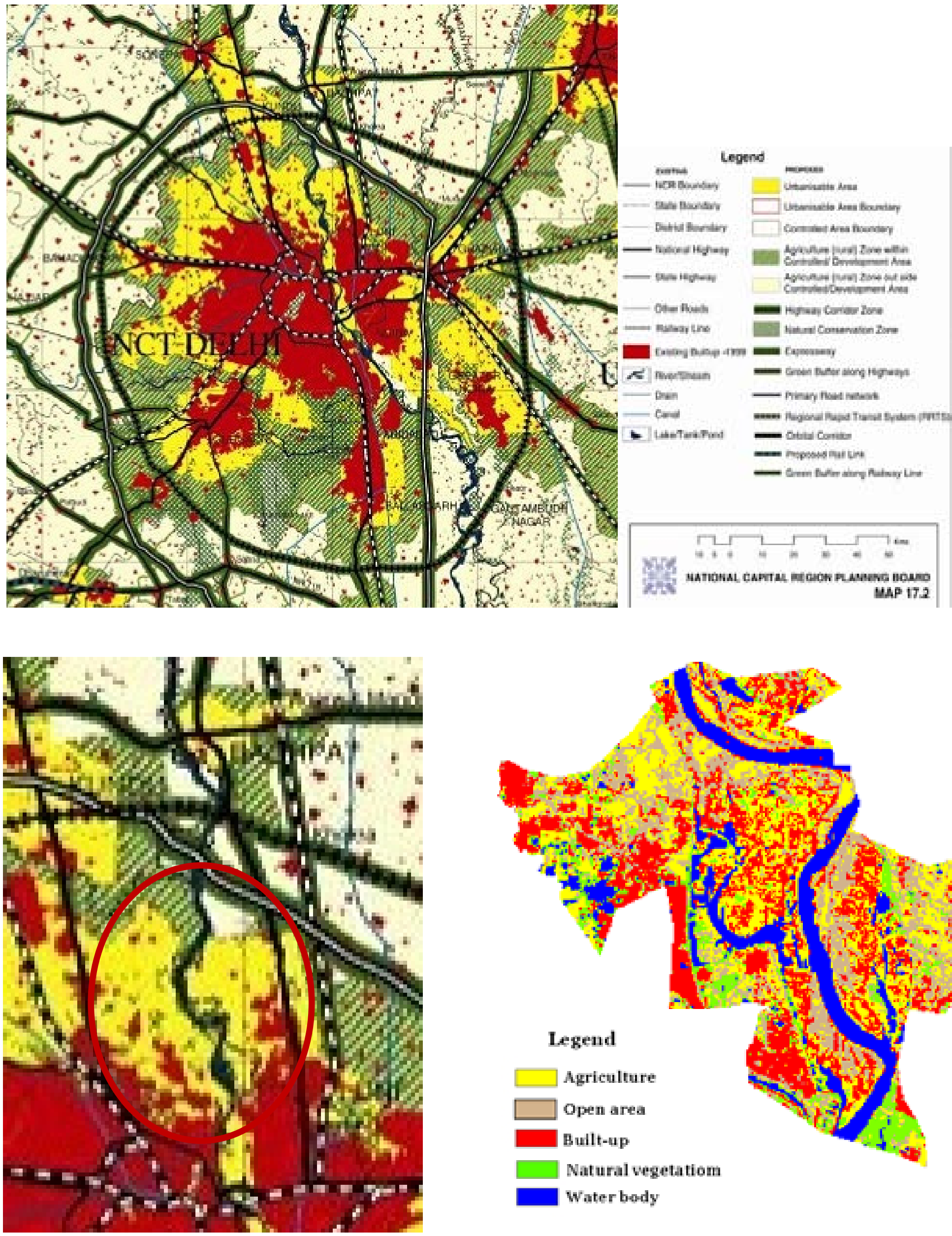

Figure 11: Proposed land use as per the NCR Plan 2021 and Classified land use map generated from landsat TM data of 2010

of floods have also triggered the motivation factor and choice of people towards increasing permanent settlements and as a cause of increased built-up area.

Four villages, viz. Burari, Pur, Sadatpur and Badarpur, show an increase in natural vegetation in the year 2010 after the floods. This has revealed the possibility that the area left fallow or un sown was encroached by weeds.

In general there has been slight but not much significant decrease in area under agriculture but the loss of natural or open area has been evident. People have probably chosen to build effective and better settlement to meet the challenges of some level of floods risk. People based on their experience or the inherited perception develops a notion of relative safety from floods by commissioning and occupying a pakka house or a permanent settlement rather than a kachcha house or temporary dwelling.

Present study has generated broad interpretations of increasing area under settlement and reduction of natural vegetation or open spaces. It is also important to mention that the natural or open spaces sometimes topographically low lying can serve as natural flood control sites as they can offer flood water collection and retention potentials. Loss of such natural areas on the turn also increase the risk of flood impacts on settlements and property including agriculture.

The present study has clearly found out the relationship between the human-induced land-use changes causing changes in the levels of flood risk, whereas increased understanding of the physical exposure of the land belonging to villagers have motivated the shifts to use of better construction materials and conversion of area non-under agriculture to settlement purposes.

Interestingly, the land use changes monitored through present study supersede the projected or envisaged land use for NCR planning for year 2021 (Figure 11). It presents a caution to the urban land use planners and environmental managers as the projections have been crossed even 10 years before the projected growth trend (2021). It has been indicated in NCR planning report that the region is prone to flooding in river Yamuna with return period of 5, 10, 25, 50 and 100 years, and need to be identified on map for land use zoning at regional, sub-regional levels. It is therefore recommended that regions from the NCR states should come up with detailed risk maps for their regions on a scale of 1:1, with marked areas under flood susceptibility.

In the absence of effective regulations of flood plain zoning and land-use controls in the peri-urban areas or villages adjacent to flood prone river channels and under control areas, the conversion of non-organ sable areas into urban uses especially into the settlements of built-up nature has continued unabated. This has caused significant loss of cultivable land as well besides aggravating the floods. The satellite imageries have revealed that environmentally fragile and sensitive areas such as Yamuna riverbed or associated wetlands, ridge areas, forest areas are being subjected to developments authorized or un-authorized. Further detailed study to understand the trends and implications of flood risk on patterns of cropping, types of housing, and aspects on non-structural mitigation with development of vulnerability indicators is recommended as followup to this study.

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Identification and Mapping of Land degradation in Ramgarh district of Jharkhand using Multi temporal Satellite data

Vivek Kumar Singh[1], Reshma Praveen[2] and Sreeja S. Nair[3]

Abstract

Land degradation takes a number of forms, including depletion of soil nutrients, salinisation, agrochemical pollution, soil erosion, vegetative degradation as a result of overgrazing and the cutting of forests for farmland leading to increase in frequency and intensity of drought in the district. All of these types of degradation cause a decline in the productive capacity of the land, reducing potential yields. Remote sensing provides an opportunity for rapid inventorying of degraded lands to generate realistic database by virtue of multi-spectral and multi-temporal capabilities. The present study is based on remote sensing data acquired from IRS-P6, LISS-III satellite data of three different seasons viz. Kharif, Rabi and summer season of year 2006 in conjunction of with Survey of India toposheet and subsequent ground truth has been used for assessment of land degradation using onscreen visual interpretation. We have examined how different remote sensing indicators work for identifying land degradation. Based on severity of degradation the area is mapped into sheet erosion, rill erosion, gully erosion, ravenous land, seasonal water logging and rock out crops. 25.80% of the area of Ramgarh district is under the category of degraded land , out of which more than 22% is severely affected by sheet erosion. The depletion of vegetation cover in the district and subsequent cultivation without proper protection measures is the reason for severe soil erosion and land degradation. The data base would enable to develop District Information System using advanced technology for periodic monitoring and development of degraded lands.

Key words: *Land degradation, IRS-P6 LISS-III, Visual interpretation*

Introduction

Land degradation is one of the most serious global environmental issues. Over 250 million people are directly affected by desertification and some one billion

1. Geologist, Department of Mining and Geology, Corporate Ispat Alloys Limited, Abhijeet Group, Nagpur, India.
2. Project Scientist, Jharkhand Space Application Center (JSAC), Department of Information Technology, Govt of Jharkhand.
3. Assistant Professor, National Institute of Disaster Management

people in over 100 countries are at risk (Adger et al., 2000). Land degradation is a composite term; it has no single readily-identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rocks, air, climate, relief) has changed for the worse. Land degradation is the temporary or permanent lowering of the productive capacity of land (UNEP, 1992). It includes various forms of soil degradation, adverse human impacts on water resources, deforestation and lowering of the productive capacity of range lands. Land gets degraded when it suffers from loss of its intrinsic qualities or there is a decline in its capabilities as a consequence of forces, or the product of an equation, in which both human and natural forces find a place (Blaikie and Brookfield, 1987). According to Chisholm and Dumsday (1987) land degradation is something that can result from any causative factor or a combination of factors, which reduce the physical, chemical or biological status of the land and which may restrict the land's productive capacity.

The land degradation process is generally divided into three classes: (1) physical degradation, (2) biological degradation, and (3) chemical degradation (Barrow, 1991). The assessment of land degradation requires the identification of indicators such as soil vulnerability to erosion. Generally, the assessment of the state of land degradation can be carried out using the Global Assessment of Soil Deterioration (GLASOD) method (Oldeman et al., 1991). Hoosbeek et al. (1997) recommended a qualitative method to classify soil degradation using remote sensing data. Though conventional soil surveys provide information on land degradation, they are quite expensive and time-consuming and require large man power. Spaceborne Remote Sensing is one of the state-of-the-art technologies being used for the study and management of natural resources because it facilitates synoptic view of terrain features, repetitive coverage of the same area at regular time intervals, and the amenability of data to computer analysis, thus, covers large area, consumes less time and is less expensive than ground surveys involving less man power.

Agricultural production in Ramgarh district is charactarised by mono cropping practices with only 14.5% of the net sown area being irrigated; 61% of the agricultural land holding belongs to small and marginal farmers which have contributed to poor level of mechanised farm operations in the district. Agriculture is mainly rainfed; the major crops cultivated are paddy, wheat, maize and vegetables. Situation in the district has worsened in the recent times due to land degradation. It is important to check land degradation and encourage sustainable agricultural practices in the district.

Quantification of a spatial extent during a particular time period is the first step in monitoring the progress of land degradation. Remote sensing data are handy for land degradation assessment and monitoring these periodically in time and space domain using multi temporal datasets in India (Venkataratnam and Rao, 1977; Venkataratnam, 1989; Rao et al., 1991; Venkataratnam and Ravisankar, 1992; NRSA, 1995). Most importantly, it helps to identify features and their conditions in inaccessible areas like that of Tons river catchment.

It is essential to bring about a balance between economic development and environmental conservation. Needless to mention, up-to-date information on the state of natural resources is essential for planning the sustainable development of mountain regions.

Study Area

The study area (Figure 1) Ramgarh exists between latitude 23°25' to 23°58' N and 85°12' to 85°53' E. The general climate of the area is tropical with maximum annual temperature between 37.7°C to 44.3°C and minimum temperature between 3°C to 14°C. The area receives normal rainfall between 1102 mm to 1472 mm with significant seasonal variation.

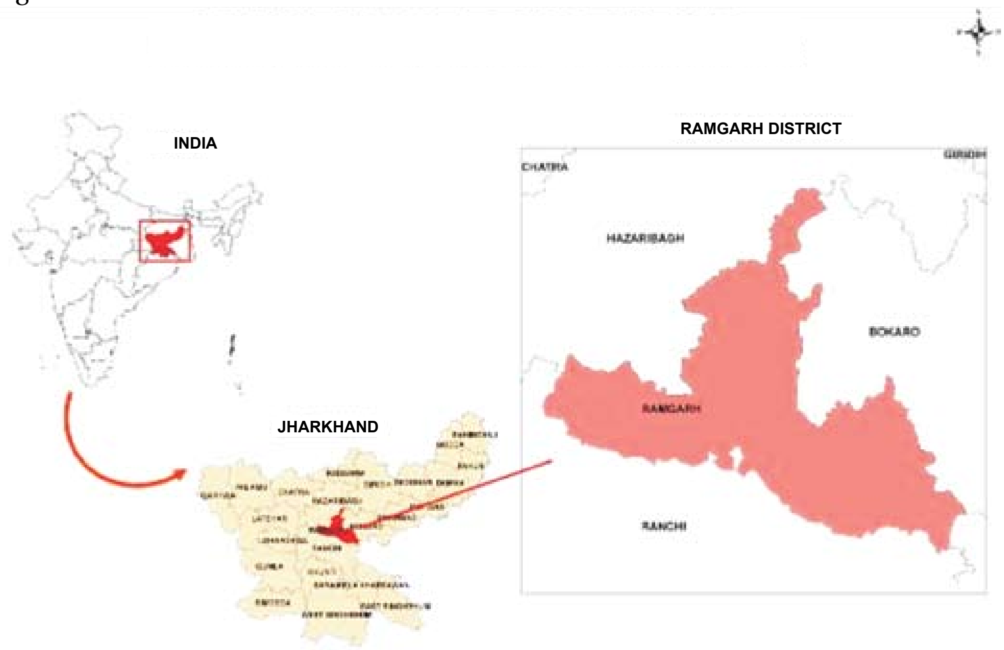


Figure 1: Location of Ramgarh district of Jharkhand

The area is drained by Damodar river with Nalkari river as its main tributary. Forest covers are mainly in the hilly terrains of the study area. Most of the forests are of deciduous type. Some are also of evergreen type. Agricultural lands are located in the plain area i.e. in the central part of the study area. The land use in the area is governed by mining activity and its concomitant effect on land. The land cover dominates by urban residential and industrial build up lands correspond to mining operations and related industries whereas forests dominates over the hilly terrain reflecting the natural climatic setting of the region.

Methodology & Data used

The methodology used to obtain and evaluate information on the status of degraded land in the basin was based on Resourcesat-1, LISS-III images of three seasons viz. Rabi, Kharif and Zaid of year 2005-06 and field investigations. The primary information for this study was obtained from the False Colour Composite (FCC) of the LISS-III satellite image of the study area. The spatial resolution of the image is 23.5 meter in first three bands. The geometrical correction of the images was made by using the ERDAS IMAGINE software, and accuracy within one pixel was achieved. Visual mode of interpretation technique based on image characteristics followed by ground verification has been employed for mapping of degraded lands. Image interpretation key was formulated based on the spectral signatures of various causative factors of different kinds of degraded lands (Table 1). The mapping legend has been made systematic and connotative. The extent and spatial distribution of different kinds of degraded lands with degree of severity under major land form and major land use in a district could be derived easily from multi temporal satellite data. The detailed methodology has been given as flowchart (Figure 2).

Image interpretation was carried out to identify the types and extent of degraded land using image interpretation keys (Table 2). The interpretation was also supported by field observations. The field study was carried out in two seasons namely Rabi and Kharif and representative soil sample were collected and have been sent for laboratory test. On the basis of the field work and results of laboratory tests, the pre interpretation was corrected. During the fieldwork the relationship between image elements and tentatively identified land degradation classes were established that were delineated during preliminary interpretation. Terrain features were also used for improving the classification accuracy (Boyed et al., 1996; Malingreau et al., 1996).

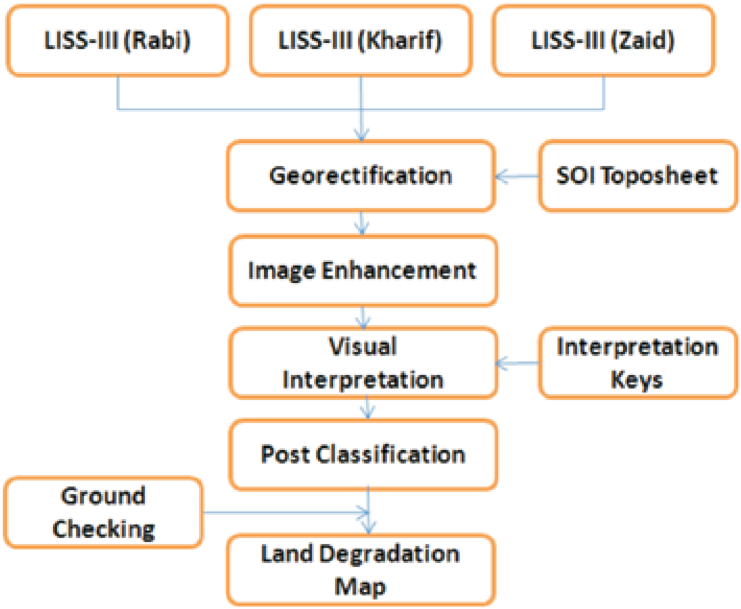


Figure 2: Methodology Flow Chart

Table 1: Main visual indicators for the different types of land degradation

Visual Indicator	Types of Soil & Land Degradation					
	Water erosion	Wind erosion	Salinity or Alkalinity	Chemical degradation	Physical degradation	Biological
Rills	√	x	x	x	x	x
Gullies	√	x	x	x	x	x
Pedestals	√	√	x	x	x	x
Armour layer	√	√	x	x	x	x
Deposits of soil on gentle slopes	√	X	x	x	x	x
Exposed roots or parent material	√	√	x	x	x	x
Muddy water/mudflows during and shortly after storms	√	x	x	x	x	x
Sedimentation in streams and reservoirs	√	x	x	x	x	x

Visual Indicator	Types of Soil & Land Degradation					
	Water erosion	Wind erosion	Salinity or Alkalinity	Chemical degradation	Physical degradation	Biological
Dust storms/clouds	x	√	x	x	x	x
Sandy layer on soil surface	x	√	x	x	x	x
Parallel furrows in clay soil or ripples in sandy soil	x	√	x	x	x	x
Bare or barren spots	√	√	√	√	x	x
Efflorescence	x	x	√	x	x	x
Soil particles unstable in water	x	x	√	x	x	√
pH	x	x	√	x	x	x
Nutrient deficiency/ toxicity symptoms evident on plants	√	x	x	√	x	√
Decreasing yields	√	√	√	√	√	√
Changes in vegetation species	√	x	√	√	x	x
Plough pan	x	x	x	x	√	x
Restricted rooting depth	√	x	x	x	√	x
Structural degradation, including compaction	x	x	√	x	√	x
Poor response to fertilizers	x	x	x	√	x	√
Decrease in organic matter (lighter-colored soils)	√	x	√	x	x	√
Increased sealing, crusting and run-off; reduced soil water	x	x	√	√	√	√
Decrease in number of earthworms/ants and similar	x	x	x	x	x	√

Although not all degradation features can be detected directly from remote sensing imageries, many can be digitally enhanced (e.g. PAN sharpening and contrast stretching of the images, for mining related degradation while applying spatial filters like high pass filtering for Gullies and Ravines) and mapped. Remote sensing data substantially contribute to the mapping and monitoring of degradation features, but their use is limited by relief-controlled factors in mountainous areas causing geometric distortions and atmospheric constraints (Zinck et al., 2001). To remove the topography-induced constraints for land degradation assessment, intensity normalisation of multi-spectral data was used as a pre-processing technique for image classification of the mountainous areas (Shrestha and Zinck, 2001). By normalising the Multispectral data, possible bimodal distribution of training samples was avoided and classification errors were minimised.

Topography is an important parameter for assessing land degradation in mountainous areas. In the case of sheet erosion, slope gradient in combination with slope length controls soil susceptibility to detachment by runoff, which is dependent upon soil cohesion at saturation and the overland flow velocity.

Results & Discussion

Visual mode of interpretation technique based on image characteristics followed by ground verification has been employed for mapping of degraded lands. Image interpretation key has been formulated based on the spectral signatures of various causative factors of different kinds of degraded lands. The extent and spatial distribution of different kinds of degraded lands with degree of severity has been mapped (Figure 3&4).

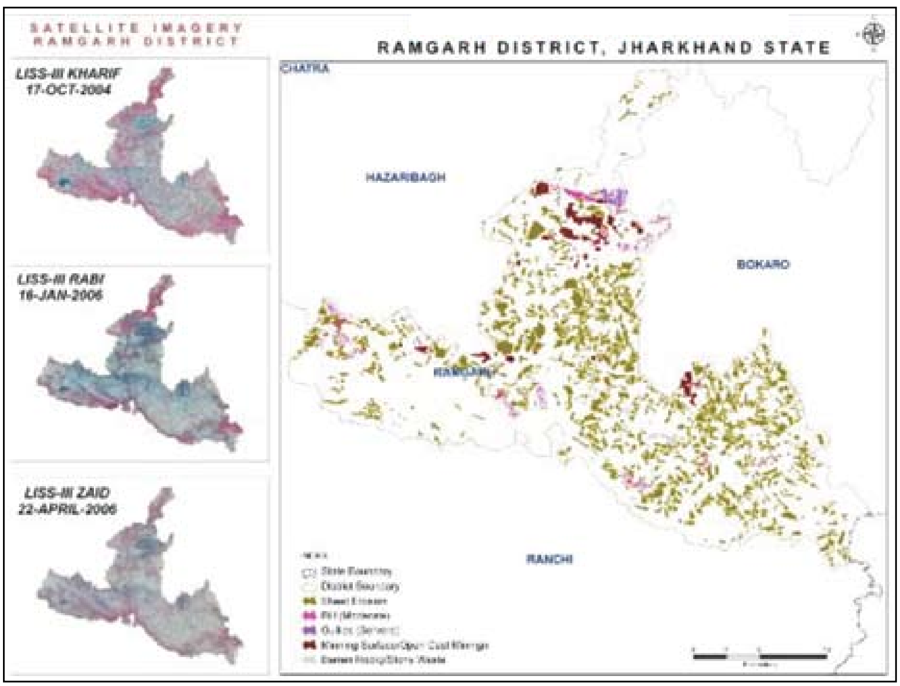
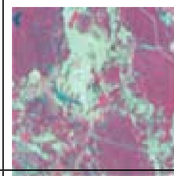
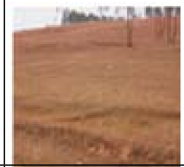
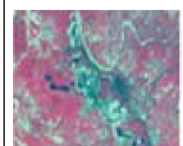
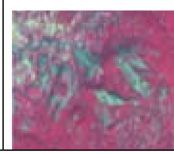
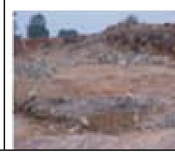


Figure 3: Land degradation Map of Ramgarh district

Table 2: Visual Interpretation keys for mapping of Land Degradation in Ramgarh District of Jharkhand

Land degradation type	Field Indicators	Physiography	Land cover	Soil type	Appearance on Remote Sensing Data	Satellite Image of Study Area	Field photo of Study Area
Sheet Erosion	Muddy runoff during rainy season/Soil color is lighter than surrounding soils / Concretions/ coarse fragments on surface	Plains/ valleys / pediments with >1-3% slope class	Crop lands/ fallows/ land with / without scrub/ degraded forests. Grass cover and thick forests reduce erosion rates. Poor vegetal cover enhances erosion rate	Predominantly in soils with fine texture, low organic matter and weak structure	Slightly brighter than surrounding land of its class. Smooth to medium texture		
Gullies	Well defined and permanent incised land neither cultivable nor traversable	Occurs on >5% slope lands. Starts at the lower element of slope and gradually creeps to upper slopes	Mostly land with / without scrub	Predominant in loams and associated textures	Brighter than surrounding land / gray in color depending on soil color. Mainly associated with first order streams		
Ravines	Well defined and permanent incised land neither cultivable nor traversable Network of deepened gullies	Associated with major streams / river network	Mostly land with / without scrub	Predominant in loams and associated textures	Medium gray to dark gray tone. Slightly coarse texture. Large to very large size & associated with stream		
Mining surface /open	Associated with open cast mining and its surrounding		Wastelands, land with / without scrub		Shades of yellow, green, black and varies on mining stage and type of mineral explored		
Barren Rocky	Contiguous rock exposure on surface or covered with stones	Hill / pediment region	Wastelands	No remarkable soil cover	Light to medium grey/yellowish white. Mainly in hilly or pediment regions		

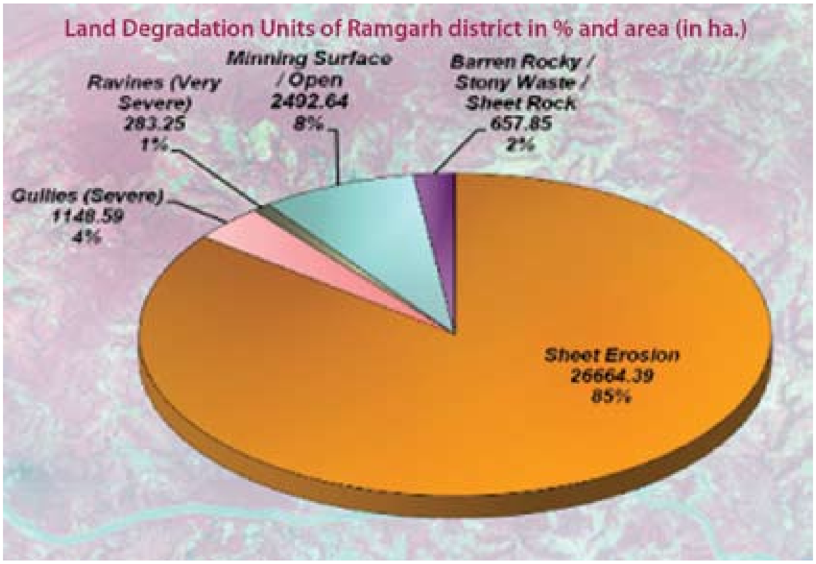


Figure 4: Land degradation Map of Ramgarh district

Table 3: Degraded Land Categories

Name of the District	Degraded Land Categories	Total Area (in Ha)	Total Area (in %)
Ramgarh (Total Geographic area 1,21,111 Ha)	Sheet Erosion	26664.39	22.02
	Gully Erosion	1148.59	0.95
	Ravines	283.25	0.23
	Mining Surface/open cast mines	2492.64	2.06
	Barren rocky/Stony waste	657.85	0.54
	Total Degraded Area	31246.73	25.80

The district Ramgarh (total geographical area is 1,21,111 ha) is showed 31246.73 ha (25.80%) is under degraded area. Out of these, the sheet erosion is 26664.39 ha (22.02%), gully erosion is 1148.59 ha (0.89%), ravines is 283.25 ha (0.35%), mining surface/open cast mines is 2492.64 ha (1.80%) and the barren rocky/Stony waste is 657.85 ha (0.54%) as shown in Table 3.

Sheet Erosion is a common problem resulting from loss of top soil. The soil particles are removed from the whole soil surface on a fairly uniform basis in the form of thin layers. They appear slightly brighter than the surrounding background soil colour with smooth texture. The total area of sheet erosion is 26664.39 ha, which is 85% of the total degraded land of Ramgarh district.

Gully Erosion, the first stage of excessive land dissection followed by their networking which leads to ravine, are commonly found in sloping lands. It appears brighter than the surrounding with coarse image texture. It is associated directly with natural stream network of the area. The erosion starts near the stream and proceeds upward along the slope. The total area of gully erosion is 1148.59 ha, which is 4% of the total degraded area.

Ravines are basically extensive systems of gullies developed along the river course. They are clearly visible on the Rabi data, in general. They are deep near the river and as we go away from stream/river, the depth decreases and image texture becomes smoother. The total areas of ravines are 283.25 ha, which is less than 1% of the total degraded area.

Mining Surface/open cast mines includes surface rocks and stone query, sand and gravel pits, brick kilns etc. Appears as discrete shades of yellowish green, black, yellow in small to medium patches. It is clearly visible in all season data. The total area of mining surface/open cast mines are 2492.64 ha, which is 8% of the total degraded area.

Barren rocky/Stony waste appears as irregular discrete/contiguous medium to large patches of light to medium grey/yellowish white colour on all three seasons satellite data. These are found near the hills and in the pediment portion. The total area of barren rocky/stony waste are 657.85 ha, which is 2% of the total degraded area.

Conclusion

Land degradation hazard assessment is crucial for risk sensitive land use planning activities. Mountainous areas are frequently affected by more than one type of degradation occurring simultaneously. From the present study, it is clear that 85% of the study area is under sheet erosion. The northern part area is vulnerable to land degradation basically due to mining activities while degradation in the form of gullies and ravines can also be not neglected. This research indicates that remotely sensed data can be effectively used for identification and mapping of land degradation risks and monitoring of land degradation changes in the study area. The complexity and interplay of drivers causing land degradation vary in different sites, thus there is lack of a suitable approach to implement land degradation assessments. This paper is on a approach based on purely remote sensing techniques for mapping and monitoring of land degradation risks in a Ramgarh district. It is found that remotely sensed data have the potential to provide new insights for rapidly assessing land degradation risks in large areas. Although detailed assessments of land degradation risk results are not conducted in this paper, visual analyses of the results have indicated that the developed land degradation risk maps appear to be very reasonable and represent the real situation where land cover change increases or decreases land degradation risks.

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An Overview of Environmental Impact Assessment Study of Swan River Flood Management Project-II, District Una, Himachal Pradesh, India

Venu[1], Madhuri S. Rishi[2] and Abinder S. Chadda[2]

Abstract

Environmental Impact Assessment (EIA) appraise and predicts the impacts of a proposed project or action on human well & being, as well as the well-being of ecosystems on which human survival depends. Environmental Impact Assessment (EIA) is one of the major instruments integrated with a goal of making economic development project, environmentally sound and sustainable. The main objective of this paper is to give a combined and integrated overview of environmental, economic and social impact assessments of Swan River Flood Management Project-II. The Swan River of district Una, Himachal Pradesh, once, was known as River of sorrow as during monsoon period the flood creates havoc in District Una. During past 10-12 years loss of property due to floods in river Swan has been estimated as more than Rs. 1,666 million. Human and livestock loss has been to the extent of 50 and 236 numbers respectively. But it was taken under the reclamation process by Swan River Flood Management and Integrated Development Project and turned to the gift for district. This would revolutionise the economy of the farmers of Una district as it would result in raising of 1,500 metric tonnes of fish, 14,450 metric tonnes of food-grains, pulses, vegetables and 7,700 metric tonnes of fruits every year besides mitigating miseries caused due to floods to life and property both. This paper is an overview of EIA study of Swan River Flood Management and Integrated development Project-II. The EIA study gives the maximum thrust to the impacts on water environment and its cascading effects on the biotic as well as abiotic environment.

Keywords: *EIA, Environment, Sustainable, Flood Management, Economy*

Introduction

With the tropical climate and unstable landforms, coupled with high population density, poverty, illiteracy and lack of adequate infrastructure, India is one of the

1. Research Scholar, Dept of Environment & Vocational Studies, Punjab University, Chandigarh.
2. Assistant Professor, Dept of Environment & Vocational Studies, Punjab University, Chandigarh
3. Abinder. S.Chadda, Executive Engineer, Irrigation and Public Health Department, District Bilaspur, Himachal Pradesh.

most vulnerable developing countries to suffer very often from various natural disasters, namely drought, flood, cyclone, earth quake, landslide, forest fire, hail storm etc. which strike causing a devastating impact on human life, economy and environment. However, if we are adequately prepared with disaster management, it is possible to severely reduce the impact of a disaster. The impact can be reduced through a good understanding of preventive actions, as well as having the knowledge of certain life-saving tools and techniques, which when used at the time of the event of disaster can control the total damage to life and belongings. Environmental Impact Assessment is the official appraisal process to identify, predict, evaluate and justify the ecological, social, and related biophysical effects of a proposed policy, program or project on the environment and plays a very significant role in any disaster management project. The overall objective of the EIA is to design developmental projects and activities taking into consideration the environmental perspective. India is the worst flood-affected country in the world after Bangladesh and accounts for one-fifth of the global death count due to floods. About 40 million hectares or nearly 1/8th of India's geographical area is flood-prone.

The River Swan flows through district of Una and after traversing a distance of 85 km, it confluences with River Satluj at Anandpur Sahib in Punjab. The catchment of River Swan is largely degraded due to significant human interferences. The forests have been cleared to meet the fuelwood, fodder and timber requirements, or for commissioning of various infrastructure projects. This has led to serious drainage problems. As a result, the entire precipitation results in rapid flow into the tributaries. It results in flash floods leading to heavy floods. During past 10-12 years loss of property due to floods in river Swan has been estimated as more than Rs. 166.6 crore. Human and livestock loss has been to the extent of 50 and 236 numbers respectively. Because of such misery caused by the swan river, it was called Sorrow of Una.

Considering the misery of the people, a flood control scheme envisaging construction of embankments on both banks of Swan River was conceived. In Phase-I the embankments were proposed to be constructed in the lowest reach of the river. The bed slope in the stretch is 1:1160. The State Government of Himachal Pradesh has now decided to undertake flood protection works between Gagret Bridge to Jhalera Bridge for a stretch of about 28.34 km. This will enable reclamation of about 5,000 ha of land.

Methodology

The paper is based on the review of the relevant literature and internet sources on Flood management and overview of the EIA studies that are available on internet. That was supplemented with content analysis of secondary data and information from official publications and other related literature. The present paper covers the specific aspects of EIA which deals only with prevention of long term disaster impacts and flood management.

Location

District Una is situated on the bank of Swan River and spans between 75°58’2” - 76°28’25” East longitude and 31°17’52” - 31°52’0” North latitude. River flows from North to West direction. The river Swan originates from Joh-Marwari village near Daulatpur Chowk in Amb tehsil (nearly 35 km from Una) in district Una, Himachal Pradesh (Figure 1 & 2).

Figure: 1 Map showing District Una and Swan River Watershed

Figure 2: Map showing District Una and Swan River Watershed

Discussion

Table. 1 outlines the salient features of the Swan River Flood Management Project.

Table 1: Salient features of the Project

S.No.	Parameter	Value
General Information		
1	Length of Swan River in HP	65 km
2	Total catchment area of Swan	1400 Sq.Kms
3	Catchment area falling in HP	1200 Sq.Kms.
4	Nos. of Tributaries	73
5	Design Flood	5300 cumecs
6	Mean Annual Rainfall	1205 mm
7	Annual rate of siltation	0.25 ha m/yr/km

S.No.	Parameter	Value
Main Embankment		
1	Length	2x28.34 km
2	Free Board	1.00 m
3	Stone pitching	0.30 m thick in wire crate
4	Width of apron	
5	a) Gagret bridge to Loharli RD 47500 to 33200 6.00 m	6.00 m
6	b) Loharli to Jhalera bridge RD 33200 to 19160 7.00 m	7.00 m
7	Thickness	0.60 m in two layers & 0.30 m each
8	Spacing c) Gagret bridge to Loharli RD 47500 to 33200 555 m	555 m
9	d) Loharli to Jhalera bridge RD 33200 to 19160	665 m
10	Slide slope	2:1
Cost (Rs. Lacs)		
1	Civil Works	21524.94
2	Fishery Development	1058.00
3	Horticulture Development	438.03
4	Forestry Development	292.00
5	Agriculture Development	239.21
6	Total Project Cost (Rs. lacs)	23552.18
7	Benefits (Rs. lacs)	
8	Flood Benefits	485.63
9	Benefits from Fisheries Development	274.50
10	Benefits from horticulture development	365.38
11	Benefits from Forestry development	2617.67
12	Benefits from agriculture development	1307.83
Total Annual benefits (Rs. lacs)		**5051.01**
Benefit Cost Ration		**1.30:1**

Embankments & spurs

The core of the embankment shall be of clayey soil and spur will be in stones duly filled in wire crates. The top width of embankment is 6 m with side slope of 2:1. Free board of 1 m is kept and seepage protection is through clay core. The salient features of the project are given in Table 1.

Figure 3: Photo graphs depicting structural mitigation measures viz. stone spurs, embankments, aprons and stone pitching.

Demography

The total population of district Una is 378,269. The population of the Swan sub-catchment is about 0.25 million of which 92% lives in the rural areas. The construction of the embankments will mitigate the measures of flood in various villages in district Una. As per 2001 census, the population affected due to the floods is likely to be of the order of 102,737.

Land use pattern

The major land use category in the study area is, area under barren land, which accounts for 37.81% of the study area. The other dominant land use categories are open forest (23.77%), agricultural land (21.24%) and medium forest (15.65%). Details of the land use pattern of the study area given in table 2.

Table 2: Land use pattern of the study area

Land use Cover	Area (in %)
Water bodies	0.35
Scrub	0.16
Open forest	23.77
Medium forest	15.65
Agricultural land	21.24
Settlements	1.02
Barren land	37.81
Total	100.00

Source: IPH (1999)

Environmental Baseline Status

Before start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. Table 3 outlines the environmental baseline status of the study area.

Table 3: Environmental baseline status

S.No.	Component	Remarks
1.	Geology	main formations are alluvial fans, river terraces and gravel beds of the recent age & the sandstone, clay stone and conglomerates belonging to Shivalik group.
2.	Soils	Developed from colluvium & alluvium brought down & deposited in the valleys. The pH of soil at various sites lies within neutral range. The general soil composition includes 84% of sand, 11% of silt and 5% of clay. Thus, the soils have low clay.
3.	Meteorology	Area lies within Outer Himalayan zones. Climatically, the year can be divided into four well defined seasons.
4.	Water resources	The steep slope results in quick build up of runoff into steep, nallas, outfalling in river Swan. The major contribution to river Swan is monsoon months is the direct runoff.
5.	Water quality	The total hardness in various water samples ranged from 152-200 mg/l. The low calcium and magnesium levels are responsible for soft nature of water. The EC and TDS values indicate the lower concentration of cations and anions
6.	Ambient air quality	At all monitoring stations, the SPM level was much below the permissible limit, specified for residential and rural areas.
7.	Ambient noise level	The noise level at various sampling stations ranged from 32 to 40 dB(A), which were very well within permissible limits specified for residential area.
8.	Vegetation	Flora: Two types (Northern dry mixed deciduous type and Lower Shivalik Chil pine type) Fauna: No major faunal species and wildlife. Mainly livestock, etc. Few rabbit, blue bull and jackal, etc. are reported
9.	Fisheries	The major species found in river Swan are Sal, Mahseer, Gid & Dol
10.	Agriculture	Major crops are wheat and maize, pulses, mash and moong the other major crops grown during the Kharif season.

Overview of EIA of Swan River Flood Management Project

Based on the project details and the baseline environmental status, potential impacts which will help in mitigating flood damages and development of the project area as a result of the construction and operation of the proposed Swan river flood management are summarised in the following sections.

Operation Phase

The construction of the proposed embankment would lead to reclamation of 5000 ha of land. The land reclaimed from the floods in phase-II will be earmarked to various departments such as Agriculture, Fisheries, Forestry and Horticulture Departments.

Table 4: Land Reclaimed from Floods

The afforestation component envisages the following:		
S.N.	Component	Area
1.	Plantation along embankment	52 ha
2.	Pasture development	21 ha
3.	Plantation over government land	400 ha
4.	Distribution of saplings to public for afforestation over an area	857 ha
Total		1330 ha
The land earmarked for use by various departments is as follows:		
1.	Fisheries Department	400 ha
2.	Horticulture Department (Guava=120 ha, Pear=220ha , Grapes=110 ha, Pomegranate=220 ha ,Total =670 ha)	670 ha
3.	Forest Department	1330 ha
4.	Agriculture Department	2600 ha
	Total	5000 ha

The increase in vegetation cover will increase the microbial activity, organic matter with an improvement in soil binding capacity. The vegetal cover would reduce the velocity of runoff, reducing the vulnerability to soil. The increase in vegetal cover and increased agriculture production would increase the fodder availability.

Table 5: Impact on Water Environment

S.N.	IMPACT on Water environment	
1	Water Resources	Construction of embankment leads to the reduction in the valley storage. Hence, the flood peaks in Swan river stretches downstream of the embankment will increase. The effect of the increase in the flood intensity will be mainly felt in the Anandpur Sahib area of Punjab where the impact due to flooding would be minimal.
2.	Changes in water levels	The construction of embankment will constrict the width of flow channel in river Swan. This would lead to increase in the water level. The height of the embankments is 2.6 to 3.0 m which is much higher than 1.55 m, the highest increase in water level (1.55 m) for a discharge of 4500 m^3/s. This flood would neither overtop the embankment, nor would affect the structural stability of the embankments.
3.	Effect on flow velocity	Range of velocity remains same throughout the stretch of river Swan. Therefore, no downstream erosion of land due to increased velocity of the river in response to the training of the river is expected.
4.	Effect on discharge intensities	The maximum increase in depth is of the order of 0.7 m. As far as discharge is concerned the increase is more pronounced on the downstream side.
5.	Impacts of silt deposition	The canalisation from Santokhgarh bridge to Jhalera bridge would prevent the deposition .The silt deposition with sand content and low organic matter led to reduction in soil productivity. Thus, the canalisation project would lead to improvement in productivity of soils. An area of about 5,000 ha is likely to be reclaimed on this account.
6.	Effect on drainage system	About 26 small streams/tributaries join the Swan river. During high floods, the tributaries may be blocked at junction point with the main river. To counteract this problem of interface, drainage and for the safety of the embankment, provision for channelsing the tributaries upto the HFL line has been made.

Impacts on Socio Economic Environment

The river Swan is notorious for its flash floods causing damage to land, property and even human and cattle lives along its banks. The construction of embankments will mitigate the damages due to flood and reclaim the land for other productive use (Table 5). This will also increase the employment opportunities in and surrounding areas of Project site.

Table 6: Impact on Socio-economic Environment

S.N	Impact on socio-economic environment	
1.	Fisheries Development	Proposed to bring about 400 ha of land under pond fisheries in the low lying areas adjacent to river Swan which will be saved from floods as a result of the construction of embankments. The net profit will be Rs. 91,500 ha/year. About 1200 unemployed youths are likely to be benefitted.
2.	Horticulture Development	Will develop orchards (including demonstration areas) in an area of 670 ha over the reclaimed land. Guava, grape and pear are proposed to be grown for development of orchards in the area.
3.	Agriculture Development	About 2,600 ha of the total reclaimed land will be brought under agriculture. At present, most of the land in the flood-prone areas is left fallow. However, once the embankments are constructed, these lands can be tilled. The increase in revenue generation from agriculture production over reclaimed has been estimated as Rs.130.78 million per annum.
4.	Afforestation	About 1,330 of reclaimed area would be afforested. This will result in direct benefits to the tune of Rs. 3.9 million/ha of afforestation on government land behind embankment. Likewise, a benefit to the tune of Rs. 2.98 million is estimated on plantation over. Government/ reclaimed land behind embankments.
5.	Employment generation	The agriculture component alone will ensure employment to about 3,450 persons per year, which is a significant positive impact. Another 1200 unemployed youths are likely to get employment due to fisheries component of the project; overall, it can be concluded that the project would significantly improve the employment scenario in the area.

Figure 4 : Reclaimed Area of Swan River Catchment near Gagret, District Una, Himachal Pradesh.

Figure 5 :The Land reclaimed from the Floods being used for agricultural activities near Gagret, Dist. Una, Himachal Pradesh

Conclusion

The objective of EIA is to foresee and address potential environmental problems/ concerns at an early stage of project planning and design. The present paper is based on the overview of The EIA report of Swan Flood Management Project and covers the specific aspects of EIA which deals only with prevention of long term disaster impacts and flood management. Management of activities within the flood-prone area can significantly reduce flood damages to existing development and prevent the amount of damages from rising in the future. The river Swan is notorious for its flash floods causing damage to land, property and even human and cattle lives along its banks. The construction of embankments and the project will mitigate the damages due to flood and reclaim the land for other productive use. The paper is intended to provide an overview of the prevailing baseline conditions and the aspects which will directly help in mitigation to attenuate the impacts. It can be concluded from the impact matrix that the project will help not only in flood management in future but also in improving the socio-economic conditions of the area surrounding the project site as a whole.

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Traditional Water Management System: A Case Study of *Ahar Pyne* System in Angra Village of Palamu District of Jharkhand

Swati Singh[1]

Abstract

The traditional water harvesting system that existed decades ago in various Indian states is as relevant today as it was then and perhaps even more. Present day India is no stranger to nature's fury like floods, drought, famine and hurricanes and it would be well to learn from the old wisdom of traditional customs of water harvesting. The traditional irrigation systems developed through indigenous knowledge find the maximum potential to be revived and enhance the irrigation potential. Ahar-Pyne system is one such indigenous irrigation technology of South Bihar and Jharkhand States of India, which continue to irrigate substantial areas even today, but has been in bad shape in recent years due to manifold reasons. In the present study, it has been tried to review the present status of Ahar-pyne by taking example of Angra, a small village in the Palamu district looking into the institutional and management issues attempting to assess the reasons for its decline and explore the possibility of revival of the system.

Key words: *Traditional Water harvesting, Ahar-pyne*

Introduction

Palamu district in Jharkhand state is normally characterised by drought leading to considerable loss of agricultural production and livestock wealth, besides causing misery to people inhabiting the area. Ecological degradation on account of denudation of forests and excessive grazing has resulted in soil erosion and decline in the productivity of the land. Palamu is considered as one of the districts under Drought-Prone Areas Programme (DPAP) launched by the Central Government in 1973-74 to tackle the special problems faced by those fragile areas, which are constantly affected by severe drought conditions. Rainfall in the district is either deficient or unevenly distributed. Palamu gets as much as 1200-1300 mm of rain in normal year but in its worst year (2009) it received around 600 mm[3] of rainfall. Several districts in Jharkhand including Palamu were crippled by drought in 2009 for two consecutive years. In Palamu, the distance between drought and famine or near famine conditions seems to be much shorter. Palamu is the region of enormous

1. Project Associate, Indo German Environment Partnership, GIZ India

potential and presently not equipped to conserve the water it receives as compared to the past (Sainath, 1996).

Figure 1: Barka Ahar of Village Angra

Traditional water harvesting systems have met both the domestic and irrigation needs of the people over years. *Ahar-Pyne* is one of such traditional rainwater and floodwater harvesting system, which is indigenous to South-Bihar and parts of Jharkhand. The *Ahar-Pyne* system of irrigation in Bihar was probably in use during the time of the Jatakas (tales of Buddha in his previous birth). In Kautilya's Arthashastra there is a reference to *Ahar* yodaka–setu as a method used for irrigation. Megasthenes, an ancient Greek traveller who visited India during the reign of Chandragupta Maurya (340-293 BC) mentioned the existence of closed canals in Bihar. The concept of Ahar in Palamu was used during the reign of King Medni in the 15^{th} century A.D., then come the Britishers who by their technical and managerial skills strengthened the Ahar-Pyne system of irrigation suiting the physiology and geography of the area. In Palamu, Ahar is not one structure rather it is a channel system. An *Ahar* resembled a rectangular catchment basin with embankments on three sides, the fourth side being the natural gradient of the land itself. *Ahar* beds were also used to grow a Rabi crop (sown in winter and harvested in summer. e.g. wheat) after draining out the excess water that remained after Kharif (sown in monsoon and harvested in autumn. e.g. paddy) cultivation. *Ahars* differ from the regular tanks in that the bed of an *ahar* is not dug and usual tanks do not have the raised embankment of an *ahar*. While ahars irrigating more than 400 ha are not rare, the average area irrigated by an *ahar* during early 20th century was said to be 57 ha (Sengupta, 1993; Pant, 2004). Water supply for an *ahar* comes either from natural drainage after rainfall (rainfed *ahars*) or through *pynes* where necessary diversion works are carried out. *Pynes* are artificial channels constructed to utilise river water in agricultural fields. Apart from irrigating agriculture fields, system of *Ahar-Pyne* is used to control torrential floodwater and thus was a tool to mitigate flood. According to O'Malley (1919), this indigenous system is the outcome of the natural conditions and physical configuration of the country, and has been evolved to meet the obstacles which they place in the way of cultivation. However, with the passage of time, the collective institutions of management of the *Ahar-Pyne* system have declined (Table 1).

Table 1: Area irrigated by ahar-pyne system

Year	Area irrigated (mha)	Region Covered
1930	0.94	South Bihar
1971	0.64	South Bihar
1976	0.55	South Bihar
1997	0.53	Whole of Bihar

Source: Pant (2004)

As per the Government figures, the area irrigated by *Ahar-Pyne* system in whole of Bihar came down to about 0.53 mha constituting about 12% of all irrigated sources in the year 1997 compared to about 18% in South and North Bihar alone during the first two decades of 20th century. In Palamu district of Jharkhand, rice cultivation was and is still mainly dependent on small bunds called *Ahars*. The irrigated area varied from less than a hectare up to 40 hectares, depending upon the size of the Ahars (Agarwal & Narain, 1997). These were made by constructing embankments across drainage hollows or across the natural slope of the fields, so as to intercept or impound a stream. They had several outlets called *bhaos,* consisting of cylinders or tubes of baked earth. As a rule, the outlets were kept closed during the rainy season and water thus accumulated in the bed of *Ahar*. The *bhaos* were opened when water was required, for instance, when rains failed in August, when transplantation was in full swing or at the close of monsoon. After the rains and after the irrigation of the paddy was completed, the remaining water left in the bund was drained off and the bed of the reservoir was cultivated with wheat, barley and other winter crops (Singh, 2013).

Irrigation was also done through dug wells at few locations where water table is shallow. Vegetables were grown in small plots adjoining the village homesteads and were watered by permanent wells. For the cultivation of sugarcane, temporary wells were generally used. The water was raised from the wells using a *latha* or lever, a long beam resting on an upright forked post with a *kunri* (bucket) at one end and a stone or a mass of dried mud at the other end. As wells were limited only to small part of the district, artificial irrigation was almost entirely confined to the Ahars and Pynes. The district depended almost entirely on bunds or reservoirs for the success or failure of the winter rice crops. Thus, these water harvesting structures played a crucial role in the economic stability of the district, especially during the years of deficient and unequally distributed rainfall.

Overview of the study area

Palamu district is situated 165 km away from Ranchi, the capital city of Jharkhand State. The district lies within the 23° 50’ and 24° 8’ north latitudes and 83° 55’ and 84°

30’ east longitudes covering an area of 4606 sq km. District has a total population of around 15 lakh among which 93% is rural and dispersed in around 2000 villages in 12 Blocks (2001 census).

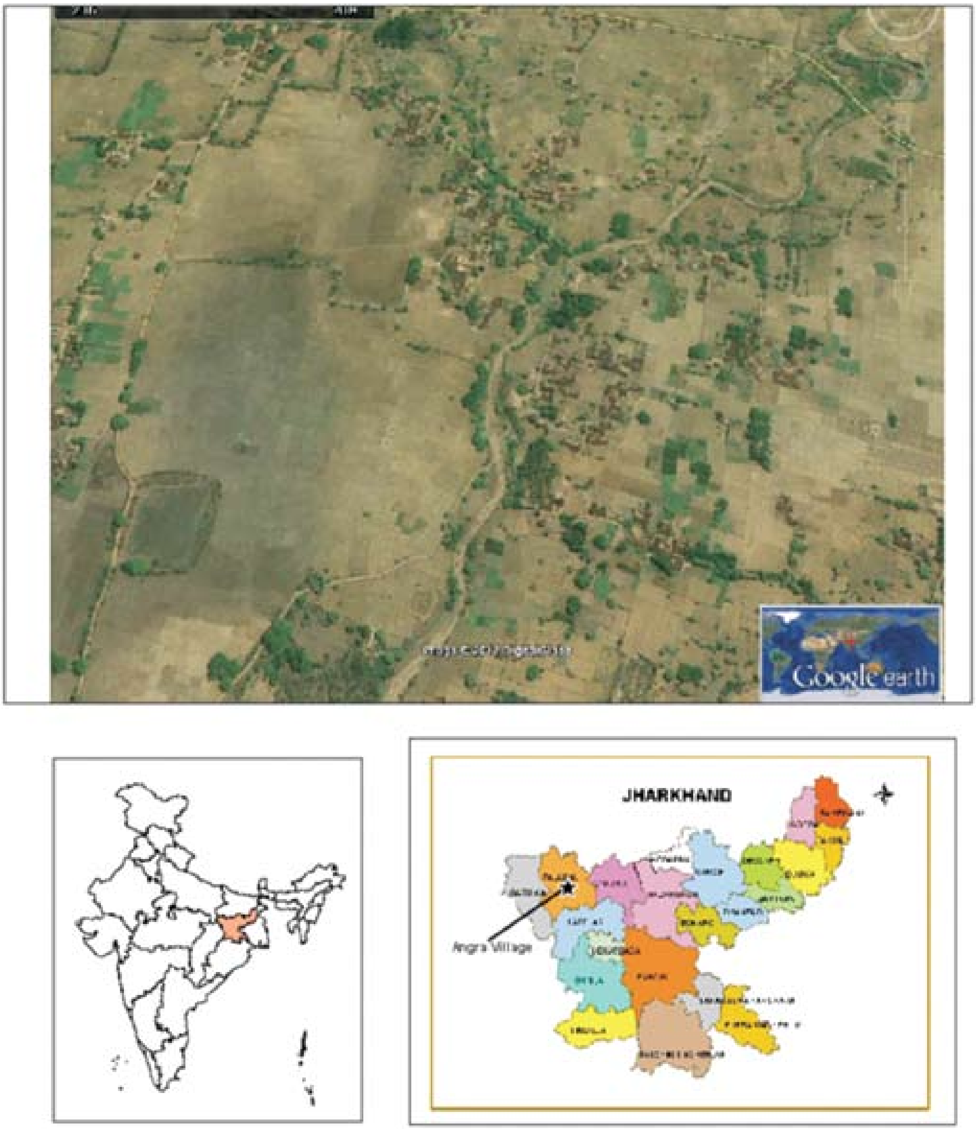

Figure 2: Map showing the study area.

The district has a population density around 240 per sq km (population density in the state is 338 and India 325), which is lower than the state. Palamu district is characterised by a series of parallel ranges of hills through which the Koel river passes. The most valuable arable land in the district is found in the valleys and on the banks of Koel and Son. Otherwise the district consists of hilly broken country covered with low-growth jungle and dissected by deep cuts caused by numerous streams and torrents which dry up in summer and come in spate during the monsoons. Unfortunately, rainfall in the district is either deficient or unfavourably distributed. Hence, agriculture is dependent on artificial irrigation. Both Rabi and Kharif crops suffer due to uncertain rainfall and the rapidity with which water

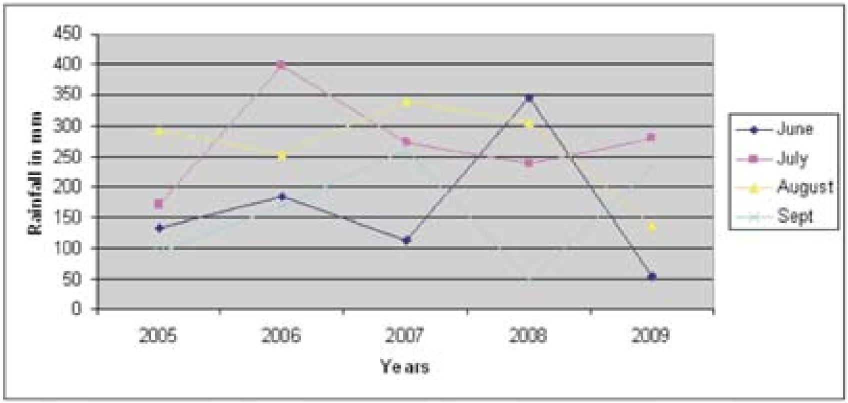

Figure 3: Monsoon rainfall during 2005-09 period (Source: imd.gov.in).

flows down to the main streams. The fate of rice crop is equally precarious, unless a means for storing water to irrigate the fields is devised. The district remained as one of the most backward region of the state and in the country (http://planningcommission.nic.in/reports/publications/tsk_idw.pdf) on around almost all development indicators. It is normally associated with droughts, large SC/ST population, large forest cover and recently increased naxalite activity. Palamu district is characterised by a series of parallel ranges of hills through which the Koel river passes. The rainfall in the district is both erratic and skewed, with annual average rainfall of about 700 mm.

The graph above shows how erratic the rainfall is even within the best four monsoon months. So kharif agriculture also suffers due to erratic rain. Even within a good month of rain, dry spell prolongs for 15 to 20 days which proves very fatal for the standing crops.

Hence agriculture is dependent on secondary sources of irrigation. The government data reveals that 19% of total cultivable land is irrigated but the actual percentage should be well below that according to the local people. Village Angra comes under Patan block, Kishunpur Panchayat of Palamu district which is dominated by tribals mainly belonging to Oraon tribe. Angra is *Khasmahal*[13] village which is endowed with rich forest resources and trees like *Sorea robusta* (Sal), *Madhuca indica* (Mahua), *Butea monosperma* (Palash), are dominant species. Total households in the village are 194, with population of 1033 and are dominated by scheduled tribes (70%) followed by schedule caste (30%). Map showing the study area is given Figure 2.

Research Methodology

Research design selected for the study was exploratory survey and evaluation. Purposive sampling at Ahar level was done and transect walk was done to get the overview and clarity of the structure. At farmer's level, detailed survey was done randomly and sampling size was 10% of the total households. Thus a total of 72 farmers were selected out of 708 for the study. Participatory Rural Appraisal techniques were adopted and mapping was done in order to get a fair idea about the state of the resources, social setup of the villages as well as the location and suitability of the structures. Focused Group Discussion helped to understand the historical perspective of the *Ahar-pynes*, socio-economic status of the farmers and to know from them how the system can be improved.

Research Findings

The total geographical area of this village is 732.90 acres with maximum percentage of upland (65.44%) followed by middle (19.91%) and lowland (14.65%). Once it was bestowed with rich forest resources but with increasing population this natural resource is dwindling very fast. Today forest cover is just 19.9% of the total geographical area.

Table 2: Land Type of Village Angra

Land Type	Area in acre
Total geographical area	732.90
Forest area	145.87
Irrigated land	107.4
Non irrigated	401.47

Major Sources of Livelihood

Agriculture: Angra is a rainfed village where agriculture depends on monsoon. The major Kharif crops of this village are paddy and maize. The average land holding is 3.34 acres per farmer with standard deviation (SD) ± 2.38. The SD is high because most of the respondents were small and marginal farmers. About 49.12% of total cultivable land is under paddy cultivation (this includes irrigated and non-irrigated land both). Maize occupies only 4.91% of the total cultivable land and source of irrigation is monsoon. The average production of paddy is 6.75 q/a and that of maize is 2.40 q/a. Because of lack of irrigation and other facilities like hybrid seeds, manures, new technology etc. the production is low as compared to the national average. Apart from paddy and maize, other crops grown are wheat, barley and *Cajanas cajan* (arhar). The major sources of livelihood of Angra are agriculture followed by labour work. Almost 100% of households practice agriculture in their own land for around four months which is mostly consumed by themselves only.

Labour: Nearly half the village is into non-agriculture labour for about six months in a year, which is just after the harvest of Kharif crops. Average per family income from labour was found to be Rs. 13,425 per annum with SD of Rs. 1153.

Sale of Non-Timber Forest Produce: Apart from agriculture and labour, the other source of income is selling of forest produce like flowers of *Madhuca indica (*Mahua) and leaves of *Diospyros melanoxylon (*Tendu*)*. They depend on these forest products for approximately 45 days. Each household collects around one to two quintals of Mahua. Most of them are consumed by themselves in the form of liquor and left over is sold in the market @ Rs.18/kg. villagers also collect kendu leaves and sell in the market @ Rs.47-50/*sekra* (1 sekra = 100 pola, 1 pola = 50 leaves) they sell around 10-15 sekra of kendu leaves. Some of the households also collect fruit of *Shorea robusta* called *sarai* in local language. They exchange *sarai* with salt. Average annual income from the sale of forest produce was found to be Rs.1090 with SD of Rs.115.

Overall these livelihood sources all together provide only about Rs.10,267/annum for each household. The economy is very poor and households basically have to depend on multiple sources in which agriculture to a large extent takes the primary role.

Migration Status: Inadequate irrigation facilities and limited agronomic inputs have resulted into poor productivity in the area and the agriculture production is mostly of subsistence level. The villagers are forced to migrate outside as there is scarcity of food for nearly half the year. The study shows that at least one member from every household migrates and the duration of migration varies from three to eight months. The general trend observed was that after paddy cultivation in October, villagers migrate in search of labour work. Around 72% of the households migrate as far as to Punjab, Dihri, Sasaram, Karnataka and Ranchi and remaining 28% remain in the vicinity of the area. Those who migrate outside live very miserable life and are forced to work in hostile condition and earn only on an average Rs.1,800 with SD of Rs. 254.

Village institutions: Except for four Self Help Groups, no village level institution was found to be functioning here. *Van Suraksha Samiti* was formed by the villagers who used to look after the forest, but at present it is dysfunctional.

Sources of irrigation: At present the irrigation facility is inadequate in the village. Due to the lack of irrigation facilities second season crops are grown on very small patch of land and most of the land is left fallow.

Table 2: Irrigation facilities in Angra village

Sources	Numbers	Area irrigated (acres)	Crops grown
Tube wells	9	0	Nil
Dug wells	28	10	Wheat, vegetables
Ahars	5	153	Paddy
Ponds	2	0	Nil
Check dam	1	0	Nil

Among different sources of irrigation maximum area is irrigated by *Ahars* even today. There are nine tube wells in the village out of which three are out of order. The remaining ones are used for drinking water purpose. Most of the dug wells get dry by the end of the winter season. Though there are 28 wells but most of them are *kuchha* wells and in total they irrigate approximately 10.34 acres of land. Government schemes are also visible in the form of two ponds and one check dam but they do not irrigate any land. The State Government has recently built a check dam in the year 2005 under minor irrigation scheme on stream that originates from the Angra Mountain but it has been unable to help in irrigating the land due to technical problems.

Rice cultivation is mainly dependent on *ahars* even today. Since the topography of the region is undulating; *ahars* were made in almost every depression to store the rainwater. The total *Ahars* in village are five but the most important and biggest *Ahar* of this village is *Barka Ahar* (which in local language means big or huge). It is considered as the life line of the village and was built in the year 1912 by the British. It is more or less rectangular in shape facing north-south direction with three sides closed and one side open to receive runoff water. It occupies around 36 acres of land (catchment area) which is 5% of the total geographical area of the village. At present it irrigates approximately 150 acres of land and if revived it has a potential of irrigating around 412 acres of land approximately. It means that there will be net increase in command area of 262 acres. Along with paddy cultivation, Rabi crops particularly wheat can also be irrigated with the water in the *Ahar*. Its revival will not only benefit farmers of Angra but will also benefit four more villages namely Arredana, Loinga, Sutha and Barwadih respectively.

Reasons for the decline of Ahars

1. Abolition of Zamindari (during the British period all cultivated lands belonged to Zamindars i.e. feudal landlords, who paid a fixed revenue to the British Government. After independence in 1952 this system was abolished and the land was distributed among the erstwhile tenants) system: Though zamindari system was never considered good for common people but its abolition has in real sense affected the ahar-pyne system of irrigation. Zamindars used to collect tax under the name of *Malgujari* which was a type of land excise. Taxes were either collected in the form of money or in the form of produce which was called produce rent according to the local people. If any damage occurred to the structure it was repaired by them from the money which they collected. Farmers were not charged separately for its repair though initial tax was high.
2. Apathy of Government towards *Ahar-pyne* system is the major reason why the old system is dying a silent death. The Government put lot of emphasis upon various irrigation projects in the District with no concrete result. The final nail in the coffin for the *Ahar-pyne* system was the implementation of Jawahar Rozgar Yojana around 1989 in the area where many of the *pynes* and raised embankments were converted to roads.
3. Large scale land encroachment and also selling of plots of lands by Zamindars was a factor for decline of the system. At present we can witness almost all types of constructions and activities on the old *Ahars* and *Pynes*. Converting the reservoir into full-fledged agriculture plots also slowly led to reduction in efficiency of the structure.
4. Siltation of the *Ahars* due to inadequate soil checks has led to decrease in water storage capacity and in some places; the *Ahar* beds are nearly reaching the ground level in absence of any desiltation activity.
5. After the Zamindars stopped having the centralised authority over the management of *Ahar-pynes*, the villagers or other authorities have not taken any

concrete steps for their management. There are no institutional management systems and the people became disinterested towards the traditional system. The farmers do not want to spend time for collective action and are focused on individual plots to benefit their own agricultural fields. Also, gradually they lost interest in agriculture and the current production is mostly subsistence level only. The local contractors and middlemen also discourage the local farmers for doing collective efforts towards repair and maintenance of the system.

Future strategy

This study tried to find alternatives of improving the irrigation status and income of farmers in Palamu and came to the conclusion that it was very critical to work towards revival of traditional *Ahar-pyne* system at the earliest as more delay would lead to a state where revival is impossible. Emphasis has to be laid upon people's participation and farmer-based system where the *Ahars* and *Pynes* would be collectively owned and managed. Study revealed that this was the only way to solve the problem of persistent drought and floods in the area. The following strategy is suggested:

1. Increasing the capacity of *Ahar*: The *Barka Ahar* has the total catchment area of 36 acres and has earthen embankment in three of its sides. The storage capacity can be increased either by deepening the bed or raising the height of the embankment or at times exercising both the options.
2. Desilting and lining the *pyne*: The *pyne* feeding water to the *Barka Ahar* is silted with around two to three feet depth of sand and the side embankments are broken at many sections. This has led to loss of water in the pyne and less storage in the *Ahar*. Desilting the *pyne*, strengthening its embankments and lining it, can feed more water to the *Ahar* and increase its storage.
3. Structural Rehabilitation of Barka *Ahar* for better operation: The *Ahar* has pipe spillway called *kanwa* to drain the surplus water and it goes below the village road. The pipe spillway is to be repaired and on the top of that a wider spillway can be provided for safety of the earthen embankments of the *Ahar*. When the surplus water is less in quantity it can be discharged through the existing pipe spillway and the new one would provide path to the flood water when it is in more quantity. The outlets have become weak and are made up of mud. These can be repaired and replaced to have better utility.
4. Institution Building for Operation, Maintenance of the Structures, Equitable Water Distribution and Agricultural Development: Irrigation through *Ahar pyne* system requires regular maintenance of the structures and every time government or other agencies cannot step in to rehabilitate the structure. So a Water User's Group (WUG) of the farmers to be benefited would be formed for

operation and maintenance of the structure and regulate water distribution in the command area. The systems of the institution should be designed adequately to collect the water charge and effectively take up the maintenance work when required. The WUG would ensure equitable distribution of the water and resolve any conflict arising during shortage of water. With maturity, the WUG can assist in agricultural production and marketing.

5. Collaboration with the Government Schemes: Since revival of Ahar-pyne is basically earthwork it can be dovetailed with Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). This will also help in getting employments and reducing stressed migration.

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Indigenous Knowledge in Disaster Risk Reduction and Climate Change Adaptation: Study of Housing pattern and Agricultural practices of Mishing community on Majuli Island, Assam

Sunanda Dey[1]

Abstract

Use of Indigenous knowledge in times of climate change needs an urgent reckoning. Indigenous and non-indigenous communities have been adapting for centuries to climatic trends and extremes. The Mishings of Majuli Island, Assam have their own traditional preparedness plans for the annual floods. The house structure, management of food storage and rescue boats is vital to Mishings. The case study of Mishing community of Majuli Island shows how eco-friendly development in the areas where indigenous people reside can be made by incorporating indigenous knowledge, disaster risk reduction and climate change adaptations. The assimilation of indigenous knowledge supports the disaster risk reduction plans made for local environment as they are evolved over period of time inculcating various aspects and needs of the ecology and ecosystems. Planners need to acknowledge the role of indigenous knowledge for better mitigation of disasters in future.

Keywords: *Indigenous knowledge, climate change, Majuli Island, Mishing Community*

Introduction

In the times when climate change has become a regular jargon being used in disaster mitigation policies the role of indigenous knowledge or the traditional knowledge becomes more imperative. Development professionals are talking about climate change adaptation and disaster risk reduction measures to cope with the impacts of disasters but lesser number of them are aware of the potential of indigenous knowledge; that too with the Midas touch of sustainable development. Indigenous (and non-indigenous) communities have been adapting for centuries to climatic trends and extremes (Brokensha et al., 1980; Campbell, 1990, 2006; Inglis, 1993; Nunn and Britton, 2001; Gaillard, 2007; Nunn et al., 2007, UK; Anchorage Declaration, 2009). Whilst some have experienced losses, other communities have adequately recovered through 'building back better' or 'building back safer'.

Broadly defined indigenous knowledge is the systemic information that remains in

1. Project Associate, National Institute of Disaster Management, New Delhi

the informal sector, usually unwritten and preserved in oral tradition rather than in texts. Indigenous knowledge helps in natural resource management which is really crucial for well being of the overall environment and sustainability. It is referred to as traditional environmental/ ecological knowledge or traditional knowledge in different places. Deborah McGregor (2004) in an, article says that Traditional Ecological Knowledge (TEK) as a construct of broader society is a relatively recent phenomenon, and the field that supports the acquisition of environmental knowledge from aboriginal people has rapidly grown over the last two decades. In part, TEK has emerged from the growing recognition that indigenous people all over the world developed sustainable environmental knowledge and practices that can be used to address problems that face global society. David Suzuki, scientist and environmentalist, writes, "My experience with Aboriginal people convinced me ... of the power and relevance of their knowledge and worldview in a time of imminent global ecocatastrophe." The international community has also recognised the important role Indigenous people and their knowledge can play in global society. In 1987 the Report of the World Commission on Environment and Development (or the Brundtland Report) recognised the important role of Indigenous people in sustainable development. Five years later, at the United Nations Conference on Environment and Development, the Convention on Biodiversity (CBD) was signed. The CBD reiterated the important role of Indigenous people and their knowledge for achieving sustainable environmental and resource management.

Case Study of Majuli Island

Mishing is a tribe settled mostly in the districts of Dibrugarh, Lakhimpur, Sibsagar, Jorhat, Darrang and Goalpara of Assam. Ethnically, the Mishings are mongoloid and belong to its Indo- Tibetan group (Figure 1). They belong to the tribal groups of Miyongs, Padams and Nishis of Arunachal Pradesh. It is said that the Mishings migrated from the hills of Arunachal to the plains of Assam about eight centuries ago and the process continued up to the first part of the 19^{th} century. Although they identify themselves as Mishing and regard it to be correct name of their community, they have been identified by the term Miri by the people of Assam and as mentioned in list of scheduled castes and tribes of India.

The Mishing people speak Mishing dialect. Their language belongs to the northern Assam branch of the Tibeto- Burman languages. There are almost 500,000 speakers of the language. It is also known as Plains Miri or Takam. The speakers of the language inhabit mostly Lakhimpur, Sonitpur, Dhemaji, Dibrugarh, Sibsagar, Jorhat, Golaghat, Tinsukia districts of Assam. Assamese language is as popular among them as their own dialect though pronunciation and expression in Assamese is not sound. The Mishings came into contact with the Ahom in the early part of the 16^{th} century. Most probably they know Assamese language since then. In the later period

Figure 1: Study Area Map

Assamese language was the medium of the Gosains and Brahmins who converted them into Hinduism. Assamese is the official language of working in Assam so in Majuli Island. The villagers can also understand Hindi to some extent and Bengali also. But the proportion of the villagers is comparatively less. The Mishing script is roman-based. The premier literary body of Mishing language is known as 'Mising Agom Kébang'.

Majuli's economy is predominantly an agrarian rural economy with more than 75 % of its population earning their livelihood from agriculture and allied activities like fishery and animal husbandry.

a) Agriculture: Out of the total arable land of 30,556 hectares, the net area sown is 28,452 hectares, with a cropping intensity of 175.70 %. The principal crops grown are paddy of three varieties viz. summer paddy, winter paddy and autumn paddy, rape and mustard, wheat, pulses, potato, garlic and sugarcane. Among the pulses grown in the island are black gram, green gram and peas. Sugarcane and arum are grown in the char areas of the island.

b) Animal Husbandry: It is not only subsidiary income to about 80 % of the families but also generates employment for thousands of people. A large number of cattle and goat farms are there in the islets or char areas. Piggery and pottery are two important sources of income for the tribal families, particularly the women folk.

c) Fishery: About 20% of the total geographical area of the island is covered by water throughout the year. With 152 natural registered fisheries and more than

Figure 2: A Traditional Mishing Ghar

200 cultured fisheries, about 10% of the population of Majuli earns their livelihood through fishery. Climate change and disasters impact the agricultural productivity of the farmers which crucially affects sustaining capacity of the inhabitants.

Disaster Preparedness by Mishings of Majuli Island

The Mishings have their own preparedness plans for the annual floods. The house structure, management of food storage and rescue boats is vital to Mishings. The traditional *Chang ghars* are built by them where the impacts of flood are least observed, as it saves their belongings during high floods. The bamboo used houses on slits are their cultural identity and is an indigenous method of protection and adaptation to the local environment.

Non-governmental organisations help them in reconstruction of their houses if any damaged during floods, and also provide economic relief through national schemes like Indira Awas Yojna to build their houses. The newly formed *chang ghar*s are modified in the building material used, keeping the original design intact. Though some educated Mishings have started to build Assamese style house in some part of Majuli Island-Jengraimukh. They are now more oriented towards modern living, though their number is very less now.

Nowadays due to more of NGOs penetration into the lives of Mishing, they are prepared well to face the wrath of floods. There are posters in Assamese language through which they are taught about cleanliness and hygiene to be maintained during flood times and otherwise. Mishing people are provided sanitation kits, soaps and foladies-sanitary pads to be used in general life and specially during disasters.

Figure 3: A Traditional granary with modern implants (front one- in preparation stage, back one- ready)

They are told by posters about rescue operation methods, in times of emergency evacuation, personal hygiene to be maintained during floods and in case some one falls ill, the symptoms to detect the disease.

For the protection of the food items during flood times the NGOs help inhabitants of a village or a group of villages in constructing granaries. These granaries are built on strong foundation instead of bamboo slits which are their traditional types. The granary's base pillars are covered by steel sheets so that it gets protected from rodents and other small animals attack. The construction is traditional in design but the parts constituting it are modern, so that the sentiments of the villagers are intact and also the purpose of building strong, protective granary is attained. For this often NGOs sponsor and sometimes villagers contribute according to their capacity.

Ham radio sets are provided to locals before the onset of floods to communicate. Boats are also provided which are used to rescue people during floods. Otherwise bamboo constructed temporary boat kind planks are provided. Besides, every villager knows swimming. They also sow deep water rice which is their specialty. This kind of rice can withstand floods and after the floods, can be harvested without worrying about the result. These are sown in low lying areas of the island. In high line areas they grow, *saali* paddy, which is another kind of rice.

Early Warning Systems for Flood

There are some signals from nature which it provides before any major event that is about to happen. The people living in consonance with nature are able to detect and identify them and are able to protect themselves in advance. Tribal people are masters in this. Mishing community has their own set of early warning signs which help them to prepare and know about the upcoming natural event. Related to floods, they have some signs and symptoms. The nearest river to Mishing people in Majuli is Brahmaputra and its tributary Luit. When they observe the soil sediments coming downstream, they can get an idea of how heavy the rains would be. If soil sediments are flowing in the river before the onset of monsoon, it signals that flood will come and the rain would be heavy leading to floods. Another warning system that works is observing the rain pattern. If during the beginning of the rainy season, it rains heavily for first week or more than 10 days continuously, it predicts heavy flooding. During these times Mishing community and other community people are evacuated to higher grounds. Another one is when wild animals start to retract to higher grounds, which shows that floods are approaching.

Besides this, the local information system is quite active during flood season or the rainy season. Regular updates are circulated by radio and ham radios to the villagers about the approaching floods or any unpleasant natural event. Some localised radio stations are opened up or local body operation centre is set up which updates them on hourly basis or as the situation demands. Nowadays television has penetrated into the lives of Mishing community, so live updates help people to assess the situation properly and act accordingly.

Indigenous Methods of Mishings

Patterns of House - the Mishing villages are situated on the banks of the river or a stream. A typical Mishing village usually consists of a population of less then one thousand living in about hundred households. The houses in the village always face running water. They are generally constructed close to one another without much thought for planning of the village. Unlike an Assamese village, the Mishing villages present a bleak landscape because the Mishing houses are seldom surrounded by kitchen gardens or fruit trees, although lately they have started planting some trees near their houses.

A Mishing village is distinguished by typical long dwelling houses (*Chang ghar*) which are built on a bamboo platform raised about six feet above ground on wooden poles. The width of the house is about 20 feet and its length depends on the size of the domestic family that occupies it. Nowadays the trend of nuclear families has shrunken the size of the houses. A Mishing house is not partitioned into small rooms but the entire domestic group lives in one single large barrack like hall. Each house has extended verandah in the front. There are only two doors in the house, one in front and the other in the rear. There are no windows in the house. The architectural pattern of the Mishing house has no variation in any form in the entire community though recently the more economically sound families have constructed brick pillars instead of wood pillar for their house foundation or have renovated their traditional house with contemporary building material. The traditional thatched roof is replaced with tin sheets in some dwellings.

A Mishing house built on a platform is highly adapted to the frequent floods that visit most parts of upper Assam and specially the riverine tracts. During normal floods, a Mishing village looks like a vast canvas with their houses quite above the water level. Unless the flood rises as high as seven feet, the Mishing house is quite safe. During the floods, the daily life of the people is modified but is not disrupted. The cattle are of course taken to a higher ground, but the poultry and pigs which every household possesses are housed on the raised pigsties and platforms. Each household also owns a few large boats and dugout canoes and instead of walking from one house to another, during the flood season they just row their canoes to visit others in the village. Thus the social life of the people is not greatly disrupted.

Every Mishing - man, woman and child- knows swimming and rowing and they are well adapted to the environmental conditions. The floods usually occur in late May and continue up to mid-July. If floods are not serious, they are in a way beneficial for the people. First, it's like annual cleaning of the underneath their houses and secondly, the flood waters also deposit rich silt on their fields and enrich its fertility. The last major flood came in July 2008 in recent history and the latest being the 2012 floods when three waves of floods happened and ravaged the island badly.

Farming Methods: Mishings are exclusively settled agriculturists. In their original home in the hill, they practiced shifting cultivation and after migrating to the plains, they did not totally abandon this practice. They could practice shifting cultivation initially in the plain because there were vast tracts of grasslands and forests in the alluvial plains of upper Assam. With the availability of fresh land the Mishing seldom stayed at one place permanently. They moved to a new site after a few years soon after the fertility of the soil was exhausted. The Mishings in Majuli Island grow *Saali* paddy in high line areas and deep water rice in low line areas. This is so because they don't waste their agricultural produce because of floods which come every year. The deep water rice is not affected by flood waters and can be harvested after the floods recede. The main problems for farmers are soil erosion and sand deposition in their fields when the water level recedes. Large chunk of lands are lost to the river Brahmaputra. When flood water enters the land, it brings sand along with it which remains afterwards affecting the fertility of the land.

Early Warning Symptoms: Mishing community people have developed some expertise on the forthcoming floods indicators which help them to forecast a flood and normal rains. The older generation people are expertise because of the experience they have over the years. One of the warning signs is observing the river system flowing near them. If there are soil sediments coming through river flows before the onset of monsoon, it indicates flooding for the year. Another indicator is rain at the beginning of the season. If the situation is such that it rains continuously for one week at the beginning of the rainy season, it indicates heavy floods.

The Mishing community when affected with disaster has its own ways and means to cope with annual flood events; still external assistance whatever received if not in their desired form is of no use to them. This is depicted in the above description of external help which they get from non-governmental organisations during preparedness phase and during disaster times. Indigenous people are really sensitive towards their cultural norms and practices and thus when have to adjust to some thing totally alien they succumb to extinction in extreme cases. This issue was a concern when NGO people were there on Majuli Island to help build resilient Mishing community and Majuli Island on the whole. In the present case of Mishing community, indigenous disaster risk reduction measures, which are existing in the form of their cultural native practices and rituals, with incorporation of climate change adaptation, were introduced in the development policy of the local government. In process the community benefits by becoming better equipped to future's impending disasters and sustain the aggravated impacts due to climate change.

Conclusion

In today's times when development practices are followed rampantly without putting mind over it, the significance of indigenous knowledge is getting forgotten. In time of disaster when relief and rehabilitation works are going on, the basic needs of the affected community are not met as according to their needs, the form in which they require it. There have been incidences of communities being offered tinned food (in Africa) during relief food material but it has not helped the aggrieved people as they didn't know how to use it. The culture and social norms which are followed by the indigenous people of a place need to be kept in mind when they are being helped in the aftermath of a disaster. The unique practices which they follow for specific purposes need a space in crisis times or they lose spatial correlations and it can endanger their identity. This shall be a huge impediment for them.

Today's rate of change may be reducing the viability of indigenous knowledge, it should still be considered a valuable knowledge base, from which it may be pertinent to draw on for devising new technologies or techniques for climate change adaptations

(Shea, 2003; Campbell, 2006; Gaillard, 2007; Anchorage Declaration, 2009) or disaster risk reduction measures. The integration of indigenous and scientific knowledge may strengthen the ability of indigenous communities to cope with climate change, whilst retaining their traditional practices (Kelman et al., 2009; Mercer et al., 2008, 2009, 2010).

The case study of Mishing community of Majuli Island shows how eco-friendly development in the areas where indigenous people reside can be made by incorporating indigenous knowledge, disaster risk reduction and climate change adaptations. The assimilation of indigenous knowledge supports the disaster risk reduction plans made for local environment as they are evolved over period of time inculcating various aspects and needs of the ecology and ecosystems. The native measures used for disaster mitigation are in sync with the local environment and needs and thus adapt smoothly without disturbing the flora or fauna much as compared to some totally unfamiliar activity which can be exploitive or endangering the local biodiversity of the place.

Note : The case study presented in the text was conducted in the month of November, 2010 as part of M. Phil. dissertation.

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National Institute of Disaster Management
IIPA Campus, I.P. Estate, Mahatma Gandhi Marg, New Delhi -110002
Phone: 91- 11 -23702445, Fax: 91- 11- 23702446
e-mail: ed.nidm@nidm.net, dharc@nic.in